

**CONTRACT DOCUMENTS & SPECIFICATIONS
FOR
CONTRACT NO. eDPW-040925**

Fair Acres Geriatric Kitchen Renovations

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Volume 2

Prepared for:

**The County of Delaware
Department of Public Works**
Government Center Building
201 West Front Street, Suite 207
Media, PA 19063

Prepared by:

Spiezle Architectural Group, Inc.



Delaware County Council:

**Dr. Monica Taylor, Chair
Richard R. Womack, Vice Chair
Kevin M. Madden
Elaine Paul Schaefer
Christine A. Reuther**

PROJECT MANUAL

ADDITIONS AND ALTERATIONS TO FAIR ACRES GERIATRIC CENTER KITCHEN RENOVATIONS

340 MIDDLETOWN RD
MEDIA, PENNSYLVANIA 19063

FOR THE

DELAWARE COUNTY FAIR ACRES
340 MIDDLETOWN ROAD
MEDIA, PENNSYLVANIA 19063

ARCHITECT'S PROJECT NUMBER: 23H033

FOR PERMIT SUBMISSION DATE: 04/09/2025



ADDITIONS AND ALTERATIONS TO

FAIR ACRES GERIATRIC CENTER KITCHEN RENOVATIONS

FOR THE

FAIR ACRES GERIATRIC CENTER

340 MIDDLETOWN ROAD

MEDIA, PENNSYLVANIA 19063

ARCHITECTS/PLANNERS:

SPIEZZLE ARCHITECTURAL GROUP, INC.

900 W. SPROUL RD.

SUITE 201

SPRINGFIELD, PENNSYLVANIA 19064

RA-403934

RICHARD QUINN

**MECHANICAL, ELECTRICAL, PLUMBING, AND
FIRE PROTECTION ENGINEER:**

REESE HACKMAN

3800 HORIZON BLVD., SUITE 503

TREVOSE, PA 19053

**MECHANICAL, PLUMBING, & FIRE
PROTECTION**

PE075392

SCOTT A. WHITE, P.E

ELECTRICAL

PE074556

**JEFFREY E. HOLSTEIN,
P.E.**

END OF SECTION 00 01 07

SECTION 210500 - COMMON WORK RESULTS FOR FIRE SUPPRESSION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

1.3 DEFINITIONS

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

G. The following are industry abbreviations for rubber materials:

1. EPDM: Ethylene-propylene-diene terpolymer rubber.
2. NBR: Acrylonitrile-butadiene rubber.

1.4 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.

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 fire-suppression installations.
- B. Coordinate requirements for access panels and doors for fire-suppression items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 08 Section "Access Doors and Frames."

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

2.2 PIPE, TUBE, AND FITTINGS

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

2.3 JOINING MATERIALS

- A. Refer to individual Division 21 piping Sections for special joining materials not listed below.
- B. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
 - 1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.
 - a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
 - b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.
 - 2. AWWA C110, rubber, flat face, 1/8 inch thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.
- C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
- D. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.
- E. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
- F. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.
- G. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
- H. Solvent Cements for Joining CPVC Plastic Piping: ASTM F 493.

2.4 MECHANICAL SLEEVE SEALS

- A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
 - 1. 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. Connecting Bolts and Nuts: of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.5 SLEEVES

- A. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.
- B. Cast Iron: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
- C. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
 - 1. Underdeck Clamp: Clamping ring with set screws.

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, Cast-Brass Type: With set screw.
 - 1. Finish: Polished chrome-plated.

2.7 GROUT

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

PART 3 - EXECUTION

3.1 PIPING SYSTEMS - COMMON REQUIREMENTS

- A. Install piping according to the following requirements and Division 21 Sections specifying piping systems.
- B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction

loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

- C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.
- D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- F. Install piping to permit valve servicing.
- G. Install piping at indicated slopes.
- H. Install piping free of sags and bends.
- I. Install fittings for changes in direction and branch connections.
- J. Install piping to allow application of insulation.
- K. Select system components with pressure rating equal to or greater than system operating pressure.
- L. Install escutcheons for penetrations of walls, ceilings, and floors.
- M. Permanent sleeves are not required for holes formed by removable PE sleeves.
- N. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs.
- O. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
 - 1. 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.
- P. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 07 Section "Penetration Firestopping" for materials.
- Q. Verify final equipment locations for roughing-in. Coordinate with other trades to allow adequate space for other systems.

3.2 PIPING JOINT CONSTRUCTION

- A. Join pipe and fittings according to the following requirements and Division 21 Sections specifying piping systems.
- B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.
- E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.
- F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- G. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.
- H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.
- 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. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
- J. Plastic Pressure Piping Gasketed Joints: Join according to ASTM D 3139.

3.3 PAINTING

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

3.4 CONCRETE BASES

- A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.
 - 1. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit.
 - 2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of the base.
 - 3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
 - 4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 5. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - 6. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.5 GROUTING

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

END OF SECTION 210500

SECTION 211100 - FIRE-SUPPRESSION 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.
- B. Refer to the P series and A series drawings for additional requirements and information.

1.2 SUMMARY

- A. This Section includes fire-suppression piping and equipment for the following building systems:
 - 1. Wet-pipe, fire-suppression sprinklers, including piping, valves, specialties, and automatic sprinklers throughout all areas of the new and existing facilities.
 - a. Existing Building (Renovations and additions)
 - 2. Dry-pipe fire-suppression sprinklers and valve assemblies, including piping, valves, specialties, automatic sprinklers, air compressors, and accessories for each of the following areas:
 - a. Walk-in Cooler boxes (New and Existing)
 - 3. Existing System Modifications shall be included in the scope.
 - a. The existing fire service entry will remain in place and be reused.
 - b. The existing backflow preventer, flow switch and tamper switches for the existing fire service entry shall remain.
 - c. Existing piping located within the areas of renovation shall be assumed to be in conflict with new work from other trades and therefore shall be replaced, however, existing piping may be retained and reused at the discretion of the contractor. Relocation and deletion of existing heads and branch pipe to accommodate the new space layout and modifications shall be included. This shall include the addition of new piping and sprinkler heads to ensure the system design meets all NFPA 13 requirements and to provide coverage of the additions and renovated areas.
 - d. Any existing piping which is retained and reused shall be raised and / or relocated throughout all areas of work to accommodate new partitions and ceiling arrangements, new higher ceiling heights and installation of new piping and ductwork systems. Existing piping may be reused, added to, and modified as required where possible and when in good condition. New components shall be provided as needed to meet all NFPA 13 requirements.
 - e. At the completion of the project the system shall be fully compliant with NFPA 13 and shall be fully documented in shop drawings and provided with new hydraulic calculations for the entire system.

- f. This contractor shall be responsible for visiting the project site prior to bid submittal. This contractor shall review all existing conditions and be responsible for including all products and services required to complete the scope of work outlined within this specification under this bid submittal. Change orders will not be approved for items resulting from this contractor's lack of knowledge of an existing condition.
 - g. All sprinkler heads within areas of renovation shall be replaced unless noted otherwise.
- 4. The project shall include galvanized, schedule 40 steel pipe and fittings for all piping in each dry system.
- 5. Install sprinklers in the center of tile.
- 6. Install sprinklers in the center row of each corridor.
- 7. Head placement shall be symmetrical and coordinated with all ceiling equipment, lights, air devices and other ceiling mounted devices. The Architect and Engineer shall review the Shop Drawings and modify proposed head arrangement to meet the Architect's aesthetic requirements for the project.
- 8. The system shall be designed in accordance with NFPA 13.
- 9. All systems drains shall be routed concealed through the building structure and shall discharge onto grade or into an approved receptor. Requests for approval to discharge into a receptor shall be submitted to the engineer for review and approval. Terminations to the exterior shall be painted to match the exterior wall.
- 10. All sprinkler heads shall be quick response style.
- 11. The building and spaces adjacent to the renovation shall remain occupied and operational during construction. The contractor shall be responsible for providing the necessary arrangements, both temporary and permanent, to maintain occupancy in accordance with NFPA 241 and local requirements.
- 12. The contractor shall be responsible for providing all heads required to comply with NFPA whether specifically indicated on the Construction Drawings or not. The contractor shall coordinate with other trades to provide an arrangement of devices in the ceiling that meets the aesthetic requirements indicated in the Architectural documents.

B. Related Sections include the following:

- 1. Division 28 Section "Fire Alarm Systems" for alarm devices not in this Section.

1.3 DEFINITIONS

- A. Working Plans: Documents, including drawings, calculations, and material specifications prepared according to the most current version of NFPA 13 for obtaining approval from authorities having jurisdiction and the Owner's insurance company.

1.4 SYSTEM PERFORMANCE REQUIREMENTS

- A. Design sprinkler system according to the following and obtain approval from authorities having jurisdiction:
 - 1. Include 10 percent margin of safety for available water flow and pressure in all calculations.

2. Include losses through water-service piping, valves, and backflow preventers.
 3. Sprinkler Occupancy Hazard Classifications: As follows:
 - a. Building Service Areas: Ordinary Hazard, Group 1.
 - b. Electrical Equipment Rooms: Ordinary Hazard, Group 1.
 - c. General Storage Areas: Ordinary Hazard, Group 1.
 - d. Mechanical Equipment Rooms: Ordinary Hazard, Group 1.
 - e. Public Areas: Light Hazard.
 - f. Kitchen Service Areas: Ordinary Hazard, Group 1.
 4. Minimum Density for Automatic-Sprinkler Piping Design: As follows:
 - a. Light-Hazard Occupancy: 0.10 gpm over 1500-sq. ft. area.
 - b. Ordinary-Hazard, Group 1 Occupancy: 0.15 gpm over 1500- sq. ft. area.
 5. Maximum Protection Area per Sprinkler:
 - a. According to NFPA 13 recommendations, unless otherwise indicated. Extended coverage systems shall not be included in the design of any portion of the fire protection system.
- B. Components and Installation: Capable of producing piping systems with 175-psig minimum working-pressure rating, unless otherwise indicated.

1.5 SUBMITTALS

- A. Product Data: For the following:
1. Pipe and fitting materials and methods of joining for sprinkler piping.
 2. Pipe hangers and supports.
 3. Valves, including specialty valves, accessories, and devices.
 4. Alarm devices. Include electrical data.
 5. Sprinklers, escutcheons, and guards. Include sprinkler flow characteristics, mounting, finish, and other pertinent data.
- B. Fire-Hydrant Flow Test Report: Flow test data must be performed within six months of project start date.
- C. Approved Sprinkler Piping Drawings: Working plans, prepared according to NFPA 13 that have been approved by authorities having jurisdiction. Include hydraulic calculations.
1. All plans and calculations shall be approved by the Owner's insurance company prior to submission to the jurisdictional authorities and engineer.
 2. Include site plan with water service size and location.
- D. Field Test Reports and Certificates: Indicate and interpret test results for compliance with performance requirements and as described in NFPA 13.
- E. Maintenance Data: Each type of sprinkler specialty to include in maintenance manuals specified in Division 01.

- F. Details shall be included for the building expansion joints to accommodate the anticipated seismic displacements across the joints.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: An experienced installer who has designed and installed fire-suppression piping similar to that indicated for this Project for 10 years and obtained design approval and inspection approval from authorities having jurisdiction.
- B. Engineering Responsibility: Preparation of working plans, calculations, and field test reports by a qualified professional. Base calculations on results of fire-hydrant flow test.
- C. Professional Qualifications: A professional fire protection engineer who is legally qualified to practice in jurisdiction where Project is located and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for installations of fire-suppression piping that are similar to those indicated for this Project in material, design, and extent. All State of Pennsylvania licensure requirements shall be followed to identify a professionals approved for engineering and stamping of the design documents.
- D. Manufacturer Qualifications: Firms whose equipment, specialties, and accessories are listed by product name and manufacturer in UL's "Fire Protection Equipment Directory" and FM's "Fire Protection Approval Guide" and that comply with other requirements indicated.
- E. Sprinkler Components: Listing/approval stamp, label, or other marking by a testing agency acceptable to authorities having jurisdiction.
- F. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction.
- G. NFPA Standards: Equipment, specialties, accessories, installation, and testing complying with the following:
 - 1. NFPA 13, "Installation of Sprinkler Systems."

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. Sprinkler Cabinets: Finished, wall-mounting steel cabinet and hinged cover, with space for a minimum of six spare sprinklers of each type used in the facility plus sprinkler wrench. Include the number of sprinklers required by NFPA 13 and wrench for sprinklers. Include separate cabinet with sprinklers and wrench for each type of sprinkler on Project.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Specialty Valves and Devices:
 - a. Central Sprinkler Corp.
 - b. Firematic Sprinkler Devices, Inc.
 - c. Globe Fire Sprinkler Corp.
 - d. Grinnell Corp.
 - e. Reliable Automatic Sprinkler Co., Inc.
 - f. Viking Corp.
 2. Water-Flow Indicators and Supervisory Switches:
 - a. Gamewell Co.
 - b. Grinnell Corp.
 - c. Pittway Corp.; System Sensor Div.
 - d. Potter Electric Signal Co.
 - e. Reliable Automatic Sprinkler Co., Inc.
 - f. Viking Corp.
 3. Sprinkler, Drain and Alarm Test Fittings:
 - a. Central Sprinkler Corp.
 - b. Fire-End and Croker Corp.
 - c. Grinnell Corp.
 - d. Victaulic Co. of America.
 4. Sprinkler, Branch-Line Test Fittings:
 - a. Elkhart Brass Mfg. Co., Inc.
 - b. Fire-End and Croker Corp.
 - c. Smith Industries, Inc.; Potter-Roemer Div.
 5. Sprinkler, Inspector's Test Fittings:
 - a. Fire-End and Croker Corp.
 - b. G/J Innovations, Inc.
 - c. Triple R Specialty of Ajax, Inc.
 6. Sprinklers:
 - a. Central Sprinkler Corp.
 - b. Firematic Sprinkler Devices, Inc.
 - c. Globe Fire Sprinkler Corp.
 - d. Grinnell Corp.
 - e. Reliable Automatic Sprinkler Co., Inc.
 - f. Viking Corp.
 7. Indicator Valves:

- a. Central Sprink, Inc.
 - b. Grinnell Corp.
 - c. McWane, Inc.; Kennedy Valve Div.
 - d. Milwaukee Valve Co., Inc.
 - e. Nibco, Inc.
 - f. Victaulic Co. of America.
- 8. Fire-Protection-Service Valves:
 - a. Central Sprink, Inc.
 - b. Central Sprinkler Corp.
 - c. Grinnell Corp.
 - d. McWane, Inc.; Kennedy Valve Div.
 - e. Nibco, Inc.
 - f. Stockham Valves & Fittings, Inc.
 - g. Victaulic Co. of America.
- 9. Mechanical Couplings for Steel Piping:
 - a. Central Sprink, Inc.
 - b. Ductilic, Inc.
 - c. Grinnell Corp.
 - d. National Fittings, Inc.
 - e. Star Pipe Products, Inc.; Star Fittings Div.
 - f. Victaulic Co. of America.
- 10. Mechanical Couplings for Ductile-Iron Piping:
 - a. Victaulic Co. of America.

2.2 PIPING MATERIALS

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

2.3 PIPES AND TUBES

- A. Ductile-Iron Pipe: AWWA C151, push-on-joint type; with cement-mortar lining and seal coat according to AWWA C104 or grooved joint and coupling system. Include rubber gasket according to AWWA C111. Must be approved for potable water service.
- B. Standard-Weight Steel Pipe: ASTM A 53, ASTM A 135, or ASTM A 795; Schedule 40 in NPS 2" and smaller, and Schedule 10 in NPS 2½" and larger. Galvanized where indicated.
- C. Schedule 30 Steel Pipe: ASTM A 135 or ASTM A 795, with wall thickness less than Schedule 40 and equal to or greater than Schedule 30 or ASTM A 795 and ASME B36.10M, Schedule 30 wrought-steel pipe. (NPS 2½" and larger.) Galvanized pipe and fittings where indicated.

2.4 PIPE AND TUBE FITTINGS

- A. Ductile-Iron Fittings: AWWA C110, ductile-iron or cast-iron push-on-joint type; or AWWA C153, ductile-iron, compact push-on-joint type. Include cement-mortar lining and seal coat according to AWWA C104 and rubber gaskets according to AWWA C111.
- B. Cast-Iron Threaded Flanges: ASME B16.1.
- C. Cast-Iron Threaded Fittings: ASME B16.4.
- D. Malleable-Iron Threaded Fittings: ASME B16.3.
- E. Steel, Threaded Couplings: ASTM A 865.
- F. Steel Welding Fittings: ASTM A 234/A 234M, ASME B16.9, or ASME B16.11.
- G. Steel Flanges and Flanged Fittings: ASME B16.5.
- H. Steel, Grooved-End Fittings: UL-listed and FM-approved, ASTM A 47, malleable iron or ASTM A 536, ductile iron; with dimensions matching steel pipe and ends factory grooved according to AWWA C606. Galvanized fittings where indicated.

2.5 JOINING MATERIALS

- A. Refer to Division 21 Section "Common Work Results for Fire Suppression" for pipe-flange gasket materials and welding filler metals.
- B. Ductile-Iron, Flanged Joints: AWWA C115, ductile-iron or gray-iron pipe flanges, rubber gaskets, and steel bolts and nuts.
- C. Steel, Grooved Couplings: UL 213 and AWWA C606, for steel-pipe dimensions. Include ASTM A 536, ductile-iron housing, rubber gaskets, and steel bolts and nuts. Include listing for dry-pipe service for couplings for dry piping.
- D. Transition Couplings: AWWA C219, sleeve type, or other manufactured fitting the same size as, with pressure rating at least equal to, and with ends compatible with piping to be joined.

2.6 GENERAL-DUTY VALVES

- A. Refer to Division 22 Section "Valves" for gate, ball, butterfly, globe, and check valves not required to be UL listed and FM approved.

2.7 FIRE-PROTECTION-SERVICE VALVES

- A. General: UL listed and FM approved, with minimum 175-psig non-shock working-pressure rating. Valves for grooved-end piping may be furnished with grooved ends instead of type of ends specified.

- B. Gate Valves, NPS 2 and Smaller: UL 262; cast-bronze, threaded ends; solid wedge; OS&Y; and rising stem.
- C. Indicating Valves, NPS 2-1/2 and Smaller: UL 1091; butterfly or ball-type, bronze body with threaded ends; and integral indicating device.
 - 1. Indicator: Electrical 115-V ac, prewired, supervisory switch.
- D. Gate Valves, NPS 2-1/2 and Larger: UL 262, iron body, bronze mounted, taper wedge, OS&Y, and rising stem. Include replaceable, bronze, wedge facing rings and flanged ends.
- E. Swing Check Valves, NPS 2 and Smaller: UL 312 or MSS SP-80, Class 150; bronze body with bronze disc and threaded ends.
- F. Swing Check Valves, NPS 2-1/2 and Larger: UL 312, cast-iron body and bolted cap, with bronze disc or cast-iron disc with bronze-disc ring and flanged ends.
- G. Split-Clapper Check Valves, NPS 4 and Larger: UL 312, cast-iron body with rubber seal, bronze-alloy discs, and stainless-steel spring and hinge pin.

2.8 SPECIALTY VALVES

- A. Dry-Pipe Valves: UL 260; differential type; 175-psig working pressure; with cast-iron flanged inlet and outlet, bronze seat with O-ring seals, and single-hinge pin and latch design. Include UL 1486, quick-opening devices, trim sets for air supply, drain, priming level, alarm connections, ball drip valves, pressure gages, priming chamber attachment, and fill-line attachment. Include two pressure switches per assembly.
 - 1. Option: Grooved-end connections for use with keyed couplings.
 - 2. Air Compressor: 120-V ac, 60 Hz, single phase, 10 gallon tank minimum. Provide Low Noise air compressor in sound sensitive areas.
- B. Ball Drip Valves: UL 1726, automatic drain valve, NPS 3/4, ball check device with threaded ends.

2.9 SPRINKLERS

- A. Automatic Sprinklers: With heat-responsive element complying with the following:
 - 1. UL 199, for applications except residential.
- B. Sprinkler Types and Categories: Quick response style for "Ordinary" temperature classification rating shall be used in all areas unless otherwise indicated or required by application.
- C. Sprinkler types, features, and options include the following:
 - 1. Concealed ceiling sprinklers, including cover plate.
 - 2. Pendent sprinklers.
 - 3. Pendent, dry-type sprinklers.
 - 4. Quick-response sprinklers.

5. Recessed sprinklers, including escutcheon.
6. Sidewall sprinklers.
7. Sidewall, dry-type sprinklers.
8. Upright sprinklers.

D. Sprinkler Finishes: White enameled and bronze.

E. Sprinkler Escutcheons: Materials, types, and finishes for the following sprinkler mounting applications. Escutcheons for concealed and recessed-type sprinklers are specified with sprinklers.

1. Ceiling Mounting: White enameled steel, one piece, flat.
2. Sidewall Mounting: White enameled steel, one piece, flat.

F. Sprinkler Guards: Wire-cage type, including fastening device for attaching to sprinkler.

2.10 SPECIALTY SPRINKLER FITTINGS

- A. Specialty Fittings: UL listed and FM approved; made of steel, ductile iron, or other materials compatible with piping.
- B. Dry-Pipe-System Fittings: UL listed for dry-pipe service.
- C. Sprinkler, Drain and Alarm Test Fittings: UL-listed, cast- or ductile-iron body; with threaded inlet and outlet, test valve, and orifice and sight glass.
- D. Sprinkler, Branch-Line Test Fittings: UL-listed, brass body; with threaded inlet and capped drain outlet and threaded outlet for sprinkler.
- E. Sprinkler, Inspector's Test Fittings: UL-listed, cast- or ductile-iron housing; with threaded inlet and drain outlet and sight glass.
- F. Air Vents: FM-UL-listed manual style.

2.11 ALARM DEVICES

- A. General: Types matching piping and equipment connections.
- B. Water-Flow Indicators: UL 346; electrical-supervision, vane-type water-flow detector; with 250-psig pressure rating; and designed for horizontal or vertical installation. Include two single-pole, double-throw, circuit switches for isolated alarm and auxiliary contacts, 7 A, 125-V ac and 0.25 A, 24-V dc; complete with factory-set, field-adjustable retard element to prevent false signals and tamperproof cover that sends signal if removed.
- C. Pressure Switches: UL 753; electrical-supervision-type, water-flow switch with retard feature. Include single-pole, double-throw, normally closed contacts and design that operates on rising pressure and signals water flow.
- D. Valve Supervisory Switches: UL 753; electrical; single-pole, double throw; with normally closed contacts. Include design that signals controlled valve is in other than fully open position.

- E. Indicator-Post Supervisory Switches: UL 753; electrical; single-pole, double throw; with normally closed contacts. Include design that signals controlled indicator-post valve is in other than fully open position.

2.12 PRESSURE GAGES

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

PART 3 - EXECUTION

3.1 PREPARATION

- A. Perform fire-hydrant flow test according to NFPA 13 and NFPA 291. Use results for system design calculations required in "Quality Assurance" Article in Part 1 of this Section.
- B. Water system modeling may be used when requested by local jurisdictional official in the absence of viable flow data.
- C. Report test results promptly and in writing.

3.2 EARTHWORK

- A. Refer to Division 31 Section "Earthwork" for excavating, trenching, and backfilling.

3.3 EXAMINATION

- A. Examine walls and partitions for suitable thickness, fire- and smoke-rated construction, framing and other conditions where piping is to be installed.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.4 PIPING APPLICATIONS

- A. Do not use welded joints with galvanized steel pipe.
- B. Flanges, unions, and transition and special fittings with pressure ratings the same as or higher than system's pressure rating may be used in aboveground applications, unless otherwise indicated.
- C. Sprinklers: Use the following:
 - 1. NPS 2" and smaller: Standard-weight schedule 40 steel pipe with threaded ends or plain ends or grooved ends, cast or malleable-iron threaded fittings, and threaded joints or welded fittings and welded joints or grooved end fittings and grooved joints.

2. NPS 2-1/2" to NPS 8: Standard-weight schedule 40 or schedule 10 steel pipe with plain ends, steel welding fittings, and welded joints or grooved ends, grooved end fittings and grooved joints.
3. All piping and fittings for each dry pipe system shall be hot-dip galvanized and scheduled as noted in items 1 and 2 above.

3.5 VALVE APPLICATIONS

- A. Where specific valve types are not indicated, the following requirements apply:
 1. Fire-Protection-Service Valves: UL listed and FM approved for applications where required by NFPA 13.
 - a. Shutoff Duty: Use gate valves.
 2. General-Duty Valves: For applications where UL-listed and FM-approved valves are not required by NFPA 13.
 - a. Shutoff Duty: Use gate, ball, or butterfly valves.
 - b. Throttling Duty: Use globe, ball, or butterfly valves.

3.6 JOINT CONSTRUCTION

- A. Refer to Division 21 Section "Common Work Results for Fire Suppression" for basic piping joint construction.
- B. Ductile-Iron-Piping, Grooved Joints: Use ductile-iron pipe with radius-cut-grooved ends; ductile-iron, grooved-end fittings; and ductile-iron, keyed couplings. Assemble joints with couplings, gaskets, lubricant, and bolts according to coupling manufacturer's written instructions.
- C. Steel-Piping, Grooved Joints: Use Schedule 40 steel pipe with cut or roll-grooved ends and Schedule 30 or thinner steel pipe with roll-grooved ends; steel, grooved-end fittings; and steel, keyed couplings. Assemble joints with couplings, gaskets, lubricant, and bolts according to coupling manufacturer's written instructions. Use gaskets listed for dry-pipe service for dry piping.
- D. Dissimilar-Piping-Material Joints: Construct joints using adapters or couplings compatible with both piping materials. Use dielectric fittings if both piping materials are metal. Refer to Division 21 Section "Common Work Results for Fire Suppression" for dielectric fittings.

3.7 PIPING INSTALLATION

- A. Refer to Division 21 Section "Common Work Results for Fire Suppression" for basic piping installation.
- B. Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping. Install piping as indicated, as far as practical.

1. Deviations from approved working plans for piping require written approval from authorities having jurisdiction. File written approval with Architect before deviating from approved working plans.
- C. Use approved fittings to make changes in direction, branch takeoffs from mains, and reductions in pipe sizes.
- D. Install unions adjacent to each valve in pipes NPS 2 and smaller. Unions are not required on flanged devices or in piping installations using grooved joints.
- E. Install flanges or flange adapters on valves, apparatus, and equipment having NPS 2-1/2 and larger connections.
- F. Install "Inspector's Test Connections" in sprinkler piping, complete with shutoff valve, sized and located according to NFPA 13. Drains shall not be exposed in stairwells or finished areas of the facility.
- G. Install sprinkler piping with drains for complete system drainage.
- H. Install sprinkler zone control valves, test assemblies, and drain risers in accessible locations approved by engineer and architect.
- I. Install alarm devices in piping systems.
- J. Hangers and Supports: Comply with NFPA 13 for hanger materials. Install according to NFPA 13 for sprinkler piping.
- K. Install piping with grooved joints according to manufacturer's written instructions. Construct rigid piping joints, unless otherwise indicated.
- L. Galvanized piping may not be welded.

3.8 VALVE INSTALLATION

- A. Refer to Division 22 Section "Valves" for installing general-duty valves. Install fire-protection specialty valves, trim, fittings, controls, and specialties according to NFPA 13, manufacturer's written instructions, and authorities having jurisdiction.
- B. Gate Valves: Install fire-protection-service valves supervised-open, located to control sources of water supply except from fire department connections. Provide permanent identification signs indicating portion of system controlled by each valve.
- C. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water supply sources.
- D. Dry-Pipe Valves: Install trim sets for air supply, drain, priming level, alarm connections, ball drip valves, pressure gages, priming chamber attachment, and fill-line attachment.
 1. Air-Pressure Maintenance Devices for Dry-Pipe Systems: Install shutoff valves to permit servicing without shutting down sprinkler system; bypass valve for quick system filling;

- pressure regulator or switch to maintain system pressure; strainer; pressure ratings with 14- to 60-psig adjustable range; and 175-psig maximum inlet pressure.
2. Install air compressor and compressed-air supply piping. Secure compressor to floor with vibration isolators.

3.9 SPRINKLER APPLICATIONS

A. General: Use sprinklers according to the following applications:

1. Retain one of three subparagraphs below.
2. Rooms without Ceilings: Upright and pendent sprinklers, as required.
3. Rooms with Suspended Ceilings: Recessed or concealed sprinklers.
4. Wall Mounting: Semi-recessed sidewall sprinklers.
5. Spaces Subject to Freezing: Upright; pendent, dry-type; and sidewall, dry-type sprinklers labeled for use with dry systems.
6. Sprinkler Finishes: Use sprinklers with the following finishes:
 - a. Areas without ceilings: Upright and Pendent Sprinklers: Chrome-plated in finished spaces exposed to view; rough bronze in unfinished spaces not exposed to view.
 - b. Areas with ceilings: Semi-Recessed with white sprinkler and white escutcheon unless specifically noted below.
 - c. Sidewalls: Semi-Recessed Sidewall Sprinklers: Enameled white sprinkler and white escutcheon unless specifically noted below.

3.10 SPRINKLER INSTALLATION

- A. Install sprinklers in patterns indicated.
- B. Install sprinklers in suspended ceilings in center of acoustical panels and tiles.
- C. Do not install pendent or sidewall, wet-type sprinklers in areas subject to freezing. Use dry-type sprinklers with water supply from heated space.

3.11 CONNECTIONS

- A. Install ball drip valves at each check valve for fire department connection. Drain to floor drain or outside building.
- B. Connect piping to specialty valves, hose valves, specialties, fire department connections, and accessories.
- C. Electrical Connections: Power wiring is specified in Division 26.
- D. Coordinate connection of alarm devices to fire alarm system with Fire Alarm Contractor.
- E. Connect air compressor to the following piping and wiring:
 1. Pressure gages and controls.

2. Electrical power system.
3. Fire alarm system devices, including low-pressure alarm.

3.12 LABELING AND IDENTIFICATION

- A. Install labeling and pipe markers on equipment and piping according to requirements in NFPA 13 and in Division 21 Section "Common Work Results for Fire Suppression."

3.13 FIELD QUALITY CONTROL

- A. Flush, test, and inspect sprinkler piping according to NFPA 13, "System Acceptance" Chapter.
- B. Replace piping system components that do not pass test procedures and retest to demonstrate compliance. Repeat procedure until satisfactory results are obtained.
- C. Report test results promptly and in writing to Architect and authorities having jurisdiction.

3.14 CLEANING

- A. Clean dirt and debris from sprinklers.
- B. Remove and replace sprinklers having paint other than factory finish.

3.15 PROTECTION

- A. Protect sprinklers from damage until Substantial Completion.

3.16 OPERATION

- A. Verify that specialty valves, trim, fittings, controls, and accessories are installed and operate correctly.
- B. Verify that air compressors and their accessories are installed and operate correctly.
- C. Verify that specified tests of piping are complete.
- D. Verify that damaged sprinklers and sprinklers with paint or coating not specified are replaced with new, correct type.
- E. Verify that sprinklers are correct types, have correct finishes and temperature ratings, and have guards as required for each application.
- F. Drain dry-pipe sprinkler piping.
- G. Pressurize and check dry-pipe sprinkler piping air-pressure maintenance devices and air compressors.

- H. Fill wet-pipe sprinkler piping with water.
- I. Energize circuits to electrical equipment and devices.
- J. Start and run air compressors.
- K. Adjust operating controls and pressure settings.
- L. Coordinate with fire alarm tests. Operate as required.

3.17 DEMONSTRATION

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

END OF SECTION 211100

SECTION 21 23 00 - WET-CHEMICAL FIRE-EXTINGUISHING SYSTEM

PART 2 PRODUCTS

1.01 WET-CHEMICAL FIRE SUPPRESSION SYSTEM REQUIREMENTS

- A. Engineered fire suppression system for protection of areas associated with cooking operations, including exhaust hoods, plenums, ductwork, and cooking appliances.
- B. System to consist of manufacturer's wet chemical storage cylinders, actuation hardware, and wet chemical agent distribution nozzles attached to the pipe network.
- C. System to comply with NFPA 17A and NFPA 96 including extinguishing agent.

1.02 FIRE-SUPPRESSION SYSTEM CONTROLLER

- A. Engineered system capable of automatic and manual discharge of wet-chemical agent from cylinder(s) using actuated valve(s), heat fuel source shutdown, smoke or fire-smoke damper closure, and electrical power shutdown to equipment or protected area upon system activation by thermal fusible link or heat detector.
- B. Provide system controller in the form of fire alarm system monitored, self-contained control panel or module.
- C. Furnish fully enclosed, integral control head and actuator for each container cylinder valve assembly without exposed means for actuation.
 - 1. Control Head: Equip with micro-switch contacts for audible alarm and equipment shutdown.
- D. The container cylinders protecting one hazard area must be connected for simultaneous discharge by each method of alarm actuation.
- E. Activate control head automatically by mechanical means.
 - 1. Provide rate-compensated thermostat fire detectors, complying with NFPA 17A, with rating suitable to their expected exposure temperature, capable of detecting heat, referenced or permitted in the manufacturer's design, installation, and maintenance manual, and listed for use with the extinguishing system.
 - 2. Mechanical Activation:
 - a. Activate system control head by manufacturer supplied fire detectors incorporating mechanical thermo-bulb link systems requiring no outside power source for operation.
 - b. Provide thermo-bulb links with rating suitable to their expected exposure temperature.
- F. Initiating Devices:
 - 1. Manual Pull Station:
 - a. Provide as means of manually actuating the system from remote location.
 - b. Surface housing fitted with untensioned pull-to-trip that locks in position after allowing the control system to activate the cylinder and valve assembly, for mounting on electrical outlet box; addressable using manufacturer's standard monitor module.

- c. Functions:
 - 1) Activate audible and visual alarms.
 - 2) Override any abort station or time delay function.
 - 3) Activate release and shutdown functions normally triggered by detectors or alarm system.
- d. Identification:
 - 1) Provide engraved label for each manual release station indicating area protected and that actuation will cause discharge of fire extinguishing agent.
 - 2) Provide manufacturer's label directly on faceplate.
- 2. Manual System Abort Switch:
 - a. Stainless steel plate with momentary contact push button, countdown timer, magnetic door holders manual release, for mounting on electrical outlet box; addressable using manufacturer's standard monitor module.
 - b. Engraved Sign or Label: Provide adjacent to each manual abort station, indicating area protected and that actuation will prevent discharge of fire extinguishing agent after automatic system is activated.
- G. Notification and Control Devices:
 - 1. Alarm Bells: 24 VDC with supervision of circuit wiring, of modular design, red baked enamel finish, with minimum sound level of 84 dba at 10 feet, for mounting on 4 inch electrical outlet box.
 - 2. Alarm Horns: 24 VDC with supervision of circuit wiring, with minimum sound level of 90 dba at 10 feet, for mounting on 4 inch electrical outlet box.
 - 3. Strobe Beacon: 24 VDC with system identification on strobe lens.
 - 4. Gas Service Shut-Off Valve: Two-position full closure safety gas shut-off type, 24 volt, manual override.

1.03 SPACE OR AREA SIGNAGE

- A. Entrance Warning Sign: One warning sign at each entrance to protected area.
- B. Exit Warning Signs: One lighted, flashing warning sign at each exit from protected area.

1.04 SYSTEM PIPING AND SPECIALTIES

- A. Steel Pipe: ASTM A53/A53M or ASTM A106/A106M Schedule 40, or ASTM A135/A135M Schedule 10, black.
 - 1. Fittings: ASME B16.3 malleable iron class 300 for sizes 2 inch and smaller, or ASTM A234/A234M, wrought steel welding type fittings.
 - 2. Joints: Threaded, AWS D1.1/D1.1M welded, or grooved and shouldered pipe end couplings.
- B. Pipe Hangers: ASME B31.1, listed, split clamp up to 2-1/2 inch size, riser clamps over 2-1/2 inch size, adequate to offset discharge thrust.
- C. Escutcheons: Chrome plated pressed or stamped brass, one-piece or split pattern, minimum 2 inches larger than opening.
- D. Gauges: ASME B40.100, UL 393, or UL 404; 3-1/2 inch diameter cast aluminum case, phosphor bronze bourdon tube, rotary brass movement, brass socket, front recalibration adjustment, black figures on white background, one percent mid-scale

accuracy, scale calibrated in psi.

1.05 WET-CHEMICAL AGENT CONTAINERS

- A. Provide steel cylinder with actuated valve assemblies of the type and size required by the manufacturer for wet chemical storage.
- B. Specialties to consist of valves and pressure gauges, including reliable and safe means of minimizing accidental discharge.
- C. Container valves to be electrically or mechanically actuated with manual override.
- D. Furnish pressurized assembly with the capability of being stored and operated at 0 degrees F to 120 degrees F.
- E. Provide listed bracketing for the mounting of the cylinder securely to the intended mounting surface.
- F. Furnish manufacturer's high-pressure nitrogen tubing when control system is mounted to a wet cylinder and where actuation delay is employed.

1.06 AGENT DISCHARGE NOZZLES

- A. Provide nozzle type in accordance with manufacturer's instructions.
- B. Equip with strainers to prevent foreign matter in the agent distribution piping or tubing from clogging the nozzle orifice.
- C. Provide foil seals to be ruptured by pressure at system discharge.
- D. Identification: Permanently marked with manufacturer's identification system identifying nozzle type and listing.

END OF SECTION 21 23 00

SECTION 22 05 17 - SLEEVES AND SLEEVE SEALS FOR PLUMBING PIPING

PART 2 PRODUCTS

END OF SECTION 22 05 17

SECTION 220500 - COMMON WORK RESULTS FOR PLUMBING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Section 230500 for Plumbing / Mechanical / Electrical Coordination.

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Piping materials and installation instructions common to most piping systems.
 - 2. Transition fittings.
 - 3. Dielectric fittings.
 - 4. Mechanical sleeve seals.
 - 5. Sleeves.
 - 6. Escutcheons.
 - 7. Equipment installation requirements common to equipment sections.
 - 8. Painting and finishing.

1.3 DEFINITIONS

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

1.4 SUBMITTALS

A. Product Data: For the following:

1. Dielectric fittings.
2. Mechanical sleeve seals.

1.5 QUALITY ASSURANCE

- A. 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 at the Contractor's expense. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.
- B. All contractors shall participate in the Commissioning process of building systems as outlined in specification section 019000 series.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.
- B. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

1.7 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."
- D. Phasing: This contractor shall be responsible for all work and materials required to accommodate the phasing associated with the construction of this project. This shall include,

but is not limited to, providing temporary connections, isolation valves and piping, system fill and drain-down, system re-balancing and temporary provisions for all functions of the controls system to operate. It shall also include provisions for temporary equipment to facilitate system operation throughout the phased construction.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

2.2 PIPE, TUBE, AND FITTINGS

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

2.3 JOINING MATERIALS

- A. Refer to individual Division 22 piping Sections for special joining materials not listed below.
- B. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
 - 1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.
 - a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
 - b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.
 - 2. AWWA C110, rubber, flat face, 1/8 inch thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.
- C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
- D. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.
- E. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

- F. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAgl, silver alloy for refrigerant piping, unless otherwise indicated.
- G. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
- H. Solvent Cements for Joining Plastic Piping:
 - 1. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.

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 ranges including safety factor of 1.25. Listed for use in potable water systems.
- C. Dielectric Unions: Factory-fabricated, union assembly, for 250-psig minimum working pressure at 180 deg F. Gaskets listed to exceed temperature rating and pressure of system. Gaskets to be listed and meet NFS requirements.
 - 1. Manufacturers:
 - a. Capitol Manufacturing Co.
 - b. Central Plastics Company.
 - c. Eclipse, Inc.
 - d. Epco Sales, Inc.
 - e. Hart Industries, International, Inc.
 - f. Watts Industries, Inc.; Water Products Div.
 - g. Zurn Industries, Inc.; Wilkins Div.
- D. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig minimum working pressure at 225 deg F.
 - 1. Manufacturers:
 - a. Perfection Corp.
 - b. Precision Plumbing Products, Inc.
 - c. Sioux Chief Manufacturing Co., Inc.
 - d. Victaulic Co. of America.

2.5 MECHANICAL SLEEVE SEALS

- A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
 - 1. 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: 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.

2.6 SLEEVES

- A. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.
- B. Cast Iron: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
- C. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
 - 1. Underdeck Clamp: Clamping ring with set screws.
- D. PVC Pipe: ASTM D 1785, Schedule 40.

2.7 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. Deep-pattern type are not approved.
- B. One-Piece, Cast-Brass Type:
 - 1. Finish: Polished chrome-plated.

PART 3 - EXECUTION

3.1 PIPING SYSTEMS - COMMON REQUIREMENTS

- A. Install piping according to the following requirements and Division 22 Sections specifying piping systems.
- B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

- C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.
- D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- F. Install piping to permit valve servicing.
- G. Install piping at indicated slopes.
- H. Install piping free of sags and bends.
- I. Install fittings for changes in direction and branch connections.
- J. Install piping to allow application of insulation.
- K. Select system components with pressure rating equal to or greater than system operating pressure.
- L. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:
- M. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs.
 - 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 if ring is specified.
 - 2. Install sleeves in new walls and slabs as new walls and slabs are constructed.
 - 3. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:
 - a. Steel or Cast Iron Pipe Sleeves: For pipes smaller than NPS 6.
 - b. Steel Sheet Sleeves: For pipes NPS 6 and larger, penetrating gypsum-board partitions.
 - c. Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level. Refer to Division 07 Section "Sheet Metal Flashing and Trim" for flashing.
 - 1) Seal space outside of sleeve fittings with grout.
 - 4. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Division 07 Section "Joint Sealants" for materials and installation.

- N. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using 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.
1. Install steel pipe for sleeves smaller than 6 inches in diameter.
 2. 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.
- O. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
1. 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.
- P. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 07 Section "Penetration Firestopping" for materials.
- Q. Verify final equipment locations for roughing-in.
- R. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

3.2 PIPING JOINT CONSTRUCTION

- A. Join pipe and fittings according to the following requirements and Division 22 Sections specifying piping systems.
- B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.
- E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.
- F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- G. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.
- H. 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. 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.
 4. PVC Nonpressure Piping: Join according to ASTM D 2855.
- I. Plastic Pressure Piping Gasketed Joints: Join according to ASTM D 3139.

3.3 PIPING CONNECTIONS

- A. Make connections according to the following, unless otherwise indicated:
1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
 2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.
 3. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.
 4. Wet Piping Systems: Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.

3.4 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

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

3.5 PAINTING

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

END OF SECTION 220500

SECTION 220516 – EXPANSION FITTINGS AND LOOPS FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Metal-bellows expansion joints.
 - 2. Rubber expansion joints.
 - 3. Flexible-hose expansion joints.
 - 4. Pipe bends and loops.
 - 5. Alignment guides and anchors.
- B. Contractor is responsible for Design and Installation of Fittings, Assemblies, and Systems to facilitate expansion and contraction of all domestic water piping systems.

1.3 DEFINITIONS

- A. BR: Butyl rubber.
- B. Buna-N: Nitrile rubber.
- C. CR: Chlorosulfonated polyethylene synthetic rubber.
- D. CSM: Chlorosulfonyl-polyethylene rubber.
- E. EPDM: Ethylene-propylene-diene terpolymer rubber.
- F. NR: Natural rubber.

1.4 PERFORMANCE REQUIREMENTS

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

1.5 SUBMITTALS

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

- B. Shop Drawings: Indicating locations, style and calculations for all expansion fittings. Shop drawings and calculations shall be produced by the product manufacturer or a registered Professional Engineer. Design shall be for the entire domestic cold water and domestic hot water piping system throughout each building.
- C. Details shall be included for the building expansion joints to accommodate the anticipated seismic displacements across the joints.
- D. Welding certificates.
- E. Product Certificates: For each type of pipe expansion joint, signed by product manufacturer.
- F. Maintenance Data: For pipe expansion joints to include in maintenance manuals.

PART 2 - PRODUCTS

2.1 EXPANSION JOINTS

- A. Metal-Bellows Expansion Joints: ASTM F 1120, circular-corrugated-bellows type with external tie rods.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Adsko Manufacturing, LLC.
 - b. Anamet, Inc.
 - c. Badger Industries.
 - d. Expansion Joint Systems, Inc.
 - e. Flex-Hose Co., Inc.
 - f. Flexicraft Industries.
 - g. Flex-Pression, Ltd.
 - h. Flex-Weld, Inc.
 - i. Hyspan Precision Products, Inc.
 - j. Metraflex, Inc.
 - k. Piping Technology & Products, Inc.
 - l. Proco Products, Inc.
 - m. Senior Flexonics, Inc.; Pathway Division.
 - n. Tozen America Corp.
 - o. Unaflex Inc.
 - p. WahlcoMetroflex.
 - 2. Metal-Bellows Expansion Joints for Copper Piping: Multiple-ply phosphor-bronze bellows, copper pipe end connections, and brass shrouds.
 - 3. Minimum Pressure Rating: 150 psig, unless otherwise indicated.
- B. Rubber Expansion Joints: ASTM F 1123, fabric-reinforced rubber with external control rods and complying with FSA's "Technical Handbook: Non-Metallic Expansion Joints and Flexible Pipe Connectors."
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Flex-Hose Co., Inc.

- b. Flexicraft Industries.
 - c. Flex-Weld, Inc.
 - d. Garlock Sealing Technologies.
 - e. General Rubber Corp.
 - f. Mason Industries, Inc.; Mercer Rubber Co.
 - g. Metraflex, Inc.
 - h. MG Piping Products Co.
 - i. Proco Products, Inc.
 - j. Red Valve Company, Inc.
 - k. Senior Flexonics, Inc.; Pathway Division.
 - l. Tozen America Corp.
 - m. Unaflex Inc.
 - n. Vibration Mountings & Controls, Inc.
 - 2. Spherical Type: Single or multiple spheres.
 - a. Minimum Pressure and Temperature Ratings for NPS 1-1/2 to NPS 4: 150 psig at 220 deg F.
 - 3. Material: Buna-N.
 - 4. End Connections: Full-faced, integral, steel flanges with steel retaining rings.
- C. Flexible-Hose Expansion Joints: Manufactured assembly with two flexible-metal-hose legs joined by long-radius, 180-degree return bend or center section of flexible hose; with inlet and outlet elbow fittings, corrugated-metal inner hoses, and braided outer sheaths.
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Flex-Hose Co., Inc.
 - b. Flexicraft Industries.
 - c. Flex-Pression, Ltd.
 - d. Metraflex, Inc.
 - 2. Flexible-Hose Expansion Joints for Copper Piping: Copper-alloy fittings with solder-joint end connections.
 - a. NPS 2-1/2 to NPS 4: 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

- A. Description: Steel, factory fabricated, with bolted two-section outer cylinder and base for alignment of piping and two-section guiding spider for bolting to pipe.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 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. Piping Technology & Products, Inc.

- i. Senior Flexonics, Inc.; Pathway Division.

2.3 MATERIALS FOR ANCHORS

- A. Steel Shapes and Plates: ASTM A 36/A 36M.
- B. Bolts and Nuts: ASME B18.10 or ASTM A 183, steel, hex head.
- C. Washers: ASTM F 844, steel, plain, flat washers.
- D. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened portland cement concrete, and tension and shear capacities appropriate for application.
 - 1. Stud: Threaded, zinc-coated carbon steel.
 - 2. Expansion Plug: Zinc-coated steel.
 - 3. Washer and Nut: Zinc-coated steel.
- E. Chemical Fasteners: Insert-type-stud bonding system anchor for use with hardened portland cement concrete, and tension and shear capacities appropriate for application.
 - 1. Bonding Material: ASTM C 881, Type IV, Grade 3, 2-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.
 - 2. Stud: ASTM A 307, zinc-coated carbon steel with continuous thread on stud, unless otherwise indicated.
 - 3. Washer and Nut: Zinc-coated steel.
- F. Concrete: Portland cement mix, 3000 psi minimum. Comply with requirements in Division 03 Section "Cast-in-Place Concrete" for formwork, reinforcement, and concrete.
- G. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink, nonmetallic grout; suitable for interior and exterior applications.
 - 1. Properties: Nonstaining, noncorrosive, and nongaseous.
 - 2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 EXPANSION-JOINT INSTALLATION

- A. Install manufactured, nonmetallic expansion joints according to FSA's "Technical Handbook: Non-Metallic Expansion Joints and Flexible Pipe Connectors."
- B. Install expansion joints of sizes matching size of piping in which they are installed.
- C. Install alignment guides to allow expansion and to avoid end-loading and torsional stress.

3.2 PIPE BEND AND LOOP INSTALLATION

- A. Install pipe bends and loops cold-sprung in tension or compression as required to partly absorb tension or compression produced during anticipated change in temperature.

- B. Attach pipe bends and loops to anchors.
 - 1. Steel Anchors: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
 - 2. Concrete Anchors: Attach by fasteners. Follow fastener manufacturer's written instructions.

3.3 SWING CONNECTIONS

- A. Connect risers and branch connections to mains with at least five pipe fittings, including tee in main.

3.4 ALIGNMENT-GUIDE INSTALLATION

- A. Install guides on piping adjoining pipe expansion fittings and loops.
- B. Attach guides to pipe and secure to building structure.

3.5 ANCHOR INSTALLATION

- A. 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.
- B. Fabricate and install steel anchors by welding steel shapes, plates, and bars to piping and to structure. Comply with ASME B31.9 and AWS D1.1.
- C. Construct concrete anchors of poured-in-place concrete of dimensions indicated and include embedded fasteners.
- D. Install pipe anchors according to expansion-joint manufacturer's written instructions if expansion joints are indicated.
- E. Use grout to form flat bearing surfaces for expansion fittings, guides, and anchors installed on or in concrete.

END OF SECTION 220516

SECTION 220523 – GENERAL DUTY VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to work of this section.
- B. Section 220500 “Common Work Results for Plumbing” applies to work of this section.

1.2 SUMMARY

- A. Extent of valves required by this section is indicated on drawings and/or specified in other Division 22 sections.
- B. The types of valves specified in this section shall include the following:
 - 1. Globe valves.
 - 2. Check valves.
 - 3. Balancing valves.
 - 4. Butterfly valves.
 - 5. Drain valves.
 - 6. Ball valves.
 - 7. Plug valves.
- C. Valves furnished as part of factory-fabricated equipment are specified as part of equipment in other Division 22 sections.

1.3 SUBMITTALS

- A. Product Data: Submit manufacturer’s technical product data for each type of valve. Submit valve schedule showing manufacturer’s figure number, size, location, and valve features for each required valve.
- B. Maintenance Data: Submit recommended maintenance data as applicable and spare parts lists for each type of valve. Include this data, product data, and shop drawings in Maintenance Manual.

1.4 QUALITY ASSURANCE

- A. Provide valves of the same type by the same manufacturer throughout.
- B. Provide valves with manufacturer’s name and pressure rating clearly marked on outside of body.

C. Codes and Standards:

1. Mark valves in accordance with MSS-25 "Standard Marking System for Valves, Fittings, Flanges and Unions" as well as jurisdictional code requirements.
2. For dimensions of flanged or welded and valve bodies, comply with ANSI B16.10.
3. Provide valves used in fire protection piping, which are UL-listed and FM approved.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Provide factory-fabricated valves recommended by manufacturer for use in service indicated. Valves and valve construction shall be suitable for the pressure, temperature and fluid of the service. Provide proper selection as determined by Installer to comply with installation requirements. Provide end connections which properly mate with pipe, tube, and equipment connections. Where more than one type is indicated, selection is Installer's option.
- B. Unless otherwise indicated, provide valves of same size as upstream pipe size.
- C. Operators: Provide handwheels, fastened to valve stem, for valves other than quarter-turn. Provide lever handle for quarter-turn valves, 6" and smaller, other than plug valves. Provide one wrench for every 10 plug valves.
- D. Acceptable Manufacturers: Subject to compliance with requirements, provide valves from one of the following:
 1. Apollo
 2. Crane
 3. Fairbanks
 4. Hammond
 5. ITT Grinnell
 6. Milwaukee
 7. Nibco
 8. Powell
 9. Stockham
 10. Walworth
 11. Watts

2.2 GLOBE VALVES

- A. Use for throttling for water services: 2 inches and smaller with inside rising stem and screwed bonnet. 2 ½ inches to 6 inches larger with rising stem, outside screw and yoke and bolted bonnet. Valves to be back-seating with adjustable packing nut and be capable for re-packing under pressure. Provide valves for throttling service with renewable metallic seats of nickel alloy or stainless steel.

2.3 CHECK VALVES – SWING TYPE

- A. Use for water and low pressure general services: 2 inches and smaller with screwed bonnet; 2 ½ inches and larger with bolted bonnet. Valves to have renewable bronze seat and disc.

2.4 CHECK VALVES – NON-SLAM

- A. Use on pumps with cycling control. Valves to have semi-steel body with bronze or stainless steel trim and to be of the center guide type.

2.5 BALANCING VALVES FOR FLOW MEASUREMENT

- A. Calibrated ball type balancing valves with differential pressure readout ports across fixed geometry venturi orifice. Each port shall have positive schrader type connections for connection to portable pressure meter. Provide reduced port type specifically designed for low-flow conditions where flow rate is less than 2 GPM.
- B. Valves shall have memory feature to allow valve to be closed for service and then reopened without affecting balanced position.
- C. Where installed to insulated piping systems each valve shall be provided with insulation molded by manufacturer to permit easy access for balance and readout.
- D. Acceptable Manufacturers: Subject to compliance with requirements, provide balancing valves for flow measurement of one of the following:
 - 1. Bell & Gossett – ITT Industries
 - 2. Flow Design Inc., Accusetter series
 - 3. Preso Industries, B-Plus series
 - 4. Hydronic Components, Inc., Terminator System
 - 5. Taco, Accu-Flo
 - 6. Griswald.

2.6 BUTTERFLY VALVES

- A. Used for shut-off duty for domestic hot water, domestic cold water, and fire protection, pipe sizes 4 inches and larger. Butterfly valves shall be of the lug body style, duct-tile iron, with lugs drilled and tapped and have drip tight shutoff capabilities in either direction up to maximum system working pressure. Butterfly valves shall be capable of closing tight after long periods of inactivity. Flanges to be through drilled to ANSI Standards.
- B. Valves shall be furnished with self-lubricated bronze bearings. Shaft seals shall be provided to prevent leakage and to protect bearings from internal or external corrosion.
- C. Seats shall be of the reinforced resilient type (or retained seat on high performance valves) and shall also act as a body liner to prevent flow from contacting the body casting. Resilient seats shall have flange sealing lips to provide a positive seal without use of flanges gaskets.
- D. Seats shall be Nordel suitable for use with water to 240 degrees F. Shafts shall be one piece and shall be of Type 416 stainless steel. Shafts shall be finish ground and polished to minimize

bearing and shaft seal wear. Shafts of 8 inches and larger valves shall have a non-adjustable thrust collar.

- E. Discs shall be aluminum bronze. The disc-to-shaft connections shall be type 316 stainless steel. Pins, shaft and disc of valves shall be individually machined and completely interchangeable.
- F. On manually operated valves, latch lock levers shall provide automatic, positive latching in the open, closed or eight intermediate positions. These levers shall allow locking in any position with a standard padlock. Infinite position levers shall allow manual throttling and locking in any position from open to close.
- G. Manually actuated valves 8 inches and larger shall be operated using a cast iron housed hand-wheel actuator with chainwheel. Units to have adjustable open and closed position stops with provision to prevent accidental adjustment changes. Operating shafts to be supported axially and radially at input end by permanently lubricated bronze thrust and sleeve bearings.

2.7 DRAIN VALVES

- A. Provide drain valves with threaded ends for hose connections at drain points, at main shutoff valves, low points of piping systems, bases of vertical risers, and at equipment. Drain valves on the potable water system shall have permanently attached vacuum breakers on the hose thread connection.
- B. Brass ball valve with cap with chain, ¾ inch hose thread.

2.8 BALL VALVES

- A. Ball Valves shall be used for shutoff service for domestic water for pipe sizes up to 2½ inches.
- B. 1½" and Smaller: 125 psi steam, 400 psi WOG, bronze body, full port, 316 st/st ball and stem, bronze trim, 2 piece construction, TFE seats and seals.
- C. 2" and larger: 150 psi steam, 600 psi WOG, bronze body, full port, 316 st/st ball and stem, 2 or 3 piece body, TFE seats with bronze trim.
- D. Provide extended stem as required to accommodate piping insulation as specified elsewhere.

2.9 PLUG VALVES

- A. 2" and Smaller: 150 psi, bronze body, straightaway pattern, square head, threaded ends.
- B. 2½" and Larger: 175 psi, lubricated plug type, semi-steel body, single gland, wrench operated, flanged ends.
- C. Provide one plug cock wrench for every ten (10) plug cocks sized 2 inches and smaller. Provide each plug cock 2½ inches and larger with a wrench with set screws.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. General: Except as otherwise indicated, comply with the following requirements:
 - 1. Install valves where required for proper operation of piping and equipment, including valves in branch lines where necessary to isolate sections of piping. Locate valves so as to be accessible for operation, maintenance and re-packing, and so that separate support can be provided when necessary.
 - 2. Install isolation valves on equipment so that valve and piping do not interfere with equipment removal or maintenance. Install unions or flanges on equipment side of valves unless valve is flanged type.
 - 3. Install valves with stems pointed up, in vertical position where possible, but in no case with stems pointed downward from horizontal plane unless unavoidable. Install valve drains with hose-end adapter for each valve that must be installed with stem below horizontal plane.
 - 4. Install with operating clearance for handle and stem.
 - 5. Provide valves of a design permitting packing while open and under pressure.
 - 6. Provide all valves 8 inches and larger having a rating of over 150 lbs. with a 1 inch bypass valve of same pressure rating.
 - 7. Furnish and install other hand valves, check valves, cocks, etc., as required for the complete and proper valving of the entire installation.
 - 8. Install on all branches and mains serving 3 or more fixtures.
- B. Insulation: Where piping is insulated, install extended-stem valves, arranged in proper manner to receive insulation. Insulation cut away to receive standard stems is not acceptable.
- C. Mechanical Actuators: Install mechanical actuators with chain operators where indicated. Extend chains to about 5' above floor and hook to clips to clear aisle passage.
- D. Non-Metallic Disc: Limit selection and installation of valves with non-metallic discs to locations indicated and where foreign material in piping system can be expected to prevent tight shutoff of metal seated valves.
- E. Renewable Seats: Select and install valves with renewable seats, except where otherwise indicated.
- F. Installation of Check Valves:
 - 1. Swing Check Valves: Install in horizontal position with hinge pin horizontally perpendicular to center line of pipe. Install for proper direction of flow.
 - 2. Wafer Check Valves: Install between 2 flanges in horizontal or vertical position, position for proper direction of flow.
 - 3. Lift Check Valves: Install in piping line with stem vertically upward, position for proper direction of flow.

3.2 ADJUSTING AND CLEANING

- A. Valve Adjust: After piping systems have been tested and put into service, but before final testing, adjusting, and balancing, inspect each valve for possible leaks. Adjust or replace packing to stop leaks, replace valve if leak persists.

- B. Valve Identification: Tag each valve in accordance with Division 22.
- C. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

END OF SECTION 220523

SECTION 220529 - HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes hangers and supports for mechanical system piping and equipment.
- B. Related Sections include the following:
 - 1. Division 21 Sections on fire-suppression piping for fire-suppression pipe hangers.
 - 2. Division 23 Section "Vibration Controls for Mechanical Piping and Equipment" for vibration isolation devices.

1.3 DEFINITIONS

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

1.4 PERFORMANCE REQUIREMENTS

- A. Design channel support systems for piping to support multiple pipes capable of supporting combined weight of supported systems, system contents, and test water.
- B. Design heavy-duty steel trapezes for piping to support multiple pipes capable of supporting combined weight of supported systems, system contents, and test water.

1.5 SUBMITTALS

- A. Product Data: For each type of pipe hanger, channel support system component, and thermal-hanger shield insert indicated.

1.6 QUALITY ASSURANCE

- A. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

- B. Engineering Responsibility: Design and calculations for each multiple pipe support, trapeze, and seismic restraint by a qualified professional engineer.
1. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in jurisdiction where the Project is located and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for installations of hangers and supports that are similar to those indicated for this Project in material, design, and extent. All supports shall meet the seismic zone design criteria for the region.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Pipe Hangers:
- a. AAA Technology and Specialties Co., Inc.
 - b. B-Line Systems, Inc.
 - c. Carpenter & Patterson, Inc.
 - d. Empire Tool & Manufacturing Co., Inc.
 - e. Globe Pipe Hanger Products, Inc.
 - f. Grinnell Corp.
 - g. GS Metals Corp.
 - h. Michigan Hanger Co., Inc.
 - i. National Pipe Hanger Corp.
 - j. PHD Manufacturing, Inc.
 - k. PHS Industries, Inc.
 - l. Piping Technology & Products, Inc.
2. Channel Support Systems:
- a. B-Line Systems, Inc.
 - b. Grinnell Corp.; Power-Strut Unit.
 - c. GS Metals Corp.
 - d. Michigan Hanger Co., Inc.; O-Strut Div.
 - e. National Pipe Hanger Corp.
 - f. Thomas & Betts Corp.
 - g. Unistrut Corp.
 - h. Wesanco, Inc.
3. Thermal-Hanger Shield Inserts:
- a. Carpenter & Patterson, Inc.
 - b. Michigan Hanger Co., Inc.
 - c. PHS Industries, Inc.
 - d. Pipe Shields, Inc.
 - e. Rilco Manufacturing Co., Inc.
 - f. Value Engineered Products, Inc.

2.2 MANUFACTURED UNITS

- A. Pipe Hangers, Supports, and Components: MSS SP-58, factory-fabricated components. Refer to "Hanger and Support Applications" Article in Part 3 for where to use specific hanger and support types.
 - 1. Galvanized, Metallic Coatings: For piping and equipment that will not have field-applied finish.
 - 2. Nonmetallic Coatings: On attachments for electrolytic protection where attachments are in direct contact with copper tubing.
- B. Channel Support Systems: MFMA-2, factory-fabricated components for field assembly.
 - 1. Coatings: Manufacturer's standard finish, unless bare metal surfaces are indicated.
 - 2. Nonmetallic Coatings: On attachments for electrolytic protection where attachments are in direct contact with copper tubing.
- C. Thermal-Hanger Shield Inserts: 100-psi minimum compressive-strength insulation, encased in sheet metal shield.
 - 1. Material for Cold Piping: ASTM C 552, Type I cellular glass with vapor barrier or water-repellent-treated, ASTM C 533, Type I calcium silicate with vapor barrier.
 - 2. Material for Hot Piping: ASTM C 552, Type I cellular glass or water-repellent-treated, ASTM C 533, Type I calcium silicate.
 - 3. For Trapeze or Clamped System: Insert and shield cover entire circumference of pipe.
 - 4. For Clevis or Band Hanger: Insert and shield cover over lower 180 degrees of pipe.
 - 5. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.3 MISCELLANEOUS MATERIALS

- A. Structural Steel: ASTM A 36/A 36M, steel plates, shapes, and bars, black and galvanized.
- B. Grout: ASTM C 1107, Grade B, factory-mixed and -packaged, nonshrink and nonmetallic, dry, hydraulic-cement grout.
 - 1. Characteristics: Post hardening and volume adjusting; recommended for both interior and exterior applications.
 - 2. Properties: Nonstaining, noncorrosive, and nongaseous.
 - 3. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT APPLICATIONS

- A. Specific hanger requirements are specified in Sections specifying equipment and systems.
- B. Comply with MSS SP-69 for pipe hanger selections and applications that are not specified in piping system Specification Sections.

- C. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:
1. Adjustable Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated stationary pipes, NPS 1/2 to NPS 30.
 2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of 120 to 450 deg F pipes, NPS 4 to NPS 16, requiring up to 4 inches of insulation.
 3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes, NPS 3/4 to NPS 24, requiring clamp flexibility and up to 4 inches of insulation.
 4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes, NPS 1/2 to NPS 24, if little or no insulation is required.
 5. Pipe Hangers (MSS Type 5): For suspension of pipes, NPS 1/2 to NPS 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, NPS 3/4 to NPS 8.
 7. Adjustable Steel Band Hangers (MSS Type 7): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.
 8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.
 9. Adjustable Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 2.
 10. Split Pipe-Ring with or without Turnbuckle-Adjustment Hangers (MSS Type 11): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 8. Copper pipe rings shall be used on copper pipe. Painted steel pipe rings are not approved for use.
 11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 3.
 12. U-Bolts (MSS Type 24): For support of heavy pipe, NPS 1/2 to NPS 30.
 13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
- D. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:
1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers, NPS 3/4 to NPS 20.
 2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 20, if longer ends are required for riser clamps.
- E. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:
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.
- F. Building Attachments: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:

1. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joint construction to attach to top flange of structural shape.
 2. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
 3. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
 4. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
 5. C-Clamps (MSS Type 23): For structural shapes.
 6. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
 7. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
 8. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
 9. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
 10. Malleable Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
 11. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:
 - a. Light (MSS Type 31): 750 lb.
 - b. Medium (MSS Type 32): 1500 lb.
 - c. Heavy (MSS Type 33): 3000 lb.
 12. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
 13. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
 14. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where head room is limited.
- G. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:
1. Steel Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
 2. Protection Shields (MSS Type 40): Of length recommended by manufacturer to prevent crushing insulation.
 3. Thermal-Hanger Shield Inserts: For supporting insulated pipe, 360-degree insert of high-density, 100-psi minimum compressive-strength, water-repellent-treated calcium silicate or cellular-glass pipe insulation, same thickness as adjoining insulation with vapor barrier and encased in 360-degree sheet metal shield.
- H. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:
1. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
 2. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41 roll hanger with springs.
 3. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.

4. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from hanger.
5. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from base support.
6. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from trapeze support.
7. 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.

3.2 HANGER AND SUPPORT INSTALLATION

- A. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment. Support of piping systems shall be distributed across the roof and floor structural systems. Alternate hanger locations when multiple pipes are supported in one area to ensure single structural members are not independently bearing the weight of multiple pipes in any one area.
- B. Coordinate and follow mechanical support building attachment requirements of manufacturer.
- C. Regardless of the type of construction (i.e., concrete, concrete-deck-steel, concrete plank, wood or other variations) take particular care to support main lines and large and heavy pipes in an approved manner, including the furnishing and installation of supplementary steel, if required. Supplementary steel shall be mill-rolled sections. Submit shop drawings, indicating support methods, point loadings to the building structure and hanger locations for review.
- D. Pipe Hanger and Support Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.
- E. Channel Support System Installation: Arrange for grouping of parallel runs of piping and support together on field-assembled channel systems.
 1. Field assemble and install according to manufacturer's written instructions.
- F. Heavy-Duty Steel Trapeze Installation: Arrange for grouping of parallel runs of horizontal piping and support together on field-fabricated, heavy-duty trapezes.
 1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified above for individual pipe hangers.
 2. Field fabricate from ASTM A 36/A 36M, steel shapes selected for loads being supported. Weld steel according to AWS D-1.1.

- G. Install building attachments to structural steel. Space attachments within maximum piping span length indicated in MSS SP-69. Install additional attachments at concentrated loads, including valves, flanges, guides, strainers, and expansion joints, and at changes in direction of piping.
- H. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.
- I. Install 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.
- J. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so maximum pipe deflections allowed by ASME B31.9, "Building Services Piping," is not exceeded.
- K. Insulated Piping: Comply with the following:
 - 1. Attach clamps and spacers to piping.
 - a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
 - b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
 - c. Do not exceed pipe stress limits according to ASME B31.9.
 - 2. Install MSS SP-58, Type 39 protection saddles, if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
 - a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
 - 3. Install MSS SP-58, Type 40 protective shields on cold piping with vapor barrier. Shields shall span arc of 180 degrees.
 - a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
 - 4. Shield Dimensions for Pipe: Not less than the following:
 - a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
 - b. NPS 4: 12 inches long and 0.06 inch thick.
 - c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
 - 5. Insert Material: Length at least as long as protective shield.
 - 6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.3 EQUIPMENT SUPPORTS

- A. Fabricate structural-steel stands to suspend equipment from structure above or to support equipment above floor.
- B. Grouting: Place grout under supports for equipment and make smooth bearing surface.

3.4 METAL FABRICATION

- A. Cut, drill, and fit miscellaneous metal fabrications for heavy-duty steel trapezes and equipment supports.
- B. Fit exposed connections together to form hairline joints. Field-weld connections that cannot be shop-welded because of shipping size limitations.
- C. Field Welding: Comply with AWS D1.1 procedures for shielded metal arc welding, appearance and quality of welds, and methods used in correcting welding work, and with the following:
 - 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - 2. Obtain fusion without undercut or overlap.
 - 3. Remove welding flux immediately.
 - 4. Finish welds at exposed connections so no roughness shows after finishing and contours of welded surfaces match adjacent contours.

3.5 ADJUSTING

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

3.6 PAINTING

- A. Touching Up: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 - 1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.
- B. Touching Up: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Section "Painting."
- C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A780.

END OF SECTION 220529

SECTION 220553 – IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. This Section includes the following mechanical identification materials and their installation:
 - 1. Access panel and door markers.
 - 2. Pipe markers.
 - 3. Valve tags.
 - 4. Valve schedules.
 - 5. Warning tags.

1.2 SUBMITTALS

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

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

PART 2 - PRODUCTS

2.1 EQUIPMENT IDENTIFICATION DEVICES

- A. Access Panel and Door Markers: 1/16-inch thick, engraved laminated plastic, with abbreviated terms and numbers corresponding to identification. Provide 1/8-inch center hole for attachment.
 - 1. Fasteners: Self-tapping, stainless-steel screws or contact-type, permanent adhesive.

2.2 PIPING IDENTIFICATION DEVICES

- A. Manufactured Pipe Markers, General: Preprinted, color-coded, with lettering indicating service, and showing direction of flow.
 - 1. Colors: Comply with ASME A13.1, unless otherwise indicated.
 - 2. Lettering: Use piping system terms indicated and abbreviate only as necessary for each application length.
 - 3. Pipes with OD, Including Insulation, Less Than 6 Inches: Full-band pipe markers extending 360 degrees around pipe at each location.
 - 4. Pipes with OD, Including Insulation, 6 Inches and Larger: Either full-band or strip-type pipe markers at least three times letter height and of length required for label.
 - 5. Arrows: Integral with piping system service lettering to accommodate both directions; or as separate unit on each pipe marker to indicate direction of flow.
- B. Shaped Pipe Markers: Preformed semi-rigid plastic formed to partially cover circumference of pipe and to attach to pipe with mechanical fasteners that do not penetrate insulation vapor barrier.
- C. Self-Adhesive Pipe Markers: Plastic with pressure-sensitive, permanent-type, self-adhesive back.
- D. Plastic Tape: Continuously printed, vinyl tape at least 3 mils thick with pressure-sensitive, permanent-type, self-adhesive back.
 - 1. Width for Markers on Pipes with OD, Including Insulation, Less Than 6 Inches: 3/4 inch minimum.
 - 2. Width for Markers on Pipes with OD, Including Insulation, 6 Inches or Larger: 1-1/2 inches minimum.

2.3 VALVE TAGS

- A. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers, with numbering scheme approved by Architect. Provide 5/32-inch hole for fastener.
 - 1. Material: 0.032-inch thick brass.
 - 2. Valve-Tag Fasteners: Brass wire-link or beaded chain; or S-hook.

2.4 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. Provide in plastic sleeves located in 3-ring binder.

2.5 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: Reinforced grommet and wire or string.
 - 3. Nomenclature: Large-size primary caption such as DANGER, CAUTION, or DO NOT OPERATE.
 - 4. Color: Yellow background with black lettering.

PART 3 - EXECUTION

3.1 APPLICATIONS, GENERAL

- A. Products specified are for applications referenced in other Division 22 Sections. If more than single-type material, device, or label is specified for listed applications, selection is Installer's option.

3.2 PIPING IDENTIFICATION

- A. Install manufactured pipe markers indicating service on each piping system. Install with flow indication arrows showing direction of flow.
 - 1. Pipes with OD, Including Insulation, Less Than 6 Inches: Self-adhesive pipe markers. Use color-coded, self-adhesive plastic tape, at least 3/4 inch wide, lapped at least 1-1/2 inches at both ends of pipe marker, and covering full circumference of pipe.
 - 2. Pipes with OD, Including Insulation, 6 Inches and Larger: Shaped pipe markers. Use size to match pipe and secure with fasteners.
 - 3. Pipes with OD, Including Insulation, 6 Inches and Larger: Self-adhesive pipe markers. Use color-coded, self-adhesive plastic tape, at least 1-1/2 inches wide, lapped at least 3 inches at both ends of pipe marker, and covering full circumference of pipe.
- B. Locate pipe markers and color bands where piping is exposed in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior non-concealed 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 non-accessible 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 markers.

3.3 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 Water: 1-1/2 inches.
 - b. Fire Protection: 1-1/2 inches.
 2. Valve-Tag Color:
 - a. Domestic Cold Water: White.
 - b. Domestic Hot Water: Green.
 - c. Fire Protection: Red.
 3. Letter Color:
 - a. Domestic Cold Water: Black.
 - b. Domestic Hot Water: White.
 - c. Fire Protection: White.

3.4 VALVE-SCHEDULE INSTALLATION

- A. Mount valve schedule in plastic slip sheets located in the 3-ring binder.

3.5 WARNING-TAG INSTALLATION

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

3.6 ADJUSTING

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

3.7 CLEANING

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

END OF SECTION 220553

SECTION 220700 – PLUMBING INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes preformed, rigid and flexible pipe insulation; insulating cements; field-applied jackets; accessories and attachments; and sealing compounds.
- B. Related Sections include the following:
 - 1. Division 07 Section "Firestopping" for firestopping materials and requirements for penetrations through fire and smoke barriers.
 - 2. Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment" for pipe insulation shields and protection saddles.

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. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets with requirements indicated. Include dates of tests.

1.4 QUALITY ASSURANCE

- A. Fire-Test-Response Characteristics: As determined by testing materials identical to those specified in this Section according to ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and sealer and cement material containers with appropriate markings of applicable testing and inspecting agency.
 - 1. Insulation Installed Indoors: Flame-spread rating of 25 or less, and smoke-developed rating of 50 or less.
 - 2. Insulation Installed Outdoors: Flame-spread rating of 75 or less, and smoke-developed rating of 150 or less.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Packaging: Ship insulation materials in containers marked by manufacturer with appropriate ASTM specification designation, type and grade, and maximum use temperature.

1.6 COORDINATION

- A. Coordinate size and location of supports, hangers, and insulation shields specified in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment."
- B. Coordinate clearance requirements with piping Installer for insulation application.

1.7 SCHEDULING

- A. Schedule insulation application after testing piping systems and, where required, after installing and testing heat-trace tape. Insulation application may begin on segments of piping that have satisfactory test results.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Mineral-Fiber Insulation:
 - a. CertainTeed Manson.
 - b. Knauf FiberGlass GmbH.
 - c. Owens-Corning Fiberglas Corp.
 - d. Schuller International, Inc.
 - 2. Flexible Elastomeric Thermal Insulation:
 - a. Armstrong World Industries, Inc.
 - b. Rubatex Corp.
 - 3. Calcium Silicate Insulation:
 - a. Owens-Corning Fiberglas Corp.
 - b. Pabco.
 - c. Schuller International, Inc.

2.2 INSULATION MATERIALS

- A. Mineral-Fiber 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. U.L. 25/50 fire/smoke rating compliant.
 2. Insulation shall have a maximum k value of 0.27 Btu per inch/h-sqft-deg F.
 3. 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.
 4. Vapor-Retarder Mastics: Fire- and water-resistant, vapor-retarder mastic for indoor applications. Comply with MIL-C-19565C, Type II.
 5. Mineral-Fiber Insulating Cements: Comply with ASTM C 195.
- B. Flexible Elastomeric Thermal Insulation: 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.
 3. Insulation shall have a maximum k value of 0.27 Btu per inch/h-sqft-deg F.
- C. Calcium Silicate Insulation: Preformed pipe sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C 533, Type I.
- D. 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. Standard PVC Fitting Covers: Factory-fabricated fitting covers manufactured from 20-mil-thick, high-impact, ultraviolet-resistant PVC. U.L. 25/50 smoke/fire rating compliant.
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 VAPOR RETARDERS

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

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 pipe and fitting surfaces. 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; free of voids throughout the length of piping, including fittings, valves, and specialties.
- B. Refer to schedules at the end of this Section for materials, forms, jackets, and thicknesses required for each piping 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 insulation with longitudinal seams at top and bottom of horizontal pipe runs.
- E. Apply multiple layers of insulation with longitudinal and end seams staggered.
- F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
- G. Seal joints and seams with vapor-retarder mastic on insulation indicated to receive a vapor retarder.
- H. Keep insulation materials dry during application and finishing.
- I. Apply insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by the insulation material manufacturer.
- J. Apply insulation with the least number of joints practical.
- K. Apply insulation over fittings, valves, and specialties, with continuous thermal and vapor-retarder integrity, unless otherwise indicated. 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, taper insulation ends. Seal tapered ends with a compound recommended by the insulation material manufacturer to maintain vapor retarder.
- N. Apply adhesives and mastics at the manufacturer's recommended coverage rate.
- O. Apply insulation with integral jackets as follows:
1. Pull jacket tight and smooth.
 2. Circumferential Joints: Cover with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip and spaced 4 inches o.c.
 3. Longitudinal Seams: Overlap jacket seams at least 1-1/2 inches. Apply insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 4 inches o.c.
 - a. Exception: Do not staple longitudinal laps on insulation having a vapor retarder.
 4. Vapor-Retarder Mastics: Where vapor retarders are indicated, apply mastic on seams and joints and at ends adjacent to flanges, unions, valves, and fittings.
 5. At penetrations in jackets for thermometers and pressure gages, fill and seal voids with vapor-retarder mastic.
- P. Exterior Wall Penetrations: For penetrations of below-grade exterior walls, terminate insulation flush with mechanical sleeve seal. Seal terminations with vapor-retarder mastic.
- Q. Interior Wall and Partition Penetrations: Apply insulation continuously through walls and floors.
- R. Fire-Rated Wall and Partition Penetrations: Apply insulation continuously through penetrations of fire-rated walls and partitions.
1. Firestopping and fire-resistive joint sealers are specified in Division 07 Section "Firestopping".
- S. Floor Penetrations: Apply insulation continuously through floor assembly.
1. For insulation with vapor retarders, seal insulation with vapor-retarder mastic where floor supports penetrate vapor retarder.

3.4 MINERAL-FIBER INSULATION APPLICATION

A. Apply insulation to straight pipes and tubes as follows:

1. Where vapor retarders are indicated, seal longitudinal seams and end joints with vapor-retarder mastic. Apply vapor retarder to ends of insulation at intervals of 15 to 20 feet to form a vapor retarder between pipe insulation segments.
2. For insulation with factory-applied jackets, secure laps with outward clinched staples at 6 inches o.c.
3. For insulation with factory-applied jackets with vapor retarders, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by the insulation material manufacturer and seal with vapor-retarder mastic.
4. Hanger and piping support assemblies shall be installed on the exterior surface of the insulation with insulation shields on domestic cold water piping. Hangers and piping supports shall not penetrate the insulation jacket.

B. Apply insulation to flanges as follows:

1. Apply preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation segment the same as overall width of the flange and bolts, plus twice the thickness of the pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
4. Apply canvas jacket material with manufacturer's recommended adhesive, overlapping seams at least 1 inch, and seal joints with vapor-retarder mastic.

C. Apply insulation to fittings and elbows as follows:

1. Apply premolded insulation sections of the same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When premolded insulation elbows and fittings are not available, apply mitered sections of pipe insulation, or glass-fiber blanket insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire, tape, or bands.
3. Cover fittings with standard PVC fitting covers.
4. Cover fittings with heavy PVC fitting covers. Overlap PVC covers on pipe insulation jackets at least 1 inch at each end. Secure fitting covers with manufacturer's attachments and accessories. Seal seams with tape and vapor-retarder mastic.

D. Apply insulation to valves and specialties as follows:

1. Apply premolded insulation sections of the same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When premolded insulation sections are not available, apply glass-fiber blanket insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation. For check valves, arrange insulation for access to strainer basket without disturbing insulation.
3. Apply insulation to flanges as specified for flange insulation application.
4. Use preformed standard PVC fitting covers for valve sizes where available. Secure fitting covers with manufacturer's attachments and accessories. Seal seams with tape and vapor-retarder mastic.
5. Use preformed heavy PVC fitting covers for valve sizes where available. Secure fitting covers with manufacturer's attachments and accessories. Seal seams with tape and vapor-retarder mastic.

6. For larger sizes where PVC fitting covers are not available, seal insulation with canvas jacket and sealing compound recommended by the insulation material manufacturer.

3.5 FLEXIBLE ELASTOMERIC THERMAL INSULATION APPLICATION

- A. Apply insulation to straight pipes and tubes as follows:
 1. Follow 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 pipe surface.
- B. Apply insulation to flanges as follows:
 1. Apply pipe insulation to outer diameter of pipe flange.
 2. Make width of insulation segment the same as overall width of the flange and bolts, plus twice the thickness of the pipe insulation.
 3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of the same thickness as pipe insulation.
 4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive. Cement to avoid openings in insulation that will allow passage of air to the pipe surface.
- C. Apply insulation to fittings and elbows as follows:
 1. Apply mitered sections of pipe insulation.
 2. Secure insulation materials and seal seams with manufacturer's recommended adhesive. Cement to avoid openings in insulation that will allow passage of air to the pipe surface.

3.6 PIPING SYSTEM APPLICATIONS

- A. Insulation materials and thicknesses are specified in schedules at the end of this Section.
- B. Items Not Insulated: Unless otherwise indicated, do not apply insulation to the following systems, materials, and equipment:
 1. Flexible connectors.
 2. Vibration-control devices.
 3. Fire-suppression piping.
 4. Chrome-plated pipes and fittings, unless potential for personnel injury.
 5. Air chambers, unions, strainers, check valves, plug valves, and flow regulators.

3.7 FIELD QUALITY CONTROL

- A. Inspection: Perform the following field quality-control inspections, after installing insulation materials, jackets, and finishes, to determine compliance with requirements:
 1. Inspect fittings and valves randomly selected by Engineer.
 2. Remove fitting covers from 20 elbows or 1 percent of elbows, whichever is less, for various pipe sizes.

3. Remove fitting covers from 20 valves or 1 percent of valves, whichever is less, for various pipe sizes.
- B. Insulation applications will be considered defective if sample inspection reveals noncompliance with requirements. Remove defective Work and replace with new materials according to these Specifications.
- C. Reinstall insulation and covers on fittings and valves uncovered for inspection according to these Specifications.

3.8 INSULATION APPLICATION SCHEDULE, GENERAL

- A. Refer to insulation application schedules for required insulation materials, vapor retarders, and field-applied jackets.
- B. Application schedules identify piping system and indicate pipe size ranges and material, thickness, and jacket requirements.

3.9 INSULATION APPLICATION SCHEDULE

- A. Insulate the following piping systems with material and thickness as scheduled below:

Insulation Thickness In Inches for Pipe Sizes In Inches									
Interior Piping Service	Material	1" and less	1 1/4" to 1.5"	2" to 4"	5" to 6"	8" and larger	Notes	Vapor Barrier Yes/No	Exterior Pipe Jacket Type PVC/ALUM
Domestic Hot Water & Hot Water Recirculation	Jacketed Fiberglass	1	1	1-1/2	1-1/2	1-1/2	2, 3	No	-
Domestic Cold Water	Jacketed Fiberglass	1/2	1/2	1/2	1/2	1/2	2,3	Yes	-
Roof Drain Piping	Jacketed Fiberglass or Flexible Elastomeric	1/2	1/2	1/2	1/2	1/2	1	Yes	-

Notes:

1. All vertical risers and horizontal piping above grade must be insulated.
2. Where a rigid insulation is required because the piping is expected to be exposed to impact or abuse, use calcium silicate pipe insulation with thickness to maintain the R-value of the specified thickness schedule.

3. Plumbing Insulation Omitted: Omit insulation on chrome-plated exposed piping (except for handicapped fixtures), air chambers, unions, strainers, check valves, balance cocks, flow regulators, drain lines from water coolers, drainage piping, fire protection piping, and pre-insulated equipment. All other portions of system shall be fully insulated.

END OF SECTION 220700

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 SUMMARY

- A. This Section includes domestic water piping from locations indicated to fixtures and equipment inside the building.
- B. Related Sections include the following:
 - 1. Division 22 Section "Domestic Water Piping Specialties" for water distribution piping specialties.

1.3 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. Combined Fire-Protection and Domestic Water Service Piping: 200 psig.
 - 2. Domestic Water Distribution Piping: 125 psig.

1.4 SUBMITTALS

- A. Product Data: For pipe, tube, fittings, and couplings.
- B. Water Samples: Specified in "Cleaning" Article in Part 3.
- C. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

1.5 QUALITY ASSURANCE

- A. Piping materials shall bear label, stamp, or other markings of specified testing agency.
- B. Comply with NFPA 24, "Installation of Private Fire Service Mains and Their Appurtenances," and NSF 61, "Drinking Water System Components-Health Effects; Sections 1 through 9," for combined fire-protection and domestic water service piping to building.

- C. Comply with NSF 61, "Drinking Water System Components-Health Effects; Sections 1 through 9," for potable domestic water piping and components.

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 COPPER TUBING

- A. Soft Copper Tube: ASTM B 88, Types K and L, water tube, annealed temper.
 - 1. Copper Pressure Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint fittings. Furnish wrought-copper fittings if indicated.
 - 2. Bronze Flanges: ASME B16.24, Class 150, with solder-joint end. Furnish Class 300 flanges if required to match piping.
 - 3. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces and solder-joint or threaded ends.
- B. Hard Copper Tube: ASTM B 88, Type L, water tube, drawn temper.
 - 1. Copper Pressure Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint fittings. Furnish wrought-copper fittings if indicated.
 - 2. Bronze Flanges: ASME B16.24, Class 150, with solder-joint end. Furnish Class 300 flanges if required to match piping.
 - 3. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces and solder-joint or threaded ends.
 - 4. Copper, Grooved-End Fittings: ASTM B 75 copper tube or ASTM B 584 bronze castings.
 - a. Copper-Tubing, Keyed Couplings: Copper-tube dimensions and design similar to AWWA C606. Include ferrous housing sections, gasket suitable for hot water, and bolts and nuts.

2.3 VALVES

- A. Refer to Division 22 Section "General Duty Valves for Plumbing Piping" for bronze and cast-iron, general-duty valves.
- B. Refer to Division 22 Section "Domestic Water Piping Specialties" for balancing and drain valves.

PART 3 - EXECUTION

3.1 EXCAVATION

- A. Refer to Division 31 Section "Earthwork" 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. Underground Combined Fire-Protection and Domestic Water Service Piping: Provide piping listed for fire-protection service and complying with NSF 61. Use the piping materials listed in Section 21 11 00.
- D. Above Ground Domestic Water Piping: Use the following piping materials for each size range:
 - 1. Cold Water Systems and 110 degree Hot Water Systems, sizes: ½" through 1-1/2": Hard copper tube, Type L; copper pressure fittings; and soldered joints. Grooved ends; copper grooved-end fittings; and grooved joints.
 - 2. Cold Water Systems and 110 degree Hot Water Systems, sizes: 2" and larger: Hard copper tube, Type L; copper pressure fittings; and soldered joints.
 - 3. 140 degree Hot Water, All Sizes: Hard copper tube, Type L; copper pressure fittings; and soldered joints.
 - 4. All piping in mechanical rooms, receiving rooms, storage rooms and in exposed locations, All Sizes: Hard copper tube, Type L; copper pressure fittings; and soldered joints.
- E. Underground Domestic Water Piping NPS 4 and Smaller: Soft copper tube, Type K; continuous pipe. All joints to occur above floor slab.

3.3 VALVE APPLICATIONS

- A. Where specific valve types are not indicated, the following requirements apply:
 - 1. Shutoff Duty: Use bronze full port ball valves for piping NPS 3 and smaller. Use cast-iron butterfly valves or full port ball valves for piping NPS 4 and larger.
 - 2. Throttling Duty: Use bronze ball or globe 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: Calibrated balancing valves.
 - 4. Drain Duty: Hose-end drain valves with vacuum breaker.
 - 5. Refer to Section 220523 for valve specifications.

3.4 PIPING INSTALLATION

- A. Refer to Division 33 Section for site water distribution and service piping.
- B. Refer to Division 22 Section "Common Work Results for Plumbing" for basic piping installation.

- C. Install underground copper tubing according to CDA's "Copper Tube Handbook."
- D. Install shutoff valve, hose-end drain valve, strainer and pressure gage on the domestic water service. Refer to Division 22 Section "Meters and Gages for Plumbing Piping" for pressure gages, and to Division 22 Section "Domestic Water Piping Specialties" for drain valves and strainers.
- E. Install aboveground domestic water piping level and plumb.
- F. Fill water piping. Check components to determine that they are not air bound and that piping is full of water.
- G. 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.
- H. Check plumbing equipment and verify proper settings, adjustments, and operation. Do not operate water heaters before filling with water.
- I. Check plumbing specialties and verify proper settings, adjustments, and operation.
- J. Energize pumps and verify proper operation.
- K. Extended-tee and drilled fittings with brazed joints are not approved for use.
- L. All piping shall be installed and tested in accordance with piping manufacturer and code requirements. Compensation for expansion and contraction shall be provided in the installation. Shock absorbers shall be provided at each quick closing valve and air chambers shall be provided according to manufacturer requirements. Rough-ins for individual fixture connections shall be secured and rigid at each wall penetration.

3.5 JOINT CONSTRUCTION

- A. Refer to Division 22 Section "Common Work Results for Plumbing" for basic piping joint construction.
- B. 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.
- C. Grooved Joints: Assemble joints with keyed-coupling housing, gasket, lubricant, and bolts according to coupling and fitting manufacturer's written instructions.

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 or gate valves for piping NPS 2-1/2 and larger.
- C. Install drain valves for equipment, at base of each water riser, at low points in horizontal piping, and where required to drain water piping.
 - 1. Install stop-and-waste drain valves where indicated.
- D. Install calibrated balancing valves in each hot-water circulation return branch. Set calibrated balancing valves partly open to restrict but not stop flow. Refer to Division 22 Section "Domestic Water Piping Specialties" for calibrated balancing valves. Balancing Valves shall be sized for low flows from 0.5 to 15 gpm.

3.7 HANGER AND SUPPORT INSTALLATION

- A. Refer to Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment" for pipe hanger and support devices. 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.
- B. Install supports according to Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment."
- C. Support vertical piping and tubing at base and at each floor.
- D. Rod diameter may be reduced 1 size for double-rod hangers, 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. Install supports for vertical copper tubing every 10 feet.

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.

D. Connect domestic water piping to service piping with shutoff valve, and extend and connect to the following:

1. Water Heaters: Cold-water supply and hot-water outlet piping in sizes indicated, but not smaller than sizes of water heater connections.
2. Plumbing Fixtures: Cold- and hot-water supply piping in sizes indicated, but not smaller than required by plumbing code. Refer to Division 22 Section "Plumbing Fixtures."
3. Equipment: Cold- and hot-water supply piping as indicated, but not smaller than equipment connections. Provide shutoff valve and union for each connection. Use flanges instead of unions for NPS 2-1/2 and larger.

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. Adjust calibrated balancing valves to flows indicated.

3.11 CLEANING

- A. Clean and disinfect potable domestic water piping as follows:
 1. Purge new piping.
 2. Use purging and disinfecting procedures prescribed by authorities having jurisdiction or, if methods are not prescribed, procedures described in either AWWA C651 or 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.
- B. Prepare and submit reports of purging and disinfecting activities.
- C. Clean interior of domestic water piping system. Remove dirt and debris as work progresses.

END OF SECTION 221116

SECTION 221119 – PLUMBING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following plumbing specialties:

1. Backflow preventers.
2. Water regulators.
3. Domestic water mixing valves.
4. Strainers.
5. Drain valves.
6. Miscellaneous piping specialties.
7. Flashing materials.
8. Cleanouts.
9. Floor drains.
10. Grease Interceptors.

1.3 DEFINITIONS

- A. The following are industry abbreviations for plastic piping materials:

1. ABS: Acrylonitrile-butadiene-styrene plastic.
2. PE: Polyethylene plastic.
3. PUR: Polyurethane plastic.
4. PVC: Polyvinyl chloride plastic.

1.4 PERFORMANCE REQUIREMENTS

- A. Provide components and installation capable of producing piping systems with following minimum working-pressure ratings, unless otherwise indicated:
 1. Domestic Water Piping: 125 psig.
 2. Sanitary Waste and Vent Piping: 10-foot head of water.
 3. Storm Drainage Piping: 10-foot head of water.

1.5 SUBMITTALS

- A. Product Data: Include rated capacities and shipping, installed, and operating weights. Indicate materials, finishes, dimensions, required clearances, and methods of assembly of components; and piping and wiring connections for the following:
 - 1. Backflow preventers and water regulators.
 - 2. Water filters, and strainers.
 - 3. Domestic water mixing valves.
 - 4. Water hammer arresters.
 - 5. Drain valves.
 - 6. Cleanouts, floor drains and roof drains.
 - 7. Vent terminals and roof flashing assemblies.
 - 8. Grease interceptors.
 - 9. Cleanout carpet marker sample.
- B. Maintenance Data: For plumbing specialties to include in maintenance manuals. Include the following:
 - 1. Backflow preventers and water regulators.
 - 2. Thermostatic water mixing valves.
 - 3. Grease interceptors.

1.6 QUALITY ASSURANCE

- A. Product Options: Drawings indicate size, profiles, and dimensional requirements of plumbing specialties and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."
- B. Plumbing specialties shall bear label, stamp, or other markings of specified testing agency.
- C. 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.
- D. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for piping materials and installation.
- E. NSF Compliance:
 - 1. Comply with NSF 14, "Plastics Piping Components and Related Materials," for plastic domestic water piping components. Include marking "NSF-pw" on plastic potable-water piping and "NSF-dwv" on plastic drain, waste, and vent piping.
 - 2. Comply with NSF 61, "Drinking Water System Components--Health Effects, Sections 1 through 9," for potable domestic water plumbing specialties.

PART 2 - PRODUCTS

2.1 BACKFLOW PREVENTERS

- A. Manufacturers:

1. Cla-Val Co.
 2. CMB Industries, Inc.; Febco Backflow Preventers.
 3. Conbraco Industries, Inc.
 4. FLOMATIC Corp.
 5. IMI Cash Valve.
 6. Mueller Co.; Hersey Meters Div.
 7. Watts Industries, Inc.; Water Products Div.
 8. Zurn Industries, Inc.; Wilkins Div.
- B. General: ASSE standard, backflow preventers.
1. NPS 2 and Smaller: Bronze body with threaded ends.
 2. NPS 2-1/2 and Larger: Bronze, cast-iron, steel, or stainless-steel body with flanged ends.
 - a. Interior Lining: AWWA C550 or FDA-approved, epoxy coating for backflow preventers having cast-iron or steel body.
 3. Interior Components: Corrosion-resistant materials.
 4. Exterior Finish: Polished chrome plate if used in chrome-plated piping system.
 5. Strainer: On inlet.
- C. Pipe-Applied, Atmospheric-Type Vacuum Breakers: ASSE 1001, with floating disc and atmospheric vent.
- D. Hose-Connection Vacuum Breakers: ASSE 1011, nickel plated, with nonremovable and manual drain features, and ASME B1.20.7, garden-hose threads on outlet. Units attached to rough-bronze-finish hose connections may be rough bronze.
- E. Reduced-Pressure-Principle Backflow Preventers: ASSE 1013, suitable for continuous pressure application. Include outside screw and yoke gate valves on inlet and outlet, and strainer on inlet; test cocks; and pressure-differential relief valve with ASME A112.1.2 air-gap fitting located between two positive-seating check valves.
1. Pressure Loss: 12 psig maximum, through middle 1/3 of flow range.
- F. Double-Check Backflow Prevention Assemblies: ASSE 1015, suitable for continuous pressure application. Include shutoff valves on inlet and outlet, and strainer on inlet; test cocks; and two positive-seating check valves.
1. Pressure Loss: 5 psig maximum, through middle 1/3 of flow range.
- G. Antisiphon-Pressure-Type Vacuum Breakers: ASSE 1020, suitable for continuous pressure application. Include shutoff valves, spring-loaded check valve, spring-loaded floating disc, test cocks, and atmospheric vent.
1. Pressure Loss: 5 psig maximum, through middle 1/3 of flow range.
- H. Hose-Connection Backflow Preventers: ASSE 1052, suitable for at least 3-gpm flow and applications with up to 10-foot head of water back pressure. Include two check valves; intermediate atmospheric vent; and non-removable, ASME B1.20.7, garden-hose threads on outlet.

2.2 WATER REGULATORS

A. Manufacturers:

1. Armstrong-Yoshitake, Inc.
2. Cashco, Inc.
3. Cla-Val Co.
4. Conbraco Industries, Inc.
5. FLOMATIC Corp.
6. IMI Cash Valve.
7. Watts Industries, Inc.; Water Products Div.
8. Zurn Industries, Inc.; Wilkins Div.

B. General: ASSE 1003, water regulators, rated for initial working pressure of 150 psig minimum. Include integral factory-installed or separate field-installed, Y-pattern strainer.

1. NPS 2 and Smaller: Bronze body with threaded ends.
 - a. General-Duty Service: Single-seated, direct operated, unless otherwise indicated.
 - b. Booster Heater Water Supply: Single-seated, direct operated with integral bypass.
2. NPS 2-1/2 and Larger: Bronze or cast-iron body with flanged ends. Include AWWA C550 or FDA-approved, interior epoxy coating for regulators with cast-iron body.
3. Interior Components: Corrosion-resistant materials.

2.3 STRAINERS

A. Strainers: Y-pattern, unless otherwise indicated, and full size of connecting piping. Include ASTM A 666, Type 304, stainless-steel screens with 3/64-inch round perforations, unless otherwise indicated.

1. Pressure Rating: 125-psig minimum steam working pressure, unless otherwise indicated.
2. NPS 2 and Smaller: Bronze body, with female threaded ends.
3. NPS 2-1/2 and Larger: Cast-iron body, with interior AWWA C550 or FDA-approved, epoxy coating and flanged ends.
4. Y-Pattern Strainers: Screwed screen retainer with centered blowdown.
 - a. Drain: Field-installed, hose-end drain valve.
5. T-Pattern Strainers: Malleable-iron or ductile-iron body with grooved ends; access end cap with drain plug and access coupling with rubber gasket.
6. Basket Strainers: Bolted flange or clamp cover, and basket with lift-out handle.
 - a. Type: Simplex with one basket.
 - b. Drain: Field-installed, hose-end drain valve.

2.4 DRAIN VALVES

- A. Hose-End Drain Valves: MSS SP-110, NPS 3/4 ball valve, rated for 400-psig minimum CWP. Include two-piece, copper-alloy body with standard port, chrome-plated brass ball, replaceable seats and seals, blowout-proof stem, and vinyl-covered steel handle.
 - 1. Inlet: Threaded or solder joint.
 - 2. Outlet: Short-threaded nipple with ASME B1.20.7, garden-hose threads and cap.
- B. Stop-and-Waste Drain Valves: MSS SP-110, ball valve, rated for 200-psig minimum CWP or MSS SP-80, Class 125, gate valve; ASTM B 62 bronze body, with NPS 1/8 side drain outlet and cap.

2.5 MISCELLANEOUS PIPING SPECIALTIES

- A. Water Hammer Arresters: ASSE 1010 or PDI-WH 201, piston type with pressurized metal-tube cushioning chamber. Sizes indicated are based on ASSE 1010, Sizes AA and A through F or PDI-WH 201, Sizes A through F.
 - 1. Manufacturers:
 - a. Amtrol, Inc.
 - b. Josam Co.
 - c. Precision Plumbing Products, Inc.
 - d. Sioux Chief Manufacturing Co., Inc.
 - e. Watts Industries, Inc.; Drainage Products Div.
 - f. Watts Industries, Inc.; Water Products Div.
 - g. Zurn Industries, Inc.; Wilkins Div.
- B. Air Vents: Float type for automatic air venting.
 - 1. Bolted Construction: Bronze body with replaceable, corrosion-resistant metal float and stainless-steel mechanism and seat; threaded NPS 1/2 minimum inlet; 125-psig minimum pressure rating at 140 deg F; and threaded vent outlet.
- C. Roof Flashing Assemblies: Refer to Division 07 specifications.
- D. Open Drains: Shop or field fabricate from ASTM A 74, Service class, hub-and-spigot, cast-iron, soil-pipe fittings. Include P-trap, hub-and-spigot riser section; and where required, increaser fitting, joined with ASTM C 564, rubber gaskets.
- E. Deep-Seal Traps: Cast-iron or bronze casting, with inlet and outlet matching connected piping and cleanout trap seal primer valve connection.
 - 1. NPS 2: 4-inch- minimum water seal.
 - 2. NPS 2-1/2 and Larger: 5-inch- minimum water seal.
- F. Floor-Drain Inlet Fittings: Cast iron, with threaded inlet and threaded or spigot outlet, and trap seal primer valve connection.
- G. Fixed Air-Gap Fittings: Manufactured cast-iron or bronze drainage fitting with semiopen top with threads or device to secure drainage inlet piping in top and bottom spigot or threaded outlet

larger than top inlet. Include design complying with ASME A112.1.2 that will provide fixed air gap between installed inlet and outlet piping.

- H. Stack Flashing Fittings: Counterflashing-type, cast-iron fitting, with bottom recess for terminating roof membrane, and with threaded or hub top for extending vent pipe.
- I. Expansion Joints: ASME A112.21.2M, assembly with cast-iron body with bronze sleeve, packing gland, and packing; of size and end types corresponding to connected piping.

2.6 CLEANOUTS

- A. Cleanouts: Comply with ASME A112.36.2M.
 - 1. Manufacturers:
 - a. Josam Co.
 - a. Smith, Jay R. Mfg. Co.
 - b. Tyler Pipe, Wade Div.
 - c. Wade.
 - d. Watts Industries, Inc., Drainage Products Div.
 - e. Zurn Industries, Inc., Jonespec Div.
 - f. Zurn Industries, Inc., Specification Drainage Operation.
- B. General: Cleanouts shall be provided with a bronze plug. Floor cleanouts in wet locations to be furnished with flashing clamp device and set in the center of a 24" x 24" flashing pan except for slab on grade or grade cleanout applications.
- C. Floor Cleanouts (F.C.O.): All exposed F.C.O. to have satin finish bronze tops unless otherwise noted. Carpet markers shall be provided either by the cleanout manufacturer or by a third-party manufacturer and shall be of satin bronze finish. Submit carpet marker samples for review.

Floor Surface		Slab on Grade	Upper Floor w/Occupied Spaces Below
1.	Finished concrete	56020-15-22	56020-15-22-41
2.	Tiled	56020-12-15-22	56020-12-15-22-41
3.	Terrazzo	56020-13-15-22	56020-13-15-41-22
4.	Carpet	56020-14-15-22	56020-14-15-22-41
5.	Use Josam 56030 series cleanouts with modifications listed above, for spigot or no hub type connections.		
6.	All cleanouts located in carpeted area shall be installed flush with the concrete topping to allow for carpet installation. Install marker in cleanout cover.		

D. Wall Cleanouts (W.C.O.)

1. Provide at base of all sanitary and storm stacks.
2. For pipe spaces and walls without access:
 - a. Josam 58890-17 (use tapped C.O. tee)
 - b. The wall cleanout cover plate is to match wall finish. Apply wallpaper to match walls that are papered. Apply paint to match walls that are painted.

E. Cleanout Plugs (CO)

1. For accessible pipe spaces and exposed sewer piping (end of main, heel, wyes, etc.)
 - a. Josam 5840 plug with tapped spigot no hub or hub type.

F. Grade Cleanout (GCO)

1. Provide cast iron riser to grade with concrete base under riser wye, and 12 x 12 x 8" thick concrete pad at grade with cleanout centered in pad.
2. Josam 56040-5-15-22

2.7 FLOOR DRAINS AND FLOOR SINKS

A. Floor Drains and Floor Sinks: Comply with ASME A112.21.1M.

1. Manufacturers:
 - a. Josam Co.
 - b. Josam Co., Blucher-Josam Div.
 - c. Smith, Jay R. Mfg. Co.
 - d. Tyler Pipe, Wade Div.
 - e. Wade.
 - f. Watts Industries, Inc., Drainage Products Div.
 - g. Zurn Industries, Inc., Jonespec Div.
 - h. Zurn Industries, Inc., Specification Drainage Operation.
2. Body Material: Cast iron.
3. Seepage Flange: Required.
4. Clamping Device: Required.
5. Outlet: As schedule for all floor sinks.
6. Exposed Surfaces and Interior Lining: Acid-resistant enamel.
7. Top or Strainer Material: Nickel bronze.
8. Top Shape: As scheduled.
9. Top Loading Classification: As scheduled.
10. Interior Coating: Acid resistant (floor sinks only).
11. Provide Trap Guard insert on all floor drains.

2.8 GREASE INTERCEPTORS (Exterior)

- A. Provide grease interceptor for outside installation, constructed of precast concrete with epoxy finish on inside in accordance with jurisdictional authority's requirements and the Contract Documents.
- B. Provide manhole extensions to finish grade, manhole frames and bolted-gasketed covers, vents, inlet/outlet piping, and all accessories required. Bolts for interceptor lid access shall be stainless steel type 316 only, cast iron, steel, or brass will not be acceptable.

2.9 INDIVIDUAL-FIXTURE, WATER TEMPERING VALVES

- A. Mixing Valves:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Holby
 - b. Lawler Manufacturing Company, Inc.
 - c. Symmons
 - d. Speakman
 - 2. Standard: ASSE 1070, thermostatically controlled, water tempering valve.
 - 3. Pressure Rating: 125 psig minimum unless otherwise indicated.
 - 4. Body: Bronze body with corrosion-resistant interior components.
 - 5. Temperature Control: Adjustable.
 - 6. Inlets and Outlet: Threaded.
 - 7. Finish: Rough or chrome-plated bronze.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Refer to Division 22 Section "Common Work Results for Plumbing" for piping joining materials, joint construction, and basic installation requirements.
- B. Install backflow preventers in each water supply to mechanical equipment and systems and to other equipment and water systems that may be sources of contamination. Comply with authorities having jurisdiction.
 - 1. Locate backflow preventers in same room as connected equipment or system.
 - 2. Install drain for backflow preventers with atmospheric-vent drain connection with air-gap fitting, fixed air-gap fitting, or equivalent positive pipe separation of at least two pipe diameters in drain piping and pipe to floor drain. Locate air-gap device attached to or under backflow preventer. Simple air breaks are not acceptable for this application.
 - 3. Do not install bypass piping around backflow preventers.
- C. Install pressure regulators with inlet and outlet shutoff valves and balance valve bypass. Install pressure gages on inlet and outlet.
- D. Install strainers on supply side of each control valve, pressure regulator, and solenoid valve.

- E. Install trap seal primer valves with outlet piping pitched down toward drain trap a minimum of 1 percent and connect to floor-drain body, trap, or inlet fitting. Adjust valve for proper flow.
- F. Install expansion joints on vertical risers, stacks, and conductors.
- G. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:
 - 1. Size same as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
 - 2. Locate at each change in direction of piping greater than 45 degrees.
 - 3. Locate at minimum intervals of 50 feet for piping NPS 4 and smaller and 80 feet for larger piping.
 - 4. Locate at base of each vertical soil and waste stack.
- H. Install cleanout deck plates with top flush with finished floor, for floor cleanouts for piping below floors.
- I. Install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall, for cleanouts located in concealed piping. All covers shall be finished to match the wall material in exposed public locations.
- J. Install flashing flange and clamping device with each stack and cleanout passing through floors with waterproof membrane.
- K. Install vent flashing sleeves on stacks passing through roof. Secure over stack flashing according to manufacturer's written instructions.
- L. Install frost-proof vent caps on each vent pipe passing through roof. Maintain 1-inch clearance between vent pipe and roof substrate.
- M. Install floor drains at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated.
 - 1. Position floor drains for easy access and maintenance.
 - 2. Set floor drains below elevation of surrounding finished floor to allow floor drainage. Set with grates depressed according to the following drainage area radii:
 - a. Radius, 30 Inches or Less: Equivalent to 1 percent slope, but not less than 1/4-inch total depression.
 - b. Radius, 30 to 60 Inches: Equivalent to 1 percent slope.
 - c. Radius, 60 Inches or Larger: Equivalent to 1 percent slope, but not greater than 1-inch total depression.
 - 3. Install floor-drain flashing collar or 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, unless otherwise indicated.
- N. 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.

- O. Fasten recessed-type plumbing specialties to reinforcement built into walls.
- P. Install individual shutoff valve in each water supply to plumbing specialties. Use ball, gate, or globe valve if specific valve is not indicated. Install shutoff valves in accessible locations. Refer to Division 22 Section "General-Duty Valves for Plumbing Piping" for general-duty ball, butterfly, check, gate, and globe valves.
- Q. Install air vents at piping high points. Include ball, gate, or globe valve inlet.
- R. 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.
- S. Install interceptors, including trapping, venting, according to authorities having jurisdiction and with clear space for servicing.
 - 1. Install cleanout immediately downstream from interceptors not having integral cleanout on outlet.

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. Connect plumbing specialties to piping specified in other Division 22 Sections.

3.3 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.
- B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

3.4 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain all equipment. Refer to Division 01 Section.

END OF SECTION 221119

SECTION 221316 - SANITARY WASTE AND VENT PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes soil and waste, sanitary drainage and vent piping inside the building and to locations indicated.
- B. Related Sections include the following:
 - 1. Division 22 Section "Domestic Water Piping Specialties" for soil, waste, and vent piping systems specialties.

1.3 DEFINITIONS

- A. The following are industry abbreviations for plastic and rubber piping materials:
 - 1. EPDM: Ethylene-propylene-diene terpolymer.
 - 2. NBR: Acrylonitrile-butadiene rubber.
 - 3. PE: Polyethylene plastic.
 - 4. PVC: Polyvinyl chloride plastic.

1.4 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.

1.5 SUBMITTALS

- A. Product Data: For pipe, tube, fittings, and couplings.
- B. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

1.6 QUALITY ASSURANCE

- A. Piping materials shall bear label, stamp, or other markings of specified testing agency.
- B. Comply with NSF 14, "Plastics Piping Systems Components and Related Materials," for plastic piping components. Include marking with "NSF-dwv" for plastic drain, waste, and vent piping; "NSF-drain" for plastic drain piping; "NSF-tubular" for plastic continuous waste piping; and "NSF-sewer" for plastic sewer piping.

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 CAST-IRON SOIL PIPING

- A. Hub-and-Spigot Pipe and Fittings: ASTM A 74, Service Extra-Heavy class.
 - 1. Gaskets: ASTM C 564, rubber.
- B. Hubless Pipe and Fittings: ASTM A 888 or CISPI 301.
 - 1. Couplings: ASTM C 1277 assembly of metal housing, corrosion-resistant fasteners, and ASTM C 564 rubber sleeve with integral, center pipe stop.
 - a. Heavy-Duty, Type 304, Stainless-Steel Couplings: To be used on all systems unless noted otherwise ASTM A 666, Type 304, stainless-steel shield; stainless-steel bands; and sleeve.
 - 1) NPS 1-1/2 to NPS 4: 3-inch wide shield with 4 bands.
 - 2) NPS 5 to NPS 10: 4-inch wide shield with 6 bands.
 - b. Compact, Stainless-Steel Couplings: Acceptable for use on vent piping only. CISPI 310 with ASTM A 167, Type 301, or ASTM A 666, Type 301, stainless-steel corrugated shield; stainless-steel bands; and sleeve.
 - 1) NPS 1-1/2 to NPS 4: 2-1/8-inch wide shield with 2 bands.
 - 2) NPS 5 and NPS 6: 3-inch wide shield with 4 bands.
 - 3) NPS 8 and NPS 10: 4-inch wide shield with 4 bands.

2.3 COPPER TUBING

- A. Used for indirect waste systems only.
- B. Copper DWV Tube: ASTM B 306, drainage tube, drawn temper.
 - 1. Copper Drainage Fittings: ASME B16.23, cast copper or ASME B16.29, wrought copper, solder-joint fittings.

- C. Hard Copper Tube: ASTM B 88, Type M, water tube, drawn temper.
 - 1. Copper Pressure Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint fittings. Furnish wrought-copper fittings if indicated.
 - 2. Bronze Flanges: ASME B16.24, Class 150, with solder-joint end.
 - 3. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.

2.4 PVC PIPING

- A. PVC Pipe: ASTM D 2665 schedule 40, solid-wall drain, waste, and vent.
- B. PVC Special Fittings: ASTM F 409, drainage-pattern tube and tubular fittings with ends as required for application.

PART 3 - EXECUTION

3.1 EXCAVATION

- A. Refer to Division 02 Section "Earthwork" for excavating, trenching, and backfilling.

3.2 PIPING APPLICATIONS

- A. Transition and special fittings with pressure ratings at least equal to piping pressure ratings may be used in applications below, unless otherwise indicated.
- B. Flanges may be used on aboveground pressure piping, unless otherwise indicated.
- C. Aboveground, Soil, Waste, and Vent Piping: Use the following piping materials for each size range:
 - 1. NPS 3/4" to NPS 2": Indirect waste piping only: Copper DWV tube, copper drainage fittings, and soldered joints.
 - 2. NPS 1-1/2" to NPS 10: All waste and vent piping located in return air plenums: Hubless, cast-iron soil piping and the following:
 - a. Couplings: Heavy-duty, Type 304, stainless steel (4 and 6 band). (All waste piping.)
 - b. Couplings: Compact, stainless steel (2 and 4 band). (Vent piping only.)
 - 3. NPS 1-1/2" to NPS 10: All Waste and Vent Piping not located in return air plenums and not identified in items 1 and 2 above: Schedule 40 DWV, solid-wall, PVC.
 - 4. NPS 1-1/2" to NPS 10: Grease Waste Piping and Waste Piping Serving Commercial Kitchens: Hubless cast-iron soil piping and the following:

- a. Couplings: Heavy-duty, Type 304 stainless steel couplings (4 and 6 band) for all high temperature grease waste piping. PVC is not permitted for use for any high temperature grease waste and waste piping serving commercial kitchens.
- D. Underground, Soil, Waste, and Vent Piping: Use the following piping materials for each size range:
 - 1. All Areas: Schedule 40 DWV, solid-wall, PVC.
 - 2. Grease Waste and Commercial Kitchen High Temperature Waste Piping: All sizes. Hub-and-spigot cast iron soil piping and fittings.
- E. Condensate Drain Piping: Schedule 40 CPVC. (Type "M" copper if located in a return air plenum). Exterior terminations shall be Type "L" copper.

3.3 PIPING INSTALLATION

- A. Refer to Division 02 Section "Sanitary Sewerage" for Project-site sanitary sewer piping.
- B. Refer to Division 22 Section "Common Work Results for Plumbing" for basic piping installation.
- C. 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."
- D. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical. Use long-turn, double Y-branch and 1/8-bend fittings if 2 fixtures are installed back to back or side by side with common drain pipe. Straight tees, elbows, and crosses may be used on vent lines. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.
- E. Lay buried building drainage piping beginning at low point of each system. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements. Maintain swab in piping and pull past each joint as completed.
- F. Install soil and waste drainage and vent piping at the following minimum slopes, unless otherwise indicated:
 - 1. Building Sanitary Drain (Minimum slopes): 2 percent downward in direction of flow for piping NPS 3 and smaller; 1 percent downward in direction of flow for piping NPS 4 and larger.
 - 2. Vent Piping: 1 percent down toward vertical fixture vent or toward vent stack.
- G. Install PVC soil and waste drainage and vent piping according to ASTM D 2665.

- H. Install underground soil and waste drainage piping according to ASTM D 2321.
- I. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.
- J. Refer to Trenching and Backfilling requirements in other sections of this Specification.

3.4 JOINT CONSTRUCTION

- A. Refer to Division 22 Section "Common Work Results for Plumbing" for basic piping joint construction.
- B. Cast-Iron, Soil-Piping Joints: Make joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."
 - 1. Gasketed Joints: Make with rubber gasket matching class of pipe and fittings.
 - 2. Hubless Joints: Make with rubber gasket and sleeve or clamp.
- C. 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.

3.5 VALVE INSTALLATION

- A. Refer to Division 22 Section "General Duty Valves for Plumbing Piping" for general-duty valves.
- B. Shutoff Valves: Install shutoff valve on each sump pump discharge.
 - 1. Use gate or full-port ball valve for piping NPS 2 and smaller.
 - 2. Use gate valve for piping NPS 2-1/2 and larger.
- C. Check Valves: Install swing check valve, downstream from shutoff valve, on each sump pump discharge.

3.6 HANGER AND SUPPORT INSTALLATION

- A. Refer to Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment" for seismic-restraint devices.
- B. Refer to Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment" for pipe hanger and support devices. 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, hangers.
- C. Install supports according to Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment."
- 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. NPS 1-1/2 and NPS 2: 60 inches with 3/8-inch rod.
 2. NPS 3: 60 inches with 1/2-inch rod.
 3. NPS 4 and NPS 5: 60 inches with 5/8-inch rod.
 4. NPS 6: 60 inches with 3/4-inch rod.
 5. Spacing for 10-foot lengths may be increased to 10 feet. Spacing for fittings is limited to 60 inches.
- G. Install supports for vertical cast-iron soil piping every 15 feet.
- H. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
1. NPS 1-1/4: 72 inches with 3/8-inch rod.
 2. NPS 1-1/2 and NPS 2: 96 inches with 3/8-inch rod.
 3. NPS 2-1/2: 108 inches with 1/2-inch rod.
 4. NPS 3 to NPS 5: 10 feet with 1/2-inch rod.
 5. NPS 6: 10 feet with 5/8-inch rod.
- I. Install supports for vertical copper tubing every 10 feet.
- J. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

3.7 CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Connect soil and waste piping to exterior sanitary sewer piping. Use transition fitting to join dissimilar piping materials.
- C. Connect drainage and vent piping to the following:
1. Plumbing Fixtures: Connect drainage piping in sizes indicated, but not smaller than required by plumbing code. Refer to Division 22 Section "Plumbing Fixtures."
 2. Plumbing Fixtures and Equipment: Connect atmospheric vent piping in sizes indicated, but not smaller than required by authorities having jurisdiction.

3. Plumbing Specialties: Connect drainage and vent piping in sizes indicated, but not smaller than required by plumbing code. Refer to Division 22 Section "Domestic Water Piping Specialties."
4. Equipment: Connect drainage piping as indicated. Provide shutoff valve and union for each connection. Use flanges instead of unions for connections NPS 2-1/2 and larger.

3.8 FIELD QUALITY CONTROL

- A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.
 1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
 2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
- B. Re-inspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections, and arrange for re-inspection.
- C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
- D. Test sanitary drainage and vent piping 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. Finished Plumbing Test Procedure: After plumbing fixtures have been set and traps filled with water, test connections and prove they are gastight and watertight. Plug vent-stack openings on roof and building drains where they leave building. Introduce air into piping system equal to pressure of 1-inch wg. Use U-tube or manometer inserted in trap of water closet to measure this pressure. Air pressure must remain constant without introducing additional air throughout period of inspection. Inspect plumbing fixture connections for gas and water leaks.
 5. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
 6. Prepare reports for tests and required corrective action.

3.9 CLEANING

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

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

END OF SECTION 221316

SECTION 221413 – FACILITY STORM DRAINAGE PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes storm-drainage piping inside the building and to locations indicated.

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. Storm Drainage Piping: 10-foot head of water.

1.4 SUBMITTALS

- A. Product Data: For pipe, tube, fittings, and couplings.
- B. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

1.5 QUALITY ASSURANCE

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

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

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

2.2 PVC PIPING

- A. PVC Pipe: ASTM D 2665 schedule 40, solid-wall drain, waste, and vent.

- B. PVC Special Fittings: ASTM F 409, drainage-pattern tube and tubular fittings with ends as required for application.

2.3 CAST-IRON SOIL PIPING

- A. Hub-and-Spigot Pipe and Fittings: ASTM A 74, Service class.
 - 1. Gaskets: ASTM C 564, rubber.
- B. Hubless Pipe and Fittings: ASTM A 888 or CISPI 301.
 - 1. Couplings: ASTM C 1277 assembly of metal housing, corrosion-resistant fasteners, and ASTM C 564 rubber sleeve with integral center pipe stop.
 - a. Heavy-Duty, Type 304, Stainless-Steel Couplings: ASTM A 666, Type 304, stainless-steel shield; stainless-steel bands; and sleeve.
 - 1) NPS 1-1/2 to NPS 4: 3-inch wide shield with 4 bands.
 - 2) NPS 5 to NPS 10: 4-inch wide shield with 6 bands.

PART 3 - EXECUTION

3.1 EXCAVATION

- A. Refer to Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.

3.2 PIPING APPLICATIONS

- A. Transition and special fittings with pressure ratings at least equal to piping pressure ratings may be used in applications below, unless otherwise indicated.
- B. Flanges may be used on aboveground pressure piping, unless otherwise indicated.
- C. Aboveground Storm Drainage Piping: Use the following piping materials for each size range:
 - 1. NPS 2 to NPS 10: All storm drainage piping including piping in return air plenums: Hubless, cast-iron soil piping and one of the following:
 - a. Couplings: Heavy-duty, Type 304, stainless steel. See "E" below.
- D. Underground Storm Drainage Piping: Use the following piping materials for each size range:
 - 1. NPS 3 to NPS 10: Schedule 40, solid-wall PVC.
- E. Restrained joints shall be provided on all vertical piping and all horizontal piping that is 8" or larger in diameter.

3.3 PIPING INSTALLATION

- A. Refer to Division 33 Section "Storm Utility Drainage Piping" for Project site storm sewer and drainage piping.
- B. Install cleanouts at grade and extend to where building storm drains connect to building storm sewers.
- C. 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. Refer to Section 220500 for sleeves and mechanical sleeve seals.
- D. 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."
- E. Make changes in direction for storm piping using appropriate branches, bends, and long-sweep bends. 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.
- F. Lay buried building drain 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.
- G. Install storm drainage piping at the following minimum slopes, unless otherwise indicated:
 - 1. Horizontal Storm Drain Piping: 2 percent (Min.) downward in direction of flow for piping NPS 3 and smaller; 1 percent (Min.) downward in direction of flow for piping NPS 4 and larger.
- H. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

3.4 JOINT CONSTRUCTION

- A. Refer to Section 220500 for basic piping joint construction.
- B. Cast-Iron, Soil-Piping Joints: Make joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."
 - 1. Gasketed Joints: Make with rubber gasket matching class of pipe and fittings.
 - 2. Hubless Joints: Make with rubber gasket and sleeve or clamp.

3.5 HANGER AND SUPPORT INSTALLATION

- A. Refer to Section 220529 for pipe hanger and support devices. 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.
- B. Support vertical piping and tubing at base and at each floor.
- C. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch minimum rods.
- D. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:
1. NPS 1-1/2 and NPS 2: 60 inches with 3/8-inch rod.
 2. NPS 3: 60 inches with 1/2-inch rod.
 3. NPS 4 and NPS 5: 60 inches with 5/8-inch rod.
 4. NPS 6: 60 inches with 3/4-inch rod.
 5. NPS 8 to NPS 12: 60 inches with 7/8-inch rod.
 6. Spacing for 10-foot lengths may be increased to 10 feet. Spacing for fittings is limited to 60 inches.
- E. Install supports for vertical cast-iron soil piping every 15 feet.

3.6 CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Connect interior storm drainage piping to exterior storm drainage piping. Use transition fitting to join dissimilar piping materials.
- C. Connect storm drainage piping to roof drains and overflow drains and storm drainage specialties.

3.7 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.
 2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
- B. Re-inspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for re-inspection.
- C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

- D. Test storm drainage 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 storm drainage piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
 3. Test Procedure: Test storm drainage piping 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.

3.8 CLEANING

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

END OF SECTION 221413

SECTION 230500 – COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following basic mechanical materials and methods to complement other Division 23 Sections.
 - 1. Coordination Drawings
 - 2. Piping materials and installation instructions common to most piping systems.
 - 3. Concrete base construction requirements.
 - 4. Escutcheons.
 - 5. Dielectric fittings.
 - 6. Mechanical sleeve seals.
 - 7. Nonshrink grout for equipment installations.
 - 8. Field-fabricated metal and wood equipment supports.
 - 9. Installation requirements common to equipment specification sections.
 - 10. Cutting and patching.
 - 11. Touchup painting and finishing.
 - 12. Mechanical Demolition
- B. Phasing: This contractor shall be responsible for all work and materials required to accommodate the phasing associated with the construction of this project. This shall include, but is not limited to, providing temporary connections, isolation valves and piping, system fill and drain-down, system re-balancing and temporary provisions for all functions of the controls system to operate. It shall also include provisions for temporary equipment to facilitate system operation throughout the phased construction.

1.3 DEFINITIONS

- A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawl spaces, 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 duct shafts.
- 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. NP: Nylon plastic.
 - 4. PE: Polyethylene plastic.
 - 5. PVC: Polyvinyl chloride plastic.
- G. The following are industry abbreviations for rubber materials:
 - 1. CR: Chlorosulfonated polyethylene synthetic rubber.
 - 2. EPDM: Ethylene propylene diene terpolymer rubber.

1.4 SUBMITTALS

- A. Product Data: For dielectric fittings and flexible connectors.
- B. Coordination Drawings: Detail major elements, components, and systems of mechanical equipment and materials in relationship with other systems, installations, and building components and include all building systems in drawings. This shall include drawings for the entire area of renovation including typical sections through crucial areas around exhaust hoods. Drawings shall also be produced for all areas where physical constraints of the space require close coordination of the building components and building systems to ensure an installation that conforms to the facility design documents. Show space requirements for installation, maintenance, component replacement and access. Indicate if sequence and coordination of installations are important to efficient flow of the Work. The Contractor shall coordinate the location, size, spacing and elevation of all duct and piping penetrations of walls and load bearing masonry interior and exterior walls with the work of the various trades to assure that all such penetrations are in full compliance with the requirements of the structural design and meet with the approval of the Structural Engineer of Record. If conflicts occur, they should be identified on the drawings and provided to the Architect for review.

1.5 QUALITY ASSURANCE

- A. Comply with ASME A13.1 for lettering size, length of color field, colors, and viewing angles of identification devices.
- B. Equipment Selection: Equipment of higher electrical characteristics, physical dimensions, capacities, and ratings may be furnished provided such proposed equipment is approved in writing and connecting mechanical and electrical services, circuit breakers, conduit, motors, bases, and equipment spaces are increased. All additional costs associated to the equipment changes shall be the responsibility of the contractor requesting the use of the equipment. If

minimum energy ratings or efficiencies of equipment are specified, equipment must meet design requirements. Any equipment with larger physical dimension and/or with a larger service clearance shall be accompanied by coordination drawings detailing all service points, clearances, access areas and associated building components. Review of the request or submittal will not be reviewed without the drawings. All necessary changes to facility wall locations, construction or access points shall be incorporated into the coordination drawings prior to equipment approval.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and prevent entrance of dirt, debris, and moisture.
- B. Protect stored pipes and tubes from moisture and dirt. Elevate above grade. Do not exceed structural capacity of floor, if stored inside.
- C. Protect flanges, fittings, and piping specialties from moisture and dirt.
- D. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.
- E. Protect all ductwork from dirt, debris, and moisture. Ductwork shall have all openings covered until system is operational. Ductwork shall not be stored in areas that are not completely sealed from the weather. All ductwork shall be stored elevated above the floor surface. Any ductwork not protected shall be cleaned, treated, or replaced according to level of exposure.

1.7 SEQUENCING AND SCHEDULING

- A. Coordinate mechanical equipment installation with other building components.
- B. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction to allow for mechanical installations.
- C. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components, as they are constructed.
- D. Review truss manufacturer shop drawings during the submittal review process and indicate locations and sizes of all required openings and locations of spread truss spaces needed to accommodate ductwork, equipment, louvers, etc.
- E. Sequence, coordinate, and integrate installations of mechanical materials and equipment for efficient flow of the Work. Coordinate installation of large equipment requiring positioning before closing in building.
- F. Coordinate connection of mechanical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies.

- G. Coordinate requirements for access panels and doors if mechanical items requiring access are concealed behind finished surfaces. Access panels and doors are specified in Division 08 Section "Access Doors and Frames."
- H. Coordinate installation of identifying devices after completing covering and painting if devices are applied to surfaces. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Dielectric Unions:
 - a. Capitol Manufacturing Co.
 - b. Central Plastics Co.
 - c. Eclipse, Inc.; Rockford-Eclipse Div.
 - d. Epco Sales Inc.
 - e. Hart Industries International, Inc.
 - f. Watts Industries, Inc.; Water Products Div.
 - g. Zurn Industries, Inc.; Wilkins Div.
 - 2. Dielectric Flanges:
 - a. Capitol Manufacturing Co.
 - b. Central Plastics Co.
 - c. Epco Sales Inc.
 - d. Watts Industries, Inc.; Water Products Div.
 - 3. Dielectric-Flange Insulating Kits:
 - a. Calpico, Inc.
 - b. Central Plastics Co.
 - 4. Dielectric Couplings:
 - a. Calpico, Inc.
 - b. Epco Sales, Inc.
 - c. Metraflex Co.
 - d. Lochinvar Corp.
 - 5. Dielectric Nipples:
 - a. Epco Sales, Inc.
 - b. Grinnell Corp.; Grinnell Supply Sales Co.
 - c. Perfection Corp.
 - d. Victaulic Co. of America.

6. Metal, Flexible Connectors:
 - a. ANAMET Industrial, Inc.
 - b. Central Sprink, Inc.
 - c. Flexicraft Industries.
 - d. Flex-Weld, Inc.
 - e. Grinnell Corp.; Grinnell Supply Sales Co.
 - f. Hyspan Precision Products, Inc.
 - g. McWane, Inc.; Tyler Pipe; Gustin-Bacon Div.
 - h. Metraflex Co.
 - i. Uniflex, Inc.
7. Rubber, Flexible Connectors:
 - a. General Rubber Corp.
 - b. Mercer Rubber Co.
 - c. Metraflex Co.
 - d. Proco Products, Inc.
 - e. Red Valve Co., Inc.
 - f. Uniflex, Inc.

2.2 PIPE AND PIPE FITTINGS

- A. Refer to individual Division 23 piping Sections for pipe and fitting materials and joining methods.
- B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.3 JOINING MATERIALS

- A. Refer to individual Division 15 piping Sections for special joining materials not listed below.
- B. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
 1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness, unless thickness or specific material is indicated.
 - a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
 - b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.
 2. AWWA C110, rubber, flat face, 1/8 inch thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.
- C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
- D. Solder Filler Metals: ASTM B 32.
 1. Alloy Sn95 or Alloy Sn94: Approximately 95 percent tin and 5 percent silver, with 0.10 percent lead content.

2. Alloy E: Approximately 95 percent tin and 5 percent copper, with 0.10 percent maximum lead content.
 3. Alloy HA: Tin-antimony-silver-copper zinc, with 0.10 percent maximum lead content.
 4. Alloy HB: Tin-antimony-silver-copper nickel, with 0.10 percent maximum lead content.
 5. Alloy Sb5: 95 percent tin and 5 percent antimony, with 0.20 percent maximum lead content.
- E. Brazing Filler Metals: AWS A5.8.
1. BCuP Series: Copper-phosphorus alloys.
 2. BAg1: Silver alloy.
- F. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
- G. Solvent Cements: Manufacturer's standard solvent cements for the following:
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.
- H. Plastic Pipe Seals: ASTM F 477, elastomeric gasket.
- I. Couplings: Iron-body sleeve assembly, fabricated to match OD of plain-end, pressure pipes.
1. Sleeve: ASTM A 126, Class B, gray iron.
 2. Followers: ASTM A 47 malleable iron or ASTM A 536 ductile iron.
 3. Gaskets: Rubber.
 4. Bolts and Nuts: AWWA C111.
 5. Finish: Enamel paint.

2.4 DIELECTRIC FITTINGS

- A. General: Assembly or fitting with insulating material isolating joined dissimilar metals, to prevent galvanic action and stop corrosion.
- B. Description: Combination of copper alloy and ferrous; threaded, solder, plain, and weld-neck end types and matching piping system materials.
- C. Insulating Material: Suitable for system fluid, pressure, and temperature.
- D. Revise pressure ratings and temperatures in five paragraphs below as required or add other options for specific applications.
- E. Dielectric Unions: Factory-fabricated, union assembly, for 250-psig minimum working pressure at 180 deg F.
- F. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150- or 300-psig minimum working pressure as required to suit system pressures.

- G. Dielectric-Flange Insulation Kits: Field-assembled, companion-flange assembly, full-face or ring type. Components include neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.
 - 1. Provide separate companion flanges and steel bolts and nuts for 150- or 300-psig minimum working pressure as required to suit system pressures.
- H. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225 deg F.
- I. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig minimum working pressure at 225 deg F.
- J. NSF certified when used in potable water systems.

2.5 PIPING SPECIALTIES

- A. Sleeves: The following materials are for wall, floor, slab, and roof penetrations:
 - 1. Steel Sheet Metal: 0.0239-inch minimum thickness, galvanized, round tube closed with welded longitudinal joint.
 - 2. Steel Pipe: ASTM A 53, Type E, Grade A, Schedule 40, galvanized, plain ends.
 - 3. Cast Iron: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
 - 4. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
 - a. Underdeck Clamp: Clamping ring with set screws.
- B. Escutcheons: Manufactured wall, ceiling, and floor plates; shallow type. Deep pattern style to conceal protruding fittings and sleeves must be approved in writing prior to use.
 - 1. ID: Closely fit around pipe, tube, and insulation of insulated piping.
 - 2. OD: Completely cover opening.
 - 3. Cast Brass: One piece, with set screw.
 - a. Finish: Polished chrome-plate.

2.6 GROUT

- A. Nonshrink, Nonmetallic Grout: ASTM C 1107, Grade B.
 - 1. Characteristics: Post-hardening, volume-adjusting, dry, hydraulic-cement grout, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
 - 2. Design Mix: 5000-psig, 28-day compressive strength.
 - 3. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 MECHANICAL DEMOLITION

- A. Refer to Division 01 Section "Cutting and Patching" and Division 02 Section "Selective Structure Demolition" for general demolition requirements and procedures.
- B. Disconnect, demolish, and remove mechanical 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. Ductwork to Be Removed: Remove portion of ductwork indicated to be removed and cap remaining ductwork with same or compatible material.
 - 3. Equipment to Be Removed: Disconnect and cap services and remove equipment.
 - 4. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
 - 5. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.
- 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. General: Install piping as described below, unless piping Sections specify otherwise. Individual Division 23 piping Sections specify unique piping installation requirements.
- B. General Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings. Provide expansion devices as required by jurisdictional codes. Provide all miscellaneous, minor offsets required to accommodate other building components and provide fully functional system.
- C. Install all piping systems at indicated slope or code required slope if not indicated.
- D. Install components with pressure rating equal to or greater than system operating pressure.
- E. Install piping in concealed interior and exterior locations, except in equipment rooms and service areas.
- F. Install piping free of sags and bends.
- G. Install exposed interior and exterior piping at right angles or parallel to building walls. Diagonal runs are prohibited, unless otherwise indicated.
- H. Install piping tight to slabs, beams, joists, columns, walls, and other building elements. Allow sufficient space above removable ceiling panels to allow for ceiling panel removal.

- I. Install piping to allow application of insulation plus 1-inch clearance around insulation.
- J. Locate groups of pipes parallel to each other, spaced to permit valve servicing.
- K. Install fittings for changes in direction and branch connections.
- L. Install couplings according to manufacturer's written instructions.
- M. Install pipe escutcheons for pipe penetrations of concrete and masonry walls and wall board partitions.
 - 1. Chrome-Plated: Cast brass, one piece, with set screw, and polished chrome-plated finish in exposed areas.
 - 2. Uninsulated Piping Floor Plates in Utility Areas: Cast-iron floor plates.
 - 3. Insulated Piping: Cast brass or stamped steel; with concealed hinge, spring clips, and chrome-plated finish.
 - 4. Piping in Utility Areas: Cast brass or stamped steel, with set-screw or spring clips.
- N. Sleeves are not required for core drilled holes.
- O. Install sleeves for pipes passing through concrete and masonry walls, and concrete floor and roof slabs. Isolate chilled water piping from building components at all penetrations with pipe insulation.
- P. Install sleeves for pipes passing through concrete and masonry walls, and concrete floor and roof slabs.
 - 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 if ring is specified.
 - 2. Build sleeves into new walls and slabs as work progresses.
 - 3. Install sleeves large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:
 - a. Steel Pipe Sleeves: For pipes smaller than 6-inch NPS.
 - b. Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level. Refer to Division 07 Section "Sheet Metal Flashing and Trim" for flashing.
 - 1) Seal space outside of sleeve fittings with nonshrink, nonmetallic grout.
 - 4. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using elastomeric joint sealants. Refer to Division 07 Section "Joint Sealants" for materials.
 - 5. Use Type S, Grade NS, Class 25, Use O, neutral-curing silicone sealant, unless otherwise indicated.

- Q. Aboveground, Exterior-Wall, Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Size sleeve for 1-inch annular clear space 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 in diameter and larger.
 3. Assemble and install mechanical sleeve seals according to manufacturer's written instructions. Tighten bolts that cause rubber sealing elements to expand and make watertight seal.
- R. Underground, Exterior-Wall, Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Size sleeve for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
1. Assemble and install mechanical sleeve seals according to manufacturer's written instructions. Tighten bolts that cause rubber 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 firestopping materials. Refer to Division 07 Section "Penetration Firestopping" for materials.
- T. Provide riser clamps at each floor level of all pumped piping systems.
- U. Verify final equipment locations for roughing-in.
- V. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.
- W. Piping Joint Construction: Join pipe and fittings as follows and as specifically required in individual piping specification Sections:
1. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
 2. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
 3. Soldered Joints: Construct joints according to AWS's "Soldering Manual," Chapter "The Soldering of Pipe and Tube"; or CDA's "Copper Tube Handbook."
 4. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."
 5. Welded Joints: Construct joints according to AWS D10.12, "Recommended Practices and Procedures for Welding Low Carbon Steel Pipe," using qualified processes and welding operators according to "Quality Assurance" Article.

3.3 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

- A. Install equipment to provide maximum possible headroom, if mounting heights are not indicated.
- B. Install equipment according to approved submittal data. Portions of the Work are shown only in diagrammatic form. Refer conflicts to Architect.

- C. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.
- D. Install mechanical 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. Provide the greater of code, manufacturer or drawing clearances in all cases.
- E. Install equipment giving right of way to piping installed at required slope.
- F. Install flexible connectors on equipment side of shutoff valves, horizontally and parallel to equipment shafts if possible.

3.4 PAINTING AND FINISHING

- A. Refer to Architectural Divisions for paint materials, surface preparation, and application of paint.
- B. Paint all louvers to match the exterior wall color. Coordinate color with Architect.

3.5 CONCRETE BASES

- A. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit. Follow supported equipment manufacturer's setting templates for anchor bolt and tie locations. Use 3000-psi, 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-Place Concrete."

3.6 ERECTION OF METAL SUPPORTS AND ANCHORAGE

- A. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor mechanical materials and equipment.
- B. Field Welding: Comply with AWS D1.1, "Structural Welding Code--Steel."
- C. For design requirements refer to section 230548.

3.7 CUTTING AND PATCHING

- A. Cut, channel, chase, and drill floors, walls, partitions, ceilings, and other surfaces necessary for mechanical installations. Perform cutting by skilled mechanics of trades involved.
- B. Repair cut surfaces to match adjacent surfaces. All repairs shall be performed by individuals skilled in their particular trade.

3.8 GROUTING

- A. Install nonmetallic, nonshrink, grout for mechanical equipment base bearing surfaces, pump and other equipment base plates, and anchors. Mix grout according to manufacturer's written instructions.
- B. Clean surfaces that will come into contact with grout.
- C. Provide forms as required for placement of grout.
- D. Avoid air entrapment during placing of grout.
- E. Place grout, completely filling equipment bases.
- F. Place grout on concrete bases to provide smooth bearing surface for equipment.
- G. Place grout around anchors.
- H. Cure placed grout according to manufacturer's written instructions.

3.9 ELECTRICAL/MECHANICAL COORDINATION

- A. Furnish electrical services to Division 23 equipment as outlined below.
- B. Unless otherwise indicated, all mechanical equipment, motors and controls shall be furnished, set in place, and wired by the Division 23 Contractor. Contractor should note that the intent of this wiring schedule is to have the Division 23 Contractor responsible for coordinating all control wiring as outlined, whether or not specifically called for by the mechanical or electrical drawings and specifications. Comply with the applicable requirements of Division 23 for electrical work of this Division 26 which is not otherwise specified. No extras will be allowed for Contractor's failure to provide for these required items. The Division 26 Contractor shall refer to the Division 23 specifications and plans for all power wiring and shall advise the Architect/Engineer of any discrepancies prior to bidding.

Item	Furnished By	Set By	Power Wiring	Control Wiring
Equipment Motors	MC	MC	EC	---
Motor Starters and Overload Heaters (See Note 1)	MC	EC	EC	MC
Fused & Unfused Disconnect Switches, Thermal Overload Heaters (See Note 5)	EC	EC	EC	---
Manual Operating & Speed Switches (carrying load currents) (See Note 3 & 4)	MC	MC	MC	MC
Control Relays & Transformer (See Note 2)	MC	MC	MC	MC

Item	Furnished By	Set By	Power Wiring	Control Wiring
Thermostats (Line Voltage)	MC	MC	EC	MC
Aquastats	MC	MC	MC	MC
Temperature Control Panels	MC	MC	MC	MC
Building Fire Alarm System Fire & Smoke Detectors, including Relays for Fan Shutdown	EC	EC	EC	EC
Motor & Solenoid Valves, Damper Motors, Control Valves, Fan Interlocking Wiring, Low Voltage Thermostats	MC	MC	MC	MC
Duct Detection (Note 6)	MC	MC	---	EC
Pilot Lights (Manually operated Switches not carrying Load Currents) (See Note 3)	MC	MC	---	MC
Boiler Controls Including Gas Train	MC	MC	MC	MC
Fire Sprinkler System Alarms, Tamper Switches, Flow Switches and Fire Alarm Systems Tie-ins to provide a complete Fire Protection System	FPC	FPC	---	EC
Temporary Heating Connections	MC	MC	EC	MC
HVAC Water Treatment Interlocks	MC	MC	EC	MC
Combination Fire / Smoke Dampers	MC	MC	EC	EC

MC = Mechanical Contractor Under Division 23 of the Work

EC = Electrical Contractor Under Division 26 of the Work

FPC = Fire Protection Contractor Under Division 21 of the Work

Notes for the Electrical/Mechanical Coordination Schedule.

1. All starters, other than those noted on the Electrical Drawings shall be furnished under Division 23. All starters furnished under Division 23 shall be complete with three over-load heaters and shall conform to NEC and NEMA requirements. All starters shall have 65,000 AIC rating.
2. Control relays and control transformers shall be furnished under Division 23 except

where furnishing such items are specifically required under Division 26 specifications and/or drawings.

3. Speed controller provided and installed under Division 23 of the work.
 4. Exhaust Fans: The Electrical Contractor under Division 26 of the work shall furnish and install circuits, feeders and disconnect switches (where specified), and make all connections to motors and controls unless interlocked with other mechanical equipment or exhaust fans in locations indicated. Where exhaust fans are switched with lights, a two-pole toggle switch will be provided under Division 26. Where exhaust fans controlled by thermostat or interlocked with other mechanical equipment, the interlock wiring will be furnished by the Mechanical Contractor under Division 23.
 5. Some equipment will be furnished with integral disconnecting means. Refer to the Mechanical Equipment Schedule on the drawings for additional information.
 6. Some equipment to be provided with factory installed smoke detectors. Electrical contractor provides control wiring to fire alarm panel and from fire alarm panel to mechanical unit. Refer to the Mechanical Equipment Schedule on the drawings for additional information.
 7. Electrical contractor shall provide disconnects for all starters and variable frequency drives. Electrical contractor shall provide disconnects at the equipment if it is not in line of sight of starter disconnect.
- C. All temperature control conduit and wiring shall be furnished and installed under Division 23. All motorized damper equipment shall be furnished and installed under Division 23 and 120 volt power wired under Division 23.
1. Control wiring includes all low voltage and 120 volt wiring.

END OF SECTION 230500

SECTION 230513 – COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes basic requirements for factory-installed and field-installed motors.

1.3 DEFINITIONS

- A. Factory-Installed Motor: A motor installed by motorized-equipment manufacturer as a component of equipment.

1.4 SUBMITTALS

- A. Product Data for Motors and Controllers: For each type and size of motor, provide nameplate data and ratings; shipping, installed, and operating weights; mounting arrangements; size, type, and location of winding terminations; conduit entry and ground lug locations; and information on coatings or finishes.
- B. Qualification Data: For testing agency.
- C. Test Reports: Written reports specified in Parts 2 and 3.
- D. 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. UL listing for series rating of overcurrent protective devices in combination controllers.
 - e. 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.

- E. Maintenance Data: For enclosed controllers and components to include in maintenance manuals specified in Division 01. In addition to requirements specified in Division 01 Section "Closeout Procedures," include the following:

- 1. Routine maintenance requirements for enclosed controllers and all installed components.

1.5 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An independent testing agency, acceptable to authorities having jurisdiction, with the experience and capability to conduct the testing indicated, as documented according to ASTM E 548.
- B. Source Limitations: Obtain field-installed motors of a single type through one source from a single manufacturer.
- C. 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.
- D. Comply with NFPA 70.

1.6 PROJECT CONDITIONS

- A. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:
 - 1. Notify Architect at least two days in advance of proposed utility interruptions. Identify extent and duration of utility interruptions.
 - 2. Indicate method of providing temporary utilities.
 - 3. Do not proceed with utility interruptions without Architect's written permission.

1.7 COORDINATION

- A. Coordinate features of motors, installed units, and accessory devices. Provide motors that are:
 - 1. Compatible with the following:
 - a. Magnetic controllers.
 - 2. Matched to torque and horsepower requirements of the load.
 - 3. Matched to ratings and characteristics of supply circuit and required control sequence.
- B. 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.

- C. 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.
- 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.

1.8 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.

1.9 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Spare Fuses: Not less than one set of three of each type and rating.
 - 2. Indicating Lights: Two of each type installed.

PART 2 - PRODUCTS

2.1 MOTOR REQUIREMENTS

- A. Motor requirements apply to factory-installed motors except as follows:
 - 1. Different ratings, performance, or characteristics for a motor are specified in another Section.
 - 2. Manufacturer for a factory-installed motor requires ratings, performance, or characteristics, other than those specified in this Section, to meet performance specified.

2.2 MOTOR CHARACTERISTICS

- A. Motors 3/4 HP and Larger: Three phase. (Unless otherwise noted)
- B. Motors Smaller Than 3/4 HP: Single phase. (Unless otherwise noted)

- C. Frequency Rating: 60 Hz.
- D. Voltage Rating: NEMA standard voltage selected to operate on nominal circuit voltage to which motor is connected.
- E. Service Factor: 1.15 for open dripproof motors; 1.0 for totally enclosed motors.
- F. Duty: Continuous duty at ambient temperature of 105 deg F and at altitude of 3300 feet above sea level.
- G. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.
- H. Enclosure: Open dripproof.
- I. Starters: Provide starters of appropriate duty and rating classification for all motors. Combination starters/disconnects shall be provided for all equipment where disconnect and starter are mounted in an interior, accessible location. Starters for equipment with exterior disconnects shall be separate from the disconnect and located inside the facility.

2.3 POLYPHASE MOTORS

- A. Description: NEMA MG 1, Design B, medium induction motor.
- B. Efficiency: Premium efficiency, meeting current ASHRAE energy conservation standards.
- C. Stator: Copper windings, unless otherwise indicated.
 - 1. Multispeed motors shall have separate winding for each speed.
- D. Rotor: Squirrel cage, unless otherwise indicated.
- E. Bearings: Double-shielded, prelubricated ball bearings suitable for radial and thrust loading.
- F. Temperature Rise: Match insulation rating, unless otherwise indicated.
- G. Insulation: Class F, unless otherwise indicated.
- H. Code Letter Designation:
 - 1. Motors 15 HP and Larger: NEMA starting Code F or G.
 - 2. Motors Smaller Than 15 HP: Manufacturer's standard starting characteristic.
- I. Enclosure: Cast iron for motors 7.5 hp and larger; rolled steel for motors smaller than 7.5 hp.
 - 1. Finish: Manufacturer's standard painted finish.

2.4 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

- A. 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.
- B. Rugged-Duty Motors: Totally enclosed, with 1.25 minimum service factor, greased bearings, integral condensate drains, and capped relief vents. Windings insulated with nonhygroscopic material.
 - 1. Finish: Chemical-resistant paint over corrosion-resistant primer.
- C. 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.

2.5 SINGLE-PHASE MOTORS

- A. Type: One of the following, to suit starting torque and requirements of specific motor application:
 - 1. Permanent-split capacitor.
 - 2. Split-phase start, capacitor run.
 - 3. Capacitor start, capacitor run.
- B. Shaded-Pole Motors: For motors 1/20 hp and smaller only.
- C. Efficiency: Efficiency meeting current ASHRAE energy conservation standards.
- D. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.
- E. Bearings: Ball type for belt-connected motors and other motors with high radial forces on motor shaft; sealed, prelubricated-sleeve type for other single-phase motors.
- F. 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.

2.6 ACCEPTABLE MANUFACTURER: (MOTORS)

- A. Except where item of mechanical equipment (which otherwise complies with requirements) must be integrally equipped with motor produced by another manufacturer, provide motors for mechanical equipment manufactured by one of the following:

1. Baldor Electric Co.
2. Eaton Crop.
3. General Electric Co.
4. Lincoln Electric Co.
5. Magne Tek
6. Marathon Electric Mfg. Corp.
7. Reliance Electric Co.
8. Westinghouse Electric Corp.

2.7 ACCEPTABLE MANUFACTURERS: (STARTERS)

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Manual and Magnetic Enclosed Controllers:
 - a. General Electrical Distribution & Control.
 - b. Siemens/Furnas Controls.
 - c. Square D Co.

2.8 MAGNETIC ENCLOSED CONTROLLERS (STARTERS)

- A. Description: NEMA ICS 2, Class A, full voltage, nonreversing, across the line, unless otherwise indicated.
- B. All starters for polyphase motors (3 HP and larger) shall be provided with phase protection, to protect against loss of phase and phase reversal.
- C. Control Circuit: 120 V; obtained from equipment control system with a control power source or transformer of sufficient capacity to operate connected pilot, indicating and control devices, plus 100 percent spare capacity.
- D. Combination Controller: Factory-assembled combination controller and disconnect switch.
 1. Fusible Disconnecting Means: NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 947-4-1, as certified by a nationally recognized testing laboratory.
 2. Nonfusible Disconnecting Means: NEMA KS 1, heavy-duty, nonfusible switch.
- E. Adjustable Overload Relay: Dip switch selectable for motor running overload protection with NEMA ICS 2, Class 20 tripping characteristic, and selected to protect motor against voltage and current unbalance and single phasing. Provide relay with Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.
- F. Multispeed Enclosed Controller: Match controller to motor type, application, and number of speeds; include the following accessories:
 1. Compelling relay to ensure motor will start only at low speed.

2. Accelerating relay to ensure properly timed acceleration through speeds lower than that selected.
 3. Decelerating relay to ensure automatically timed deceleration through each speed.
- G. Solid-State, Reduced-Voltage Controller: NEMA ICS 2, suitable for use with NEMA MG 1, Design B, polyphase, medium induction motors.
1. Adjustable acceleration rate control utilizing voltage or current ramp, and adjustable starting torque control with up to 500 percent current limitation for 20 seconds.
 2. Surge suppressor in solid-state power circuits providing 3-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage.
 3. LED indicators showing motor and control status, including the following conditions:
 - a. Control power available.
 - b. Controller on.
 - c. Overload trip.
 - d. Loss of phase.
 - e. Shorted silicon-controlled rectifier.
 4. Automatic voltage-reduction controls to reduce voltage when motor is running at light load.
 5. Motor running contactor operating automatically when full voltage is applied to motor.

2.9 ENCLOSURES

- A. Description: 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.

2.10 ACCESSORIES

- A. Devices shall be factory installed in controller enclosure, unless otherwise indicated.
- B. Push-Button Stations, Pilot Lights, and Selector Switches: NEMA ICS 2, heavy-duty type.
- C. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.
- D. Control Relays: Auxiliary and adjustable time-delay relays.
- E. Elapsed Time Meters: Heavy duty with digital readout in hours.

2.11 VARIABLE FREQUENCY CONTROLLERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. ABB
 - 2. Danfoss.
- B. Description: NEMA ICS 2, IGBT, PWM, VFC; listed and labeled as a complete unit and arranged to provide variable speed of an NEMA MG 1, Design B, 3-phase induction motor by adjusting output voltage and frequency.
 - 1. Provide unit suitable for operation of standard-efficiency motor as defined by NEMA MG 1.
 - 2. Provide a filter on the incoming power to each variable frequency controller matched to the controller style and operating characteristics to prevent passage of any harmonics through any building electrical systems.
- C. Design and Rating: Match load type to fans and type of connection used between motor and load such as direct or through a power-transmission connection.
- D. Output Rating: 3-phase; 0 to 150 Hz.
- E. Unit Operating Requirements:
 - 1. Input ac voltage tolerance of 208 V, plus or minus 10 percent and 380 to 480 V, plus or minus 10 percent.
 - 2. Input frequency tolerance of 47 Hz to 63 Hz.
 - 3. Minimum Efficiency: 96 percent at 60 Hz, full load.
 - 4. Minimum Displacement Primary-Side Power Factor: 98 percent.
 - 5. Overload Capability: 1.0 times the base load current for 60 seconds; 1.5 times the base load current for 3 seconds.
 - 6. Starting Torque: 100 percent of rated torque or as indicated.
 - 7. Speed Regulation: Plus or minus 1 percent.
- F. Isolated control interface to allow controller to follow control signal over an 11:1 speed range.
 - 1. Electrical Signal: 4 to 20 mA at 24 V.
- G. Internal Adjustability Capabilities:
 - 1. Minimum Speed: 3 percent of maximum rpm.
 - 2. Maximum Speed: 150 percent of maximum rpm.
 - 3. Acceleration: 2 to a minimum of 22 seconds.
 - 4. Deceleration: 2 to a minimum of 22 seconds.
 - 5. Current Limit: 50 to a minimum of 110 percent of maximum rating.
- H. Self-Protection and Reliability Features:
 - 1. Input transient protection by means of surge suppressors.
 - 2. Under- and overvoltage trips; inverter overtemperature, overload, and overcurrent trips.
 - 3. Motor Overload Relay: Adjustable and capable of NEMA 250 performance.

4. Notch filter to prevent operation of the controller-motor-load combination at a natural frequency of the combination.
 5. Instantaneous line-to-line and line-to-ground overcurrent trips.
 6. Loss-of-phase protection.
 7. Reverse-phase protection.
 8. Short-circuit protection.
 9. Motor overtemperature fault.
- I. Automatic Reset/Restart: Attempts three restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction. Bidirectional autospeed search shall be capable of starting into rotating loads spinning in either direction and returning motor to set speed in proper direction, without damage to controller, motor, or load.
- J. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped.
- K. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.
- L. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.
- M. Status Lights: Door-mounted LED indicators shall indicate the following conditions:
1. Power on.
 2. Run.
 3. Overvoltage.
 4. Line fault.
 5. Overcurrent.
 6. External fault.
- N. Panel-Mounted Operator Station: Start-stop and auto-manual selector switches with manual speed control potentiometer.
- O. Indicating Devices: Meters or digital readout devices and selector switch, mounted flush in controller door and connected to indicate the following controller parameters:
1. Output frequency (Hz).
 2. Motor speed (rpm).
 3. Motor status (running, stop, fault).
 4. Motor current (amperes).
 5. Motor torque (percent).
 6. Fault or alarming status (code).
 7. PID feedback signal (percent).
 8. DC-link voltage (VDC).
 9. Set-point frequency (Hz).
 10. Motor output voltage (V).
- P. Control Signal Interface:

1. Electric Input Signal Interface: A minimum of 2 analog inputs (0 to 10 V or 0/4-20 mA) and 6 programmable digital inputs.
 2. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the BAS or other control systems:
 - a. 0 to 10-V dc.
 - b. 0-20 or 4-20 mA.
 - c. Potentiometer using up/down digital inputs.
 - d. Fixed frequencies using digital inputs.
 - e. RS485.
 - f. Keypad display for local hand operation.
 3. Output Signal Interface:
 - a. A minimum of 1 analog output signal (0/4-20 mA), which can be programmed to any of the following:
 - 1) Output frequency (Hz).
 - 2) Output current (load).
 - 3) DC-link voltage (VDC).
 - 4) Motor torque (percent).
 - 5) Motor speed (rpm).
 - 6) Set-point frequency (Hz).
 4. Remote Indication Interface: A minimum of 2 dry circuit relay outputs (120-V ac, 1 A) for remote indication of the following:
 - a. Motor running.
 - b. Set-point speed reached.
 - c. Fault and warning indication (overtemperature or overcurrent).
 - d. PID high- or low-speed limits reached.
- Q. Communications: Provide an RS485 interface allowing VFC to be used with an external system within a multidrop LAN configuration. Interface shall allow all parameter settings of VFC to be programmed via BAS control. Provide capability for VFC to retain these settings within the nonvolatile memory.
- R. Manual Bypass: Magnetic contactor arranged to safely transfer motor between controller output and bypass controller circuit when motor is at zero speed. Controller-off-bypass selector switch sets mode, and indicator lights give indication of mode selected. Unit shall be capable of stable operation (starting, stopping, and running), with motor completely disconnected from controller (no load).
- S. Integral Disconnecting Means: NEMA AB 1, instantaneous-trip circuit breaker with lockable handle.
- T. All starters shall be soft start.
- U. Isolating Switch: Non-load-break switch arranged to isolate VFC and permit safe troubleshooting and testing, both energized and de-energized, while motor is operating in bypass mode.

- V. NEMA 250, Type 1 enclosure.
- W. Historical Logging Information and Displays:
 - 1. Real-time clock with current time and date.
 - 2. Running log of total power versus time.
 - 3. Total run time.
 - 4. Fault log, maintaining last four faults with time and date stamp for each.
- X. Current-Sensing, Phase-Failure Relays for Bypass Controller: Solid-state sensing circuit with isolated output contacts for hard-wired connection; arranged to operate on phase failure, phase reversal, current unbalance of from 30 to 40 percent, or loss of supply voltage; with adjustable response delay.
- Y. Provide factory start-up and perform all tests stated in NETA ATS.
- Z. All variable frequency controllers shall be located within the building and not at or within equipment which is outside the building thermal envelope.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas to receive field-installed motors for compliance with requirements, installation tolerances, and other conditions affecting performance.
- B. Examine roughing-in of conduit systems to verify actual locations of conduit connections before motor installation.
- C. 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.
- B. Select horsepower rating of controllers to suit motor controlled.

3.3 MOTOR INSTALLATION

- A. Anchor each motor assembly to base, adjustable rails, or other support, arranged and sized according to manufacturer's written instructions. Attach by bolting. Level and align with load transfer link.
- B. Comply with mounting and anchoring requirements specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

3.4 CONTROLLER INSTALLATION

- A. See Division 26 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.
- C. Enclosed Controller Fuses: Install fuses in each fusible switch. Comply with requirements in Division 26.

3.5 CONTROL WIRING INSTALLATION

- A. Install wiring between enclosed controllers according to Division 26 Section "Low-Voltage Electrical Power 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 FIELD QUALITY CONTROL

- A. Prepare for acceptance tests as follows:
 - 1. Run each motor with its controller. Demonstrate correct rotation, alignment, and speed at motor design load.
 - 2. Test interlocks and control features for proper operation.
 - 3. Verify that current in each phase is within nameplate rating.
 - 4. Test insulation resistance for each enclosed controller bus.
- B. Testing: Perform the following field quality-control testing:
 - 1. Perform each electrical test and visual and mechanical inspection stated in NETA ATS, Section 7.15.1. 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.
- C. Manufacturer's Field Service: (Controllers) Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including pretesting and adjusting solid-state controllers.
 - 1. Test Reports: Prepare a written report to record the following:
 - a. Test procedures used.

- b. Test results that comply with requirements.
- c. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

3.7 ADJUSTING

- A. Align motors, bases, shafts, pulleys and belts. Tension belts according to manufacturer's written instructions.

3.8 CLEANING

- A. After completing equipment installation, inspect unit components. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.
- B. Clean motors, on completion of installation, according to manufacturer's written instructions.

3.9 STARTUP SERVICE

- A. Verify that enclosed controllers are installed and connected according to the Contract Documents.
- B. Complete installation and startup checks according to manufacturer's written instructions.

3.10 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain enclosed controllers.
 - 1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment and schedules.
 - 2. Review data in maintenance manuals. Refer to Division 01 Section "Operation and Maintenance Data."
 - 3. Schedule training with Owner, through Architect, with at least seven days of advance notice.

END OF SECTION 230513

SECTION 230516 - EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. The installing contractor for all piping systems shall be responsible to design, furnish and install expansion compensating devices, guides and anchors as required to maintain flexibility in piping systems in order to prevent undue stresses on piping and building structure.
- B. This Section includes pipe expansion fittings and loops for mechanical piping systems, and the following:
 - 1. Metal-bellows expansion joints.
 - 2. Expansion compensators.
 - 3. Rubber expansion joints.
 - 4. Flexible-hose expansion joints.
 - 5. Slip expansion joints.
 - 6. Flexible ball joints.
 - 7. Pipe bends and loops.
 - 8. Guides and anchors.

1.3 PERFORMANCE REQUIREMENTS

- A. Compatibility: Products suitable for piping system fluids, materials, working pressures, and temperatures.
- B. Capability: Absorb 200 percent of maximum piping expansion between anchors.

1.4 SUBMITTALS

- A. Product Data: For each type of expansion fitting indicated.
- B. Shop Drawings: Signed and sealed by a qualified professional engineer.
 - 1. Design Calculations: For thermal expansion of piping systems and selection and design of expansion fittings and loops.
 - 2. Anchor Details: Detail fabrication of each indicated. Show dimensions and methods of assembly.
 - 3. Alignment Guide Details: Detail field assembly and anchorage.

- C. Welding Certificates: Copies of certificates for welding procedures and personnel.
- D. Schedule: Indicate manufacturer's number, size, location, and features for each expansion fitting and loop.

1.5 QUALITY ASSURANCE

- A. Engineering Responsibility: Design and preparation of Shop Drawings and calculations for expansion fittings and loops by a qualified professional engineer.
 - 1. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in jurisdiction where Project is located and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for installations of expansion fittings and loops that are similar to those indicated for this Project in material, design, and extent.
- B. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Metal-Bellows Expansion Joints:
 - a. Adsko Manufacturing Corp.
 - b. Anamet, Inc.
 - c. Badger Industries, Inc.
 - d. Expansion Joint Systems, Inc.
 - e. Flexicraft Industries.
 - f. Flex-Weld, Inc.
 - g. Hyspan Precision Products, Inc.
 - h. Metraflex Co.
 - i. Pathway Bellows, Inc.
 - j. Piping Technology & Products, Inc.
 - k. Proco Products, Inc.
 - l. Senior Flexonics, Inc.; Expansion Joint Div.
 - m. Wahlco Engineered Products, Inc.
 - 2. Expansion Compensators:
 - a. Adsko Manufacturing Corp.
 - b. Flexicraft Industries.
 - c. Flex-Weld, Inc.
 - d. Hyspan Precision Products, Inc.

- e. Metraflex Co.
 - f. Senior Flexonics, Inc.; Expansion Joint Div.
- 3. Rubber Expansion Joints:
 - a. Flexicraft Industries.
 - b. Flex-Weld, Inc.
 - c. Garlock, Inc.
 - d. General Rubber Corp.
 - e. Mercer Rubber Co.
 - f. Metraflex Co.
 - g. MG Piping Products Co.
 - h. Proco Products, Inc.
 - i. Senior Flexonics, Inc.; Expansion Joint Div.
 - j. Vibration Mountings & Controls, Inc.
- 4. Flexible-Hose Expansion Joints:
 - a. Flexicraft Industries.
 - b. Metraflex Co.
- 5. Slip Expansion Joints:
 - a. Adscos Manufacturing Corp.
 - b. Advanced Thermal Systems, Inc.
 - c. Hyspan Precision Products, Inc.
- 6. Flexible Ball Joints:
 - a. Advanced Thermal Systems, Inc.
 - b. Hyspan Precision Products, Inc.
- 7. Guides:
 - a. Adscos Manufacturing Corp.
 - b. Advanced Thermal Systems, Inc.
 - c. B-Line Systems, Inc.
 - d. Flex-Weld, Inc.
 - e. Grinnell Corp.
 - f. Hyspan Precision Products, Inc.
 - g. Metraflex Co.

2.2 PACKLESS EXPANSION JOINTS

- A. Metal-Bellows Expansion Joints: 175-psig minimum pressure rating, with end fittings and external tie rods for limiting maximum travel, and flanged-end connections, unless otherwise indicated.
 - 1. Configuration: Single- and double-bellows type, with base, unless otherwise indicated.
 - 2. Joints for Copper Piping: Two-ply, phosphor-bronze bellows and brass shrouds.

3. Joints for Steel Piping: Two-ply, stainless-steel bellows and carbon-steel shroud.
- B. Expansion Compensators: 175-psig minimum pressure rating, with internal guides, antitorque device, and removable end clip for positioning.
1. End Connections for NPS 2 and Smaller: Threaded.
 2. End Connections for NPS 2-1/2 and Larger: Flanged.
 3. Joints for Copper Piping: Two-ply, phosphor-bronze bellows and brass shroud.
 4. Joints for Steel Piping: Two-ply, stainless-steel bellows and carbon-steel shroud.
- C. Rubber Expansion Joints: ASTM F 1123, fabric-reinforced butyl rubber, and pressure rated for 175 psig at 240 deg F minimum.
1. Configuration: Full-faced, integral, steel-flanged-end connections; external control rods; and steel retaining rings drilled to match flange bolt holes.
 2. Type: Double sphere.
- D. Flexible-Hose Expansion Joints: Manufactured assembly with two flexible-metal-hose legs joined by long-radius 180-degree return bend with inlet and outlet elbow fittings, corrugated-metal inner hoses, and braided outer sheaths.
1. Joints for Copper Piping: Copper fittings with solder-joint end connections.
 - a. NPS 2 and Smaller: Bronze hoses and single-braid bronze sheaths with 450 psig at 70 deg F and 340 psig at 450 deg F minimum pressure ratings.
 - b. NPS 2-1/2 to NPS 4: Stainless-steel hoses and single-braid, stainless-steel sheaths with 300 psig at 70 deg F and 225 psig at 450 deg F minimum pressure ratings.
 2. Joints for Steel Piping: Carbon-steel fittings.
 - a. End Connections for NPS 2 and Smaller: Threaded.
 - b. End Connections for NPS 2-1/2 and Larger: Flanged.
 - c. Joints for NPS 2 and Smaller: Stainless-steel hoses and single-braid, stainless-steel sheaths with 450 psig at 70 deg F and 325 psig at 600 deg F minimum pressure ratings.
 - d. Joints for NPS 2-1/2 to NPS 6: Stainless-steel hoses and single-braid, stainless-steel sheaths with 200 psig at 70 deg F and 145 psig at 600 deg F minimum pressure ratings.
 - e. Joints for NPS 8 to NPS 12: Stainless-steel hoses and single-braid, stainless-steel sheaths with 125 psig at 70 deg F and 90 psig at 600 deg F minimum pressure ratings.

2.3 GUIDES

- A. Steel, factory fabricated, with bolted two-section outer cylinder and base for alignment of piping and two-section guiding spider for bolting to pipe.

2.4 MISCELLANEOUS MATERIALS

- A. Structural Steel: ASTM A 36/A 36M.
- B. Bolts and Nuts: ASME B18.10 or ASTM A 183, steel, hex head.
- C. Washers: ASTM F 844, steel, plain, flat washers.
- D. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened portland cement concrete, and tension and shear capacities appropriate for application.
 - 1. Stud: Threaded, zinc-coated carbon steel.
 - 2. Expansion Plug: Zinc-coated steel.
 - 3. Washer and Nut: Zinc-coated steel.
- E. Chemical Fasteners: Insert-type-stud bonding system anchor for use with hardened portland cement concrete, and tension and shear capacities appropriate for application.
 - 1. Bonding Material: ASTM C 881, Type IV, Grade 3, two-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.
 - 2. Stud: ASTM A 307, zinc-coated carbon steel with continuous thread on stud, unless otherwise indicated.
 - 3. Washer and Nut: Zinc-coated steel.
- F. Concrete: Portland cement mix, 3000 psi minimum. Refer to Division 3 Section "Cast-in-Place Concrete" for formwork, reinforcement, and concrete.
- G. Grout: ASTM C 1107, Grade B, factory-mixed and -packaged nonshrink and nonmetallic grout; suitable for interior and exterior applications.
 - 1. Characteristics: Post-hardening, volume-adjusting, dry, hydraulic-cement grout.
 - 2. Properties: Nonstaining, noncorrosive, and nongaseous.
 - 3. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION

- A. Expansion fittings, loops, anchors and guides shall be provided throughout the entire heat pump water loop to facilitate expansion and contraction. Shop drawings shall be provided indicating location, size and specification as required by pipe manufacturer.

3.2 EXPANSION FITTING INSTALLATION

- A. Install expansion fittings according to manufacturer's written instructions.
- B. Install expansion fittings in sizes matching pipe size in which they are installed.
- C. Align expansion fittings to avoid end-loading and torsional stress.

3.3 PIPE BEND AND LOOP INSTALLATION

- A. Install pipe bends and loops cold-sprung in tension or compression as required to partly absorb tension or compression produced during anticipated change in temperature.
- B. Attach pipe bends and loops to anchors.
 - 1. Steel Anchors: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
 - 2. Concrete Anchors: Attach by fasteners. Follow fastener manufacturer's written instructions.

3.4 SWING CONNECTIONS

- A. Connect risers and branch connections to mains with at least five pipe fittings, including tee in main.
- B. Connect risers and branch connections to terminal units with at least four pipe fittings, including tee in riser.

3.5 GUIDE INSTALLATION

- A. Install guides on piping adjoining expansion fittings and loops.
- B. Attach guides to pipe and secure to building structure.

3.6 ANCHOR INSTALLATION

- A. 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.
- B. Fabricate and install steel anchors by welding steel shapes, plates, and bars to piping and to structure. Comply with ASME B31.9 and AWS D1.1.
- C. Construct concrete anchors of poured-in-place concrete of dimensions indicated and include embedded fasteners.
- D. Install pipe anchors according to expansion fitting manufacturer's written instructions if expansion fittings are indicated.
- E. Use grout to form flat bearing surfaces for expansion fittings, guides, and anchors installed on or in concrete.

3.7 PAINTING

- A. Touching Up: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Division 09 Section "Painting."

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

END OF SECTION 230516

SECTION 230519 - METERS AND GAGES FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes meters and gages for mechanical systems.

1.3 SUBMITTALS

- A. Product Data: Include scale range, ratings, and calibrated performance curves for each meter, gage, fitting, specialty, and accessory specified.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Liquid-in-Glass Thermometers:
 - a. Dresser Industries, Inc.; Instrument Div.; Weksler Instruments Operating Unit.
 - b. Ernst Gage Co.
 - c. Marsh Bellofram.
 - d. Palmer Instruments, Inc.
 - e. Trerice: H. O. Trerice Co.
 - f. Weiss Instruments, Inc.
 - g. Winter's Thermogauges, Inc.
 - 2. Direct-Mounting, Filled-System Dial Thermometers:
 - a. Dresser Industries, Inc.; Instrument Div.; Ashcroft Commercial Sales Operation.
 - b. Dresser Industries, Inc.; Instrument Div.; Weksler Instruments Operating Unit.
 - c. Marsh Bellofram.
 - d. Trerice: H. O. Trerice Co.
 - e. Weiss Instruments, Inc.
 - 3. Test Plugs:

- a. Flow Design, Inc.
- b. MG Piping Products Co.
- c. National Meter.
- d. Sisco Manufacturing Co.
- e. Trerice: H. O. Trerice Co.
- f. Watts Industries, Inc.; Water Products Div.

2.2 THERMOMETERS, GENERAL

- A. Scale Range: Temperature ranges for services listed are as follows:
 - 1. Hot Water: 30 to 300 deg F, with 2-degree scale divisions.
- B. Accuracy: Plus or minus 1 percent of range span or plus or minus one scale division to maximum of 1.5 percent of range span.

2.3 LIQUID-IN-GLASS THERMOMETERS

- A. Description: ASTM E 1.
- B. Case: Die cast and aluminum finished in baked-epoxy enamel, glass front, spring secured, 9 inches long.
- C. Adjustable Joint: Finish to match case, 180-degree adjustment in vertical plane, 360-degree adjustment in horizontal plane, with locking device.
- D. Tube: Red or blue reading, organic-liquid filled with magnifying lens.
- E. Tube: Red or blue reading, mercury filled with magnifying lens.
- F. Scale: Satin-faced nonreflective aluminum with permanently etched markings.
- G. Stem: Copper-plated steel, aluminum, or brass for separable socket; of length to suit installation.

2.4 DIRECT-MOUNTING, FILLED-SYSTEM DIAL THERMOMETERS

- A. Description: Vapor-actuated, universal-angle dial type.
- B. Case: Drawn steel or cast aluminum, with 4-1/2-inch- diameter, glass lens.
- C. Adjustable Joint: Finish to match case, 180-degree adjustment in vertical plane, 360-degree adjustment in horizontal plane, with locking device.
- D. Thermal Bulb: Copper with phosphor-bronze bourdon pressure tube.
- E. Movement: Brass, precision geared.
- F. Scale: Progressive, satin-faced nonreflective aluminum with permanently etched markings.

- G. Stem: Copper-plated steel, aluminum, or brass for separable socket; of length to suit installation.

2.5 SEPARABLE SOCKETS

- A. Description: Fitting with protective socket for installation in threaded pipe fitting to hold fixed thermometer stem.
 - 1. Material: Brass, for use in copper piping.
 - 2. Material: Steel, for use in steel piping.
 - 3. Extension-Neck Length: Nominal thickness of 2 inches, but not less than thickness of insulation. Omit extension neck for sockets for piping not insulated.
 - 4. Insertion Length: To extend to center of pipe.
 - 5. Cap: Threaded, with chain permanently fastened to socket.
 - 6. Heat-Transfer Fluid: Oil or graphite.

2.6 THERMOMETER WELLS

- A. Description: Fitting with protective well for installation in threaded pipe fitting to hold test thermometer.
 - 1. Material: Brass, for use in copper piping.
 - 2. Material: Steel, for use in steel piping.
 - 3. Extension-Neck Length: Nominal thickness of 2 inches, but not less than thickness of insulation. Omit extension neck for wells for piping not insulated.
 - 4. Insertion Length: To extend to center of pipe.
 - 5. Cap: Threaded, with chain permanently fastened to socket.
 - 6. Heat-Transfer Fluid: Oil or graphite.

2.7 DUCT THERMOMETER SUPPORT FLANGES

- A. Description: Flanged-fitting bracket for mounting in hole of duct, with threaded end for attaching thermometer.
 - 1. Extension-Neck Length: Nominal thickness of 2 inches, but not less than thickness of exterior insulation.
 - 2. Insertion-Neck Length: Nominal thickness of 2 inches, but not less than thickness of insulation lining.

2.8 TEST PLUGS AND PORTS

- A. Description: Nickel-plated, brass-body test plug in NPS 1/2 fitting.
- B. Body: Length as required to extend beyond insulation.
- C. Pressure Rating: 500 psig minimum.

- D. Core Insert: Self-sealing valve, suitable for inserting 1/8-inch OD probe from dial-type thermometer or pressure gage.
- E. Core Material for Air, Water, Oil, and Gas: 20 to 200 deg F, chlorosulfonated polyethylene synthetic rubber.
- F. Core Material for Air and Water: Minus 30 to plus 275 deg F, ethylene-propylene-diene terpolymer rubber.
- G. Test-Plug Cap: Gasketed and threaded cap, with retention chain or strap.
- H. Test Kit: Pressure gage and adapter with probe, two bimetal dial thermometers, and carrying case.
 - 1. Pressure Gage and Thermometer Ranges: Approximately two times the system's operating conditions.

PART 3 - EXECUTION

3.1 GAGE INSTALLATION, GENERAL

- A. Install gages, and accessories according to manufacturer's written instructions for applications where used.

3.2 THERMOMETER INSTALLATION

- A. Install thermometers and adjust vertical and tilted positions.
- B. Install thermometers in the following locations:
 - 1. As indicated on drawings
- C. Install separable sockets in vertical position in piping tees where fixed thermometers are indicated.
 - 1. Install with socket extending a minimum of 2 inches into fluid.
 - 2. Fill sockets with oil or graphite and secure caps.
- D. Install thermometer wells in vertical position in piping tees where test thermometers are indicated.
 - 1. Install with stem extending a minimum of 2 inches into fluid.
 - 2. Fill wells with oil or graphite and secure caps.

3.3 TEST PLUGS AND PORTS INSTALLATION

- A. Install test ports in piping located on pipe at most accessible location and position.

B. Install test ports in the following locations:

1. As indicated on drawings

3.4 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping and specialties. The following are specific connection requirements:

1. Install gages adjacent to machines and equipment to allow service and maintenance.

3.5 ADJUSTING AND CLEANING

A. Adjust faces of gages to proper angle for best visibility.

B. Clean windows of gages and clean factory-finished surfaces. Replace cracked and broken windows, and repair scratched and marred surfaces with manufacturer's touchup paint.

END OF SECTION 230519

SECTION 230523 – GENERAL DUTY VALVES FOR HVAC 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 work of this section.

1.2 SUMMARY

- A. Extent of valves required by this section is indicated on drawings and/or specified in other Division 23 sections.
- B. The types of valves specified in this section shall include the following:
 - 1. Check valves.
 - 2. Balancing valves.
 - 3. Butterfly valves.
 - 4. Drain valves.
 - 5. Ball valves.
- C. Valves furnished as part of factory-fabricated equipment are specified as part of equipment in other Division 23 sections.

1.3 SUBMITTALS

- A. Product Data: Submit manufacturer's technical product data for each type of valve. Submit valve schedule showing manufacturer's figure number, size, location, and valve features for each required valve.
- B. Maintenance Data: Submit recommended maintenance data as applicable and spare parts lists for each type of valve. Include this data, product data, and shop drawings in Maintenance Manual.

1.4 QUALITY ASSURANCE

- A. Provide valves of the same type by the same manufacturer throughout.
- B. Provide valves with manufacturer's name and pressure rating clearly marked on outside of body.
- C. Codes and Standards:
 - 1. Mark valves in accordance with MSS-25 "Standard Marking System for Valves, Fittings, Flanges and Unions" as well as jurisdictional code requirements.

2. For dimensions of flanged or welded and valve bodies, comply with ANSI B16.10.
3. Provide valves used in fire protection piping, which are UL-listed, and FM approved.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Provide factory-fabricated valves recommended by manufacturer for use in service indicated. Valves and valve construction shall be suitable for the pressure, temperature and fluid of the service. Provide proper selection as determined by Installer to comply with installation requirements. Provide end connections which properly mate with pipe, tube, and equipment connections. Where more than one type is indicated, selection is Installer's option.
- B. Unless otherwise indicated, provide valves of same size as upstream pipe size.
- C. Operators: Provide handwheels, fastened to valve stem, for valves other than quarter-turn. Provide lever handle for quarter-turn valves, 6" and smaller, other than plug valves. Provide one wrench for every 10 plug valves. Provide gear operators for quarter-turn valves 8" and larger. Provide chain-operated sheaves and chains for routinely operated overhead valves more than 8 feet above the floor in Mechanical Equipment rooms.
- D. Acceptable Manufacturers: Subject to compliance with requirements, provide valves from one of the following:
 1. Crane
 2. Fairbanks
 3. Hammond
 4. ITT Grinnell
 5. Milwaukee
 6. Nibco
 7. Powell
 8. Stockham
 9. Walworth
 10. Watts
 11. Armstrong.

2.2 CHECK VALVES – SWING TYPE

- A. Use for water and low pressure general services: 2 inches and smaller with screwed bonnet; 2 ½ inches and larger with bolted bonnet. Valves to have renewable bronze seat and disc.

2.3 CHECK VALVES – NON-SLAM

- A. Use on pumps with cycling control. Valves to have semi-steel body with bronze or stainless steel trim and to be of the center guide type.

2.4 BALANCING VALVES FOR FLOW MEASUREMENT

- A. Calibrated ball type balancing valves with differential pressure readout ports across fixed geometry venturi orifice. Each port shall have positive schrader type connections for connection to portable pressure meter. Provide reduced port type where flow rate is less than 2 GPM.
- B. Internal balls and orifices shall not be provided with plated brass construction. Stainless steel is approved.
- C. Valves shall have memory feature to allow valve to be closed for service and then reopened without affecting balanced position.
- D. Where installed to insulated piping systems each valve shall be provided with insulation molded by manufacturer to permit easy access for balance and readout.
- E. For sizes larger than 4", provide venturi or wafer type orifice plate with butterfly valve with memory stop.
- F. Acceptable Manufacturers: Subject to compliance with requirements, provide balancing valves for flow measurement of one of the following:
 - 1. Bell & Gossett – ITT Industries
 - 2. Flow Design Inc., Accusetter series
 - 3. Preso Industries, B-Plus series
 - 4. Hydronic Components, Inc., Terminator System
 - 5. Taco, Accu-Flo
 - 6. Victaulic.

2.5 BUTTERFLY VALVES

- A. Used for shut-off duty for heating water pipe sizes 4 inches and larger. Butterfly valves shall be of the lug body style, duct-tile iron, with lugs drilled and tapped and have drip tight shutoff capabilities in either direction up to maximum system working pressure. Butterfly valves shall be capable of closing tight after long periods of inactivity. Flanges to be through drilled to ANSI Standards.
- B. Valves shall be furnished with self-lubricated bronze bearings. Shaft seals shall be provided to prevent leakage and to protect bearings from internal or external corrosion.
- C. Seats shall be of the reinforced resilient type (or retained seat on high performance valves) and shall also act as a body liner to prevent flow from contacting the body casting. Resilient seats shall have flange sealing lips to provide a positive seal without use of flanges gaskets.
- D. Seats shall be Nordel suitable for use with water to 240 degrees F. Shafts shall be one piece and shall be of Type 416 stainless steel. Shafts shall be finish ground and polished to minimize bearing and shaft seal wear. Shafts of 8 inches and larger valves shall have a non-adjustable thrust collar.
- E. Discs shall be aluminum bronze. The disc-to-shaft connections shall be type 316 stainless steel. Pins, shaft, and disc of valves shall be individually machined and completely interchangeable.

- F. On manually operated valves, latch lock levers shall provide automatic, positive latching in the open, closed or eight intermediate positions. These levers shall allow locking in any position with a standard padlock. Infinite position levers shall allow manual throttling and locking in any position from open to close.

2.6 DRAIN VALVES

- A. Provide drain valves with threaded ends for hose connections at drain points, at main shutoff valves, low points of piping systems, bases of vertical risers, and at equipment.
- B. Brass ball valve with cap with chain, ¾ inch hose thread.

2.7 BALL VALVES

- A. Ball Valves shall be used for shutoff service for heating water for pipe sizes up to 3 inches.
- B. 1½” and Smaller: 125 psi steam, 400 psi WOG, bronze body, full port, 316 stainless steel ball and stainless steel stem, bronze trim, 2 piece construction, TFE seats and seals.
- C. 2” and larger: 150 psi steam, 600 psi WOG, bronze body, full port, 316 stainless steel ball and stainless steel stem, 2 piece body, TFE seats with bronze trim.
- D. Provide extended stem as required to accommodate piping insulation as specified elsewhere.
- E. On ball valves used at terminal equipment, provide drain plugs positioned for easy access and proper drainage on terminal side of valves.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. General: Except as otherwise indicated, comply with the following requirements:
 - 1. Install valves where required for proper operation of piping and equipment, including valves in branch lines where necessary to isolate sections of piping. Locate valves so as to be accessible for operation, maintenance and re-packing, and so that separate support can be provided when necessary.
 - 2. Install isolation valves on equipment so that valve and piping do not interfere with equipment removal or maintenance. Install unions or flanges on equipment side of valves unless valve is flanged type.
 - 3. Install valves with stems pointed up, in vertical position where possible, but in no case with stems pointed downward from horizontal plane unless unavoidable. Install valve drains with hose-end adapter for each valve that must be installed with stem below horizontal plane.
 - 4. Install with operating clearance for handle and stem.
 - 5. Provide valves of a design permitting packing while open and under pressure.
 - 6. Provide all valves 8 inches and larger having a rating of over 150 lbs. with a 1 inch by-pass valve of same pressure rating.

7. Furnish and install other hand valves, check valves, cocks, etc., as required for the complete and proper valving of the entire installation.
- B. Insulation: Where piping is insulated, install extended-stem valves, arranged in proper manner to receive insulation. Insulation cut away to receive standard stems is not acceptable.
- C. Mechanical Actuators: Install mechanical actuators with chain operators where indicated. Extend chains to about 5' above floor and hook to clips to clear aisle passage.
- D. Non-Metallic Disc: Limit selection and installation of valves with non-metallic discs to locations indicated and where foreign material in piping system can be expected to prevent tight shutoff of metal seated valves.
- E. Renewable Seats: Select and install valves with renewable seats, except where otherwise indicated.
- F. Fluid Control: Except as otherwise indicated, install gate, ball, globe, and butterfly valves to comply with ANSI B31.9. Where throttling is indicated or recognized as principal reason for valve, install globe or butterfly valves.
- G. Installation of Check Valves:
 1. Swing Check Valves: Install in horizontal position with hinge pin horizontally perpendicular to center line of pipe. Install for proper direction of flow.
 2. Wafer Check Valves: Install between 2 flanges in horizontal or vertical position, position for proper direction of flow.
 3. Lift Check Valves: Install in piping line with stem vertically upward, position for proper direction of flow.

3.2 ADJUSTING AND CLEANING

- A. Valve Adjust: After piping systems have been tested and put into service, but before final testing, adjusting, and balancing, inspect each valve for possible leaks. Adjust or replace packing to stop leaks, replace valve if leak persists.
- B. Valve Identification: Tag each valve in accordance with Division 23 section "Identification for HVAC Piping and Equipment".
- C. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

END OF SECTION 230523

SECTION 230529 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes hangers and supports for mechanical system piping and equipment.
- B. Related Sections include the following:
 - 1. Division 05 Section "Metal Fabrications" for materials for attaching hangers and supports to building structure.
 - 2. Division 23 Section "Vibration Controls for HVAC Piping and Equipment" for vibration isolation devices.

1.3 DEFINITIONS

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

1.4 PERFORMANCE REQUIREMENTS

- A. Design channel support systems for piping to support multiple pipes capable of supporting combined weight of supported systems, system contents, and test water.
- B. Design heavy-duty steel trapezes for piping to support multiple pipes capable of supporting combined weight of supported systems, system contents, and test water.
- C. Design seismic restraint hangers and supports for piping and equipment when required by jurisdictional authority.
- D. Design and obtain approval from authorities having jurisdiction for seismic restraint hangers and supports for piping and equipment.

1.5 SUBMITTALS

- A. Product Data: For each type of pipe hanger, channel support system component, and thermal-hanger shield insert indicated.

- B. Shop Drawings: Signed and sealed by a qualified professional engineer for multiple piping supports and trapeze hangers. Include design calculations and indicate size and characteristics of components and fabrication details.
- C. Welding Certificates: Copies of certificates for welding procedures and operators.

1.6 QUALITY ASSURANCE

- A. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
- B. Engineering Responsibility: Design and calculations for each multiple pipe support, trapeze, and seismic restraint by a qualified professional engineer.
 - 1. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in jurisdiction where the Project is located and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for installations of hangers and supports that are similar to those indicated for this Project in material, design, and extent.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Pipe Hangers:
 - a. AAA Technology and Specialties Co., Inc.
 - b. B-Line Systems, Inc.
 - c. Carpenter & Patterson, Inc.
 - d. Empire Tool & Manufacturing Co., Inc.
 - e. Globe Pipe Hanger Products, Inc.
 - f. Grinnell Corp.
 - g. GS Metals Corp.
 - h. Michigan Hanger Co., Inc.
 - i. National Pipe Hanger Corp.
 - j. PHD Manufacturing, Inc.
 - k. PHS Industries, Inc.
 - l. Piping Technology & Products, Inc.
 - 2. Channel Support Systems:
 - a. B-Line Systems, Inc.
 - b. Grinnell Corp.; Power-Strut Unit.
 - c. GS Metals Corp.
 - d. Michigan Hanger Co., Inc.; O-Strut Div.

- e. National Pipe Hanger Corp.
 - f. Thomas & Betts Corp.
 - g. Unistrut Corp.
 - h. Wesanco, Inc.
3. Thermal-Hanger Shield Inserts:
- a. Carpenter & Patterson, Inc.
 - b. Michigan Hanger Co., Inc.
 - c. PHS Industries, Inc.
 - d. Pipe Shields, Inc.
 - e. Rilco Manufacturing Co., Inc.
 - f. Value Engineered Products, Inc.

2.2 MANUFACTURED UNITS

- A. Pipe Hangers, Supports, and Components: MSS SP-58, factory-fabricated components. Refer to "Hanger and Support Applications" Article in Part 3 for where to use specific hanger and support types.
- 1. Galvanized, Metallic Coatings: For piping and equipment that will not have field-applied finish.
 - 2. Nonmetallic Coatings: On attachments for electrolytic protection where attachments are in direct contact with copper tubing.
- B. Channel Support Systems: MFMA-2, factory-fabricated components for field assembly.
- 1. Coatings: Manufacturer's standard finish, unless bare metal surfaces are indicated.
 - 2. Nonmetallic Coatings: On attachments for electrolytic protection where attachments are in direct contact with copper tubing.
- C. Thermal-Hanger Shield Inserts: 100-psi minimum compressive-strength insulation, encased in sheet metal shield.
- 1. Material for Cold Piping: ASTM C 552, Type I cellular glass with vapor barrier or water-repellent-treated, ASTM C 533, Type I calcium silicate with vapor barrier.
 - 2. Material for Hot Piping: ASTM C 552, Type I cellular glass or water-repellent-treated, ASTM C 533, Type I calcium silicate.
 - 3. For Trapeze or Clamped System: Insert and shield cover entire circumference of pipe.
 - 4. For Clevis or Band Hanger: Insert and shield cover over lower 180 degrees of pipe.
 - 5. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.3 MISCELLANEOUS MATERIALS

- A. Structural Steel: ASTM A 36/A 36M, steel plates, shapes, and bars, black and galvanized.
- B. Grout: ASTM C 1107, Grade B, factory-mixed and -packaged, nonshrink and nonmetallic, dry, hydraulic-cement grout.

1. Characteristics: Post hardening and volume adjusting; recommended for both interior and exterior applications.
2. Properties: Nonstaining, noncorrosive, and nongaseous.
3. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT APPLICATIONS

- A. Specific hanger requirements are specified in Sections specifying equipment and systems.
- B. Comply with MSS SP-69 for pipe hanger selections and applications that are not specified in piping system Specification Sections.
- C. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:
 1. Adjustable Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated stationary pipes, NPS 1/2 to NPS 30.
 2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of 120 to 450 deg F pipes, NPS 4 to NPS 16, requiring up to 4 inches of insulation.
 3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes, NPS 3/4 to NPS 24, requiring clamp flexibility and up to 4 inches of insulation.
 4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes, NPS 1/2 to NPS 24, if little or no insulation is required.
 5. Pipe Hangers (MSS Type 5): For suspension of pipes, NPS 1/2 to NPS 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, NPS 3/4 to NPS 8.
 7. Adjustable Steel Band Hangers (MSS Type 7): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.
 8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.
 9. Adjustable Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 2.
 10. Split Pipe-Ring with or without Turnbuckle-Adjustment Hangers (MSS Type 11): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 8. Copper pipe rings shall be used on copper pipe. Painted steel pipe rings are not approved for use.
 11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 3.
 12. U-Bolts (MSS Type 24): For support of heavy pipe, NPS 1/2 to NPS 30.
 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, NPS 4 to NPS 36, with steel pipe base stanchion support and cast-iron floor flange.
 15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes, NPS 4 to NPS 36, with steel pipe base stanchion support and cast-iron floor flange and with U-bolt to retain pipe.

16. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes, NPS 2-1/2 to NPS 36, if vertical adjustment is required, with steel pipe base stanchion support and cast-iron floor flange.
- D. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:
1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers, NPS 3/4 to NPS 20.
 2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 20, if longer ends are required for riser clamps.
- E. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:
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.
- F. Building Attachments: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:
1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
 2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joint construction to attach to top flange of structural shape.
 3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
 4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
 5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
 6. C-Clamps (MSS Type 23): For structural shapes.
 7. 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. Use 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 head room is limited.
- G. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:
1. Steel Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
 2. Protection Shields (MSS Type 40): Of length recommended by manufacturer to prevent crushing insulation.
 3. Thermal-Hanger Shield Inserts: For supporting insulated pipe, 360-degree insert of high-density, 100-psi minimum compressive-strength, water-repellent-treated calcium silicate or cellular-glass pipe insulation, same thickness as adjoining insulation with vapor barrier and encased in 360-degree sheet metal shield.
- H. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:
1. Restraint-Control Devices (MSS Type 47): To control piping 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 absorb 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 absorb 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 absorb 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.

3.2 HANGER AND SUPPORT INSTALLATION

- A. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment. Support of piping and ductwork systems shall be distributed across the structural system. Alternate hanger locations

when multiple pipes are supported in one area to ensure single trusses are not independently bearing the weight of multiple pipes in any one area.

- B. Coordinate and follow mechanical support building attachment requirements of manufacturers of truss and joist systems and structural components. Furnish shop drawings of proposed attachment methods which have been reviewed and approved by manufacturer of structural systems.
- C. Regardless of the type of construction (i.e., concrete, concrete-deck-steel, concrete plank, wood or other variations) take particular care to support main lines and large and heavy pipes in an approved manner, including the furnishing and installation of supplementary steel, if required. Supplementary steel shall be mill-rolled sections. Submit shop drawings, indicating support methods, point loadings to the building structure and hanger locations for review.
- D. Pipe Hanger and Support Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.
- E. Channel Support System Installation: Arrange for grouping of parallel runs of piping and support together on field-assembled channel systems.
 - 1. Field assemble and install according to manufacturer's written instructions.
- F. Heavy-Duty Steel Trapeze Installation: Arrange for grouping of parallel runs of horizontal piping and support together on field-fabricated, heavy-duty trapezes.
 - 1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified above for individual pipe hangers.
 - 2. Field fabricate from ASTM A 36/A 36M, steel shapes selected for loads being supported. Weld steel according to AWS D-1.1.
- G. Install all building attachments to structural components. Space attachments within maximum piping span length indicated in MSS SP-69. Install additional attachments at concentrated loads, including valves, flanges, guides, strainers, and expansion joints, and at changes in direction of piping. All items shall be directly supported from structure. Items shall not be suspended from other building systems.
- H. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.
- I. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
- J. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so maximum pipe deflections allowed by ASME B31.9, "Building Services Piping," is not exceeded.
- K. Insulated Piping: Comply with the following:
 - 1. Attach clamps and spacers to piping.

- a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
 - b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
 - c. Do not exceed pipe stress limits according to ASME B31.9.
- 2. Install MSS SP-58, Type 39 protection saddles, if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
 - a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
- 3. Install MSS SP-58, Type 40 protective shields on cold piping with vapor barrier. Shields shall span arc of 180 degrees.
 - a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
- 4. Shield Dimensions for Pipe: Not less than the following:
 - a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
 - b. NPS 4: 12 inches long and 0.06 inch thick.
 - c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
 - d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
 - e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick.
- 5. Pipes NPS 8 and Larger: Include inserts.
- 6. Insert Material: Length at least as long as protective shield.
- 7. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.3 EQUIPMENT SUPPORTS

- A. Fabricate structural-steel stands to suspend equipment from structure above or to support equipment above floor.
- B. Grouting: Place grout under supports for equipment and make smooth bearing surface.

3.4 METAL FABRICATION

- A. Cut, drill, and fit miscellaneous metal fabrications for heavy-duty steel trapezes and equipment supports.
- B. Fit exposed connections together to form hairline joints. Field-weld connections that cannot be shop-welded because of shipping size limitations.
- C. Field Welding: Comply with AWS D1.1 procedures for shielded metal arc welding, appearance and quality of welds, and methods used in correcting welding work, and with the following:
 - 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.

2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. Finish welds at exposed connections so no roughness shows after finishing and contours of welded surfaces match adjacent contours.

3.5 ADJUSTING

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

3.6 PAINTING

- A. Touching Up: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.
- B. Touching Up: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Division 9 Section "Painting."
- C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 230529

SECTION 230548 – VIBRATION CONTROLS FOR HVAC PIPING & EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Isolation pads.
 - 2. Isolation mounts.
 - 3. Housed spring mounts.
 - 4. Elastomeric hangers.
 - 5. Spring hangers.
 - 6. Spring hangers with vertical-limit stops.
 - 7. Pipe riser resilient supports.
 - 8. Resilient pipe guides.

1.3 DEFINITIONS

- A. IBC: International Building Code.
- B. ICC-ES: ICC-Evaluation Service.
- C. OSHPD: Office of Statewide Health Planning and Development for the State of California.

1.4 SUBMITTALS

- A. Product Data: For the following:
 - 1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
- B. Welding certificates.
- C. Qualification Data: For professional engineer and testing agency.
- D. Field quality-control test reports.
- E. Operation and Maintenance Data: For air-mounting systems to include in operation and maintenance manuals.

1.5 QUALITY ASSURANCE

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

PART 2 - PRODUCTS

2.1 VIBRATION ISOLATORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Ace Mountings Co., Inc.
 - 2. Amber/Booth Company, Inc.
 - 3. California Dynamics Corporation.
 - 4. Isolation Technology, Inc.
 - 5. Kinetics Noise Control.
 - 6. Mason Industries.
 - 7. Vibration Eliminator Co., Inc.
 - 8. Vibration Isolation.
 - 9. Vibration Mountings & Controls, Inc.
- B. Pads: Arranged in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.
 - 1. Resilient Material: Oil- and water-resistant neoprene.
- C. Mounts: Double-deflection type, with molded, oil-resistant rubber, hermetically sealed compressed fiberglass, 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. 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.
- D. 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 1/4-inch- 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.
- E. Elastomeric Hangers: Single or double-deflection type, fitted with molded, oil-resistant elastomeric isolator elements bonded to steel housings with threaded connections for hanger rods. Color-code or otherwise identify to indicate capacity range.
- F. 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.
- G. Pipe Riser Resilient Support: All-directional, acoustical pipe anchor consisting of 2 steel tubes separated by a minimum of 1/2-inch- thick 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.
- H. Resilient Pipe Guides: Telescopic arrangement of 2 steel tubes or post and sleeve arrangement separated by a minimum of 1/2-inch- thick neoprene. Where clearances are not readily visible, a factory-set guide height with a shear pin to allow vertical motion due to pipe expansion and contraction shall be fitted. Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and equipment to receive vibration isolation 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.

3.3 VIBRATION-CONTROL DEVICE INSTALLATION

- A. Comply with requirements in Division 07 Section "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.
- B. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.
- C. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

3.4 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Perform tests and inspections.
- C. Remove and replace malfunctioning isolators and retest as specified above.

3.5 ADJUSTING

- A. Adjust isolators after piping system is at operating weight.
- B. Adjust active height of spring isolators.
- C. Adjust restraints to permit free movement of equipment within normal mode of operation.

3.6 VIBRATION ISOLATION SCHEDULE

- A. Base Types:

A = No base, isolators attached directly to equipment.
B = Structural steel rails or base
C = Concrete inertia base
D = Curb-mounted base with spring isolators
E = Integral Equipment Base Rails / Feet

- B. Isolator Types:

1 = Pad

- 2 = Spring isolator
- 3 = Spring hanger
- 4 = Rubber in-shear hanger
- 5 = Thrust restraint
- 6 = Rubber in-shear isolator pad
- 7 = Spring Isolated Roof Curb
- 8 = Neoprene Hanger

Equipment Type	Slab On Grade			0-70 Ft Floor Span		
	Base Type	Isol Type	Min. Defl.	Base Type	Isol Type	Min. Defl.
Fans and Ventilation Sets						
Up thru 22" dia, Suspended	-	-	-	A	3	0.75"
Over 22" dia, Suspended	-	-	-	A	3	1.5"
VRF Outdoor Unit						
All Sizes	A	2	-	-	-	-
Suspended VRF Indoor Units - SSAH						
012 thru 036 sizes	-	-	-	A	8	0.5"
Suspended Blower Coils Equipment - BC						
All Sizes	-	-	-	A	3	0.1"

END OF SECTION 230548

SECTION 230553 – IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following mechanical identification materials and their installation:

1. Equipment markers.
2. Ceiling grid Identification
3. Equipment signs.
4. Access panel and door markers.
5. Pipe markers.
6. Duct markers.
7. Valve tags.
8. Valve schedules.
9. Warning tags.

1.3 SUBMITTALS

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

1.4 QUALITY ASSURANCE

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

1.5 COORDINATION

- A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

- B. Coordinate installation of identifying devices with location of access panels and doors.
- C. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 EQUIPMENT IDENTIFICATION DEVICES

- A. Equipment 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 code.
 - b. Equipment service.
 - 3. Size: 2-1/2 by 4 inches for control devices, dampers, and valves; 4-1/2 by 6 inches for equipment.
- B. Access Panel and Door Markers: 1/16-inch thick, engraved laminated plastic, with abbreviated terms and numbers corresponding to identification. Provide 1/8-inch center hole for attachment.
 - 1. Fasteners: Self-tapping, stainless-steel screws or contact-type, permanent adhesive.

2.2 CEILING GRID IDENTIFICATION

- A. Provide an equipment marker on ceiling grid for equipment located above the suspended ceilings.
 - 1. Equipment Markers: Engraved, color-coded laminated plastic. Include contact-type, permanent adhesive.
 - a. Terminology: Match schedules as closely as possible.
 - 1) Data: Name and plan code.
 - b. Size: 1/2 by 1 1/2 inches for control devices, dampers, and valves; 4-1/2 by 6 inches for equipment.
 - 2. Provide a colored dot/circle on ceiling grid for hot water valve or fire damper located above the suspended ceilings.
 - a. Hot Water Valve: Red dot, 1/2" in diameter.
 - b. Chilled Water: Blue Dot, 1/2" in diameter.
 - c. Fire Damper: Yellow dot, 1/2" in diameter.
 - d. Equipment: Green Dot, 1/2" in diameter.

2.3 PIPING IDENTIFICATION DEVICES

- A. Manufactured Pipe Markers, General: Preprinted, color-coded, with lettering indicating service, and showing direction of flow.
 - 1. Colors: Comply with ASME A13.1, unless otherwise indicated.
 - 2. Lettering: Use piping system terms indicated and abbreviate only as necessary for each application length.
 - 3. Pipes with OD, Including Insulation, Less Than 6 Inches: Full-band pipe markers extending 360 degrees around pipe at each location.
 - 4. Pipes with OD, Including Insulation, 6 Inches and Larger: Either full-band or strip-type pipe markers at least three times letter height and of length required for label.
 - 5. Arrows: Integral with piping system service lettering to accommodate both directions; or as separate unit on each pipe marker to indicate direction of flow.
- B. Pretensioned Pipe Markers: Precoiled semirigid plastic formed to cover full circumference of pipe and to attach to pipe without adhesive.
- C. Shaped Pipe Markers: Preformed semirigid plastic formed to partially cover circumference of pipe and to attach to pipe with mechanical fasteners that do not penetrate insulation vapor barrier.
- D. Self-Adhesive Pipe Markers: Plastic with pressure-sensitive, permanent-type, self-adhesive back.
- E. Plastic Tape: Continuously printed, vinyl tape at least 3 mils thick with pressure-sensitive, permanent-type, self-adhesive back.
 - 1. Width for Markers on Pipes with OD, Including Insulation, Less Than 6 Inches: 3/4 inch minimum.
 - 2. Width for Markers on Pipes with OD, Including Insulation, 6 Inches or Larger: 1-1/2 inches minimum.

2.4 DUCT IDENTIFICATION DEVICES

- A. Duct Markers: Preprinted, color-coded plastic with pressure-sensitive, permanent-type, self-adhesive back. Include direction and quantity of airflow and duct service (such as supply, return, and exhaust). Include contact-type, permanent adhesive.

2.5 VALVE TAGS

- A. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers, with numbering scheme approved by Architect. Provide 5/32-inch hole for fastener.
 - 1. Material: 0.032-inch thick brass.
 - 2. 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. Provide in plastic sleeves located in 3-ring binder.

2.7 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: Reinforced grommet and wire or string.
 - 3. Nomenclature: Large-size primary caption such as DANGER, CAUTION, or DO NOT OPERATE.
 - 4. Color: Yellow background with black lettering.

PART 3 - EXECUTION

3.1 APPLICATIONS, GENERAL

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

3.2 EQUIPMENT IDENTIFICATION

- A. Install and permanently fasten equipment nameplates on each major item of mechanical equipment that does not have nameplate or has nameplate that is damaged or located where not easily visible. Locate nameplates where accessible and visible. Include nameplates for the following general categories of equipment:
 - 1. Fans
 - 2. Blower Coils/Makeup Air Units
 - 3. Cabinet Heaters
 - 4. VRF Indoor Units
 - 5. Heat Pumps/Condensing units
- B. Install equipment signs with screws or permanent adhesive on or near each major item of mechanical equipment. Locate signs where accessible and visible.
 - 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. Include signs for the following general categories of equipment:
 - a. Main control and operating valves, including safety devices and hazardous units such as gas outlets.
 - b. Fuel-burning units, including boilers, furnaces, heaters, stills, and absorption units.
 - c. Pumps, compressors, condensers, and similar motor-driven units.
 - d. Heat exchangers, coils, evaporators, cooling towers, and similar equipment.
 - e. Fans, blowers, primary balancing dampers, and mixing boxes.
 - f. Packaged HVAC central-station and zone-type units.
 - g. Tanks and pressure vessels.
 - h. Strainers, filters, water-treatment systems, and similar equipment.
- C. Install access panel markers with screws on equipment access panels.

3.3 CEILING GRID IDENTIFICATION

- A. Install equipment marker with permanent adhesive at each item of mechanical equipment on suspended ceiling grid.
- B. Provide colored dot/circle on ceiling grid for hot water valve and fire dampers located above the suspended ceilings.

3.4 PIPING IDENTIFICATION

- A. Install manufactured pipe markers indicating service on each piping system. Install with flow indication arrows showing direction of flow.
 1. Pipes with OD, Including Insulation, Less Than 6 Inches: Pretensioned pipe markers. Use size to ensure a tight fit.
 2. Pipes with OD, Including Insulation, Less Than 6 Inches: Self-adhesive pipe markers. Use color-coded, self-adhesive plastic tape, at least 3/4 inch wide, lapped at least 1-1/2 inches at both ends of pipe marker, and covering full circumference of pipe.
 3. Pipes with OD, Including Insulation, 6 Inches and Larger: Shaped pipe markers. Use size to match pipe and secure with fasteners.
 4. Pipes with OD, Including Insulation, 6 Inches and Larger: Self-adhesive pipe markers. Use color-coded, self-adhesive plastic tape, at least 1-1/2 inches wide, lapped at least 3 inches at both ends of pipe marker, and covering full circumference of pipe.
- B. Locate pipe markers and color bands where piping is exposed in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior nonconcealed locations as follows:
 1. Near each valve and control device.
 2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
 3. Near penetrations through walls, floors, ceilings, and nonaccessible enclosures.

4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 50 feet 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 markers.

3.5 DUCT IDENTIFICATION

- A. Install duct markers with permanent adhesive on air ducts in the following color codes:
 1. Red: For exhaust ducts.
 2. Yellow: For outside air ducts.
 3. Blue: For return, and mixed-air ducts.
 4. Green: For supply air ducts.
 5. 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.
- B. Locate markers near points where ducts enter into 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; 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. Hot Water Heating: 1-1/2 inches.
 - b. Chilled Water: 1-1/2 inches.
 2. Valve-Tag Color:
 - a. Hot Water Heating: Red.
 - b. Chilled Water: Blue
 3. Letter Color:
 - a. Heat Water Heating: White.
 - b. Chilled Water: White

3.7 VALVE-SCHEDULE INSTALLATION

- A. Mount valve schedule in plastic slip sheets located in the 3-ring binder.

3.8 WARNING-TAG INSTALLATION

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

3.9 ADJUSTING

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

3.10 CLEANING

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

END OF SECTION 230553

SECTION 230593 - TESTING, ADJUSTING, AND BALANCING

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 testing, adjusting, and balancing HVAC systems to produce design objectives, including the following:
 - 1. Balancing airflow and water flow within distribution systems, including submains, branches, and terminals, to indicated quantities according to specified tolerances.
 - 2. Adjusting total HVAC systems to provide indicated quantities.
 - 3. Measuring electrical performance of HVAC equipment.
 - 4. Setting quantitative performance of HVAC equipment.
 - 5. Verifying that automatic control devices are functioning properly.
 - 6. Reporting results of the activities and procedures specified in this Section.
- B. The Testing, Adjusting and Balancing (TAB) contractor shall be contracted directly with the Mechanical Contractor to provide the scope of services outlined within this specification. In addition to performing the scope of services outlined within this specification, the TAB contractor shall coordinate all work with the Mechanical and General Contractor and all sub-contractors to ensure complete system installation and operation within the timeframe submitted by the General Contractor and approved by the Owner. The following shall be the responsibility of the TAB contractor:
 - 1. All scope of work shall be coordinated with the General Contractor and all sub-contractors at the start of construction. All parties shall meet to review the scope of work, responsibilities of each party, establish timelines and critical milestones and establish a process for distribution of documentation.
 - 2. Submit all documentation including submittals and requests for information through the General Contractor for review by other trades, the Engineer and the Architect.
 - 3. Submit a proposed schedule for submittals, system coordination, and system testing to the General Contractor for incorporation to the overall project schedule.
 - 4. Coordinate all items required to be provided by the General Contractor and sub-contractors. Submit an agreed upon list indicating each item and associated dates for each item to be completed.
 - 5. Attend all job conferences as outlined in item C below.
- C. A Project Manager employed directly by the TAB contractor shall be on site for supervision of all system testing. This Project Manager shall attend all job conferences and all regular contractor coordination meetings during the period where any testing, adjusting, and balancing is being performed. This shall include all preliminary coordination and final closeout meetings.

D. Preliminary and final TAB services shall be for each of the following systems:

1. All Air-based HVAC systems.
2. All Water-based HVAC systems.

1.3 DEFINITIONS

- A. Adjust: To regulate fluid flow rate and air patterns at the terminal equipment, such as to reduce fan speed or adjust a damper.
- B. Balance: To proportion flows within the distribution system, including submains, branches, and terminals, according to design quantities.
- C. Draft: A current of air, when referring to localized effect caused by one or more factors of high air velocity, low ambient temperature, or direction of airflow, whereby more heat is withdrawn from a person's skin than is normally dissipated.
- D. Procedure: An approach to and execution of a sequence of work operations to yield repeatable results.
- E. Report Forms: Test data sheets for recording test data in logical order.
- F. Static Head: The pressure due to the weight of the fluid above the point of measurement. In a closed system, static head is equal on both sides of the pump.
- G. Suction Head: The height of fluid surface above the centerline of the pump on the suction side.
- H. System Effect: A phenomenon that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
- I. System Effect Factors: Allowances used to calculate a reduction of the performance ratings of a fan when installed under conditions different from those presented when the fan was performance tested.
- J. Terminal: A point where the controlled medium, such as fluid or energy, enters or leaves the distribution system.
- K. Test: A procedure to determine quantitative performance of a system or equipment.
- L. Testing, Adjusting, and Balancing Agent: The entity responsible for performing and reporting the testing, adjusting, and balancing procedures.
- M. AABC: Associated Air Balance Council.
- N. AMCA: Air Movement and Control Association.
- O. CTI: Cooling Tower Institute.
- P. NEBB: National Environmental Balancing Bureau.
- Q. SMACNA: Sheet Metal and Air Conditioning Contractors' National Association.

1.4 SUBMITTALS

- A. Contract Documents Examination Report: Within 45 days from the Contractor's Notice to Proceed, submit 6 copies of the Contract Documents review report as specified in Part 3 of this Section.
- B. Strategies and Procedures Plan: Within 60 days from the Contractor's Notice to Proceed, submit 6 copies of the testing, adjusting, and balancing strategies and step-by-step procedures as specified in Part 3 "Preparation" Article below. Include a complete set of report forms intended for use on this Project.
- C. Certified Testing, Adjusting, and Balancing Reports: Submit 6 copies of reports prepared, as specified in this Section, on approved forms certified by the testing, adjusting, and balancing Agent.
- D. System Observations and Corrections List: Submit 6 copies of written report indicating conditions which will prevent the system from being properly balanced or performing properly. The report shall identify all system issues observed during the system examination as specified in Part 3 below.

1.5 QUALITY ASSURANCE

- A. Agent Qualifications: Engage a testing, adjusting, and balancing agent certified by NEBB or AABC with a minimum of 10 years of balancing experience on the specified system types.
- B. Testing, Adjusting, and Balancing Conference: Meet with the General Contractor's and Sub-Contractor's representatives on approval of the testing, adjusting, and balancing strategies and procedures plan to develop a mutual understanding of the details. Ensure the participation of testing, adjusting, and balancing team members, the building automation system installer, and the HVAC contractor. Provide 7 days' advance notice of scheduled meeting time and location.
 - 1. Agenda Items: Include at least the following:
 - a. Submittal distribution requirements.
 - b. Contract Documents examination report.
 - c. Testing, adjusting, and balancing plan.
 - d. Work schedule and Project site access requirements.
 - e. Coordination and cooperation of trades and subcontractors.
 - f. Coordination of documentation and communication flow.
- C. Certification of Testing, Adjusting, and Balancing Reports: Certify the testing, adjusting, and balancing field data reports. This certification includes the following:
 - 1. Review field data reports to validate accuracy of data and to prepare certified testing, adjusting, and balancing reports.
 - 2. Certify that the testing, adjusting, and balancing team complied with the approved testing, adjusting, and balancing plan and the procedures specified and referenced in this Specification.

- D. Testing, Adjusting, and Balancing Reports: Use standard forms from NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems."
- E. Instrumentation Type, Quantity, and Accuracy: As described in NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems," Section II, "Required Instrumentation for NEBB Certification."
- F. Instrumentation Calibration: Calibrate instruments at least every 6 months or more frequently if required by the instrument manufacturer.

1.6 PROJECT CONDITIONS

- A. Partial Owner Occupancy: The Owner may occupy the site and portions of the building during the entire testing, adjusting, and balancing period. Cooperate with the Owner during testing, adjusting, and balancing operations to minimize conflicts with the Owner's operations.

1.7 COORDINATION

- A. Coordinate the efforts of factory-authorized service representatives for systems and equipment, HVAC controls installers, and other mechanics to operate HVAC systems and equipment to support and assist testing, adjusting, and balancing activities.
- B. Notice: Provide 7 days advance notice for each test. Include scheduled test dates and times.
- C. Perform testing, adjusting, and balancing after leakage and pressure tests on air and water distribution systems have been satisfactorily completed by the HVAC contractor.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine Contract Documents to become familiar with project requirements and to discover conditions in systems' designs that may preclude proper testing, adjusting, and balancing of systems and equipment.
 - 1. Contract Documents are defined in the General and Supplementary Conditions of the Contract.
 - 2. Verify that balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are required by the Contract Documents. Verify that quantities and locations of these balancing devices are accessible and appropriate for effective balancing and for efficient system and equipment operation.
- B. Examine approved submittal data of HVAC systems and equipment.

- C. Examine Architect's and Engineer's design data, including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and design documents for HVAC system and equipment controls.
- D. Examine equipment performance data, including fan and pump curves. Relate performance data to project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
- E. Examine system and equipment installations to verify that they are complete and that testing, cleaning, adjusting, and commissioning specified in individual Specification Sections have been performed.
- F. Examine HVAC system and equipment installations to verify that indicated balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are properly installed, and their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation.
- G. Examine systems for functional deficiencies that cannot be corrected by adjusting and balancing.
- H. Examine air-handling equipment to ensure clean filters have been installed.
- I. Examine terminal units, such as heat pumps, dampers, and mixing boxes, to verify that they are accessible, and their controls are connected and functioning.
- J. Report deficiencies discovered before and during performance of testing, adjusting, and balancing procedures.

3.2 PREPARATION

- A. Prepare a testing, adjusting, and balancing plan that includes strategies and step-by-step procedures.
- B. Complete system readiness checks and prepare system readiness reports. Verify the following:
 - 1. Permanent electrical power wiring is complete.
 - 2. Hydronic systems are filled, clean, and free of air.
 - 3. Automatic temperature-control systems are operational.
 - 4. Equipment and duct access doors are securely closed.
 - 5. Balance, smoke, and fire dampers are open.
 - 6. Isolating and balancing valves are open and control valves are operational.
 - 7. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
 - 8. Windows and doors can be closed so design conditions for system operations can be met.

3.3 GENERAL TESTING AND BALANCING PROCEDURES

- A. Perform testing and balancing procedures on each system according to the procedures contained in NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and this Section or equivalent AABC Standards.
- B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing, close probe holes and patch insulation with new materials identical to those removed.
- C. Mark equipment settings with paint or other suitable, permanent identification material, including damper-control positions, valve indicators, fan-speed-control levers, and similar controls and devices, to show final settings.

3.4 FUNDAMENTAL AIR SYSTEMS' BALANCING PROCEDURES

- A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.
- B. Prepare schematic diagrams of systems' "as-built" duct layouts.
- C. Determine the best locations in main and branch ducts for accurate duct airflow measurements.
- D. Check dampers for proper position to achieve desired airflow path.
- E. Check for airflow blockages.
- F. Check for proper sealing of air-handling unit components.

3.5 CONSTANT-VOLUME AIR SYSTEMS' BALANCING PROCEDURES

- A. The procedures in this Article apply to constant-volume supply-, return-, and exhaust-air systems.
- B. Adjust fans to deliver total design airflows within the maximum allowable rpm listed by the fan manufacturer.
 - 1. Measure fan static pressures to determine actual static pressure as follows:
 - a. Measure outlet static pressure as far downstream from the fan as practicable and upstream from restrictions in ducts such as elbows and transitions.
 - b. Measure static pressure directly at the fan outlet or through the flexible connection.
 - c. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from flexible connection and downstream from duct restrictions.
 - d. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.
 - 2. Measure static pressure across each air-handling unit component.
 - 3. Compare design data with installed conditions to determine variations in design static pressures versus actual static pressures. Compare actual system effect factors with

- calculated system effect factors to identify where variations occur. Recommend corrective action to align design and actual conditions.
4. Adjust fan speed higher or lower than design. Make required adjustments to pulley sizes, motor sizes, and electrical connections to accommodate fan-speed changes.
 5. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure no overload will occur. Measure amperage in full cooling and full heating modes to determine the maximum required brake horsepower.
- C. Adjust volume dampers for main duct, submain ducts, and branch ducts to design airflows within specified tolerances.
1. Measure static pressure at a point downstream from the balancing damper and adjust volume dampers until the proper static pressure is achieved.
 - a. Where sufficient space in submains and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.
 2. Remeasure each submain and branch duct after all have been adjusted. Continue to adjust submains and branch ducts to design airflows within specified tolerances.
- D. Adjust terminal outlets and inlets for each space to design airflows within specified tolerances of design values. Make adjustments using volume dampers and the dampers at the air terminals.
1. Adjust each outlet in the same room or space to within specified tolerances of design quantities without generating noise levels above the limitations prescribed by the Contract Documents.
 2. Adjust patterns of adjustable outlets for proper distribution without drafts.

3.6 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

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

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

3.7 FUNDAMENTAL PROCEDURES FOR HYDRONIC SYSTEMS

- A. Prepare test reports with pertinent design data and number in sequence starting at pump to end of system. Check the sum of branch-circuit flows against approved pump flow rate.
- B. Prepare schematic diagrams of systems' "as-built" piping layouts.
- C. Prepare hydronic systems for testing and balancing according to the following, in addition to the general preparation procedures specified above:
 1. Open all manual valves for maximum flow.
 2. Check makeup-water-station pressure gage for adequate pressure for highest vent.
 3. Check flow-control valves for specified sequence of operation and set at design flow.
 4. Set system controls so automatic valves are wide open to heat exchangers.
 5. Check pump-motor load. If motor is overloaded, throttle main flow-balancing device so motor nameplate rating is not exceeded.
 6. Check air vents for a forceful liquid flow exiting from vents when manually operated.

3.8 HYDRONIC SYSTEMS' BALANCING PROCEDURES

- A. Determine water flow at pumps. Use the following procedures:
 1. Verify impeller size by operating the pump with the discharge valve closed. Verify with the pump manufacturer that this will not damage pump. Read pressure differential across the pump. Convert pressure to head and correct for differences in gage heights. Note the point on the manufacturer's pump curve at zero flow and confirm that the pump has the intended impeller size.
 2. Check system resistance. With all valves open, read pressure differential across the pump and mark the pump manufacturer's head-capacity curve. Adjust pump discharge valve until design water flow is achieved.

3. Verify pump-motor brake horsepower. Calculate the intended brake horsepower for the system based on the pump manufacturer's performance data. Compare calculated brake horsepower with nameplate data on the pump motor. Report conditions where actual amperage exceeds motor nameplate amperage.
- B. Set calibrated balancing valves, if installed, at calculated presettings.
 - C. Measure flow at all stations and adjust, where necessary, to obtain first balance.
 1. System components that have Cv rating or an accurately cataloged flow-pressure-drop relationship may be used as a flow-indicating device.
 - D. Measure flow at main balancing station and set main balancing device to achieve flow that is 5 percent greater than design flow.
 - E. Adjust balancing stations to within specified tolerances of design flow rate as follows:
 1. Determine the balancing station with the highest percentage over design flow.
 2. Adjust each station in turn, beginning with the station with the highest percentage over design flow and proceeding to the station with the lowest percentage over design flow.
 3. Record settings and mark balancing devices.
 - F. Measure pump flow rate and make final measurements of pump amperage, voltage, rpm, pump heads, and systems' pressures and temperatures, including outdoor-air temperature.
 - G. Measure the differential-pressure control valve settings existing at the conclusions of balancing.

3.9 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

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

3.10 MOTORS

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

3.11 HEAT-TRANSFER COILS

A. Water Coils: Measure the following data for each coil:

1. Entering- and leaving-water temperatures.
2. Water flow rate.
3. Water pressure drop.
4. Dry-bulb temperatures of entering and leaving air.
5. Airflow.
6. Air pressure drop.

3.12 TEMPERATURE TESTING

- #### A. During testing, adjusting, and balancing, report need for adjustment in temperature regulation within the automatic temperature-control system.
- #### B. Measure indoor wet- and dry-bulb temperatures every other hour for a period of 2 successive 8-hour days, in each separately controlled zone, to prove correctness of final temperature settings in 100% outside air systems.

3.13 TOLERANCES

A. Set HVAC system airflow and water flow rates within the following tolerances:

1. Supply, Return, and Exhaust Fans: Plus 5 to plus 10 percent.
2. Air Outlets and Inlets: 0 to plus 10 percent.
3. Heating-Water Flow Rate: 0 to plus 10 percent.

3.14 REPORTING

- #### A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article above, prepare a report on the adequacy of design for systems' balancing devices. Recommend changes and additions to systems' balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.
- #### B. Status Reports: As Work progresses, prepare reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.15 FINAL REPORT

- #### A. General: Typewritten, or computer printout in letter-quality font, on standard bond paper, in 3-ring binder, tabulated and divided into sections by tested and balanced systems.

- B. Include a certification sheet in front of binder signed and sealed by the certified testing and balancing engineer.
 - 1. Include a list of the instruments used for procedures, along with proof of calibration.
- C. Final Report Contents: In addition to the certified field report data, include the following:
 - 1. Pump curves.
 - 2. Fan curves.
 - 3. Manufacturers' test data.
 - 4. Field test reports prepared by system and equipment installers.
 - 5. Other information relative to equipment performance, but do not include approved Shop Drawings and Product Data.
- D. General Report Data: In addition to the form titles and entries, include the following data in the final report, as applicable:
 - 1. Title page.
 - 2. Name and address of testing, adjusting, and balancing Agent.
 - 3. Project name.
 - 4. Project location.
 - 5. Architect's name and address.
 - 6. Engineer's name and address.
 - 7. Contractor's name and address.
 - 8. Report date.
 - 9. Signature of testing, adjusting, and balancing Agent who certifies the report.
 - 10. Summary of contents, including the following:
 - a. Design versus final performance.
 - b. Notable characteristics of systems.
 - c. Description of system operation sequence if it varies from the Contract Documents.
 - 11. Nomenclature sheets for each item of equipment.
 - 12. Data for terminal units, including manufacturer, type size, and fittings.
 - 13. Notes to explain why certain final data in the body of reports vary from design values.
 - 14. Test conditions for fans and pump performance forms, including the following:
 - a. Settings for outside-, return-, and exhaust-air dampers.
 - b. Conditions of filters.
 - c. Cooling coil, wet- and dry-bulb conditions.
 - d. Face and bypass damper settings at coils.
 - e. Fan drive settings, including settings and percentage of maximum pitch diameter.
 - f. Settings for supply-air, static-pressure controller.
 - g. Other system operating conditions that affect performance.
- E. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present with single-line diagrams and include the following:
 - 1. Quantities of outside, supply, return, and exhaust airflows.
 - 2. Water flow rates.

F. Blower Coils and Air Handling Units Test Reports: For units with coils, include the following:

1. Unit Data: Include the following:
 - a. Unit identification.
 - b. Make and type.
 - c. Model number and unit size.
 - d. Discharge arrangement.
 - e. Sheave make, size in inches, and bore.
 - f. Sheave dimensions, center-to-center and amount of adjustments in inches.
2. Motor Data: Include the following:
 - a. Make and frame type and size.
 - b. Horsepower and rpm.
 - c. Volts, phase, and hertz.
 - d. Full-load amperage and service factor.
 - e. Sheave make, size in inches, and bore.
 - f. Sheave dimensions, center-to-center and amount of adjustments in inches.
3. Test Data: Include design and actual values for the following:
 - a. Total airflow rate in cfm.
 - b. Total system static pressure in inches wg.
 - c. Fan rpm.
 - d. Discharge static pressure in inches wg.
 - e. Cooling coil static-pressure differential in inches wg.
 - f. Heating coil static-pressure differential in inches wg.
 - g. Outside airflow in cfm.
 - h. Return airflow in cfm.
 - i. Outside-air damper position.
 - j. Return-air damper position.

G. Apparatus-Coil Test Reports: For apparatus coils, include the following:

1. Coil Data: Include the following:
 - a. System identification.
 - b. Location.
 - c. Coil type.
 - d. Number of rows.
 - e. Fin spacing in fins per inch.
 - f. Make and model number.
2. Test Data: Include design and actual values for the following:
 - a. Airflow rate in cfm.
 - b. Average face velocity in fpm.
 - c. Air pressure drop in inches wg.
 - d. Outside-air, wet- and dry-bulb temperatures in deg F.
 - e. Return-air, wet- and dry-bulb temperatures in deg F.

- f. Entering-air, wet- and dry-bulb temperatures in deg F.
- g. Leaving-air, wet- and dry-bulb temperatures in deg F.
- h. Water flow rate in gpm.
- i. Water pressure differential in feet of head or psig.
- j. Entering-water temperature in deg F.
- k. Leaving-water temperature in deg F.

H. Fan Test Reports: For supply, return, and exhaust fans, include the following:

- 1. Fan Data: Include the following:
 - a. System identification.
 - b. Make and type.
 - c. Model number and size.
 - d. Manufacturer's serial number.
 - e. Sheave make, size in inches, and bore.
- 2. Motor Data: Include the following:
 - a. Make and frame type and size.
 - b. Horsepower and rpm.
 - c. Volts, phase, and hertz.
 - d. Full-load amperage and service factor.
 - e. Sheave make, size in inches, and bore.
 - f. Sheave dimensions, center-to-center and amount of adjustments in inches.
- 3. Test Data: Include design and actual values for the following:
 - a. Total airflow rate in cfm.
 - b. Total system static pressure in inches wg.
 - c. Fan rpm.
 - d. Discharge static pressure in inches wg.
 - e. Suction static pressure in inches wg.

I. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:

- 1. Report Data: Include the following:
 - a. System and air-handling unit number.
 - b. Location and zone.
 - c. Traverse air temperature in deg F.
 - d. Duct static pressure in inches wg.
 - e. Duct size in inches.
 - f. Duct area in sq. ft..
 - g. Design airflow rate in cfm.
 - h. Design velocity in fpm.
 - i. Actual airflow rate in cfm.
 - j. Actual average velocity in fpm.

J. Instrument Calibration Reports: For instrument calibration, include the following:

1. Report Data: Include the following:

- a. Instrument type and make.
- b. Serial number.
- c. Application.
- d. Dates of use.
- e. Dates of calibration.

3.16 ADDITIONAL TESTS

- A. Within 90 days of completing testing, adjusting, and balancing, perform additional testing and balancing to verify that balanced conditions are being maintained throughout and to correct unusual conditions.
- B. Seasonal Periods: If initial testing, adjusting, and balancing procedures were not performed during near-peak summer and winter conditions, perform additional inspections, testing, and adjusting during near-peak summer and winter conditions.
- C. This Contractor shall include partial system and final system balancing of common hydronic and air based systems which cross phasing lines of this project. Each building or portion of building shall be balanced prior to owner occupancy. Each building shall then be rebalanced for any system which is connected to components in an adjacent building, and which was not completed at the time of initial balancing. Rebalancing shall be provided for as many phases as included in the General Contractor's construction schedule.
- D. Upon completion of testing and balancing for each building, the Contractor and Engineer shall field check up to 10% of all air devices, 10% of all hydronic devices and 10% of all equipment for verification of the Test and Balance Report Information. The Engineer shall randomly pick the items to be tested and the Contractor shall be responsible for testing the equipment in the presence of the Engineer and Owner. If 15% or more of each item type tested does not match the Test and Balance Report Information, the Contractor shall test an additional 10% of the items listed for testing. If 15% or more of each item type tested does not match the Test and Balance Report, the Contractor shall rebalance all devices and equipment.

END OF SECTION 230593

SECTION 230700 - DUCT INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes semirigid and flexible duct, plenum, and breeching insulation; insulating cements; field-applied jackets; accessories and attachments; and sealing compounds.
- B. Related Sections include the following:
 - 1. Division 07 Section "Firestopping" for firestopping materials and requirements for penetrations through fire and smoke barriers.
 - 2. Division 22 Section "Pipe Insulation" for insulation for piping systems.
 - 3. Division 23 Section "Metal Ducts" for duct liner.

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. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets with requirements indicated. Include dates of tests.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the U.S. Department of Labor, Bureau of Apprenticeship and Training.
- B. Fire-Test-Response Characteristics: As determined by testing materials identical to those specified in this Section according to ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and sealer and cement material containers with appropriate markings of applicable testing and inspecting agency.
 - 1. Insulation Installed Indoors: Flame-spread rating of 25 or less, and smoke-developed rating of 50 or less.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Packaging: Ship insulation materials in containers marked by manufacturer with appropriate ASTM specification designation, type and grade, and maximum use temperature.

1.6 COORDINATION

- A. Coordinate clearance requirements with duct Installer for insulation application.

1.7 SCHEDULING

- A. Schedule insulation application after testing duct systems. Insulation application may begin on segments of ducts that have satisfactory test results.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Mineral-Fiber Insulation:
 - a. CertainTeed.
 - b. Knauf FiberGlass GmbH.
 - c. Owens-Corning Fiberglas Corp.
 - d. Schuller International, Inc.
 - 2. Firewrap Insulation:
 - a. 3M

2.2 INSULATION MATERIALS

- A. Mineral-Fiber Board Thermal Insulation: Glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IB, without facing and with all-service jacket manufactured from kraft paper, reinforcing scrim, aluminum foil, and vinyl film. Thermal conductivity (k-value) shall not exceed 0.26 Btu x in./h x sq. ft. x deg F after 180 days of aging.
- B. Mineral-Fiber Blanket Thermal Insulation: 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. Thermal conductivity (k-value) shall not exceed 0.26 Btu x in./h x sq. ft. x deg F after 180 days of aging.
- C. Polystyrene: Rigid, extruded cellular polystyrene intended for use as thermal insulation. Comply with ASTM C 578, Type IV or Type XIII, except thermal conductivity (k-value) shall not exceed 0.24 Btu x in./h x sq. ft. x deg F at 75 deg F after 180 days of aging. Fabricate

shapes according to ASTM C 450 and ASTM C 585. Note: Polyurethane insulation to have the same performance properties.

- D. Fire-Rated Blanket (Firewrap): High-temperature, flexible, blanket insulation with FSK jacket that is tested and certified to provide a 2-hour fire rating and zero clearance to combustibles by a NRTL acceptable to authority having jurisdiction.

2.3 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. 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.
- D. Adhesive-Attached Anchor Pins and Speed Washers: Galvanized steel plate, pin, and washer manufactured for attachment to duct and plenum with adhesive. Pin length sufficient for insulation thickness indicated.
 - 1. Adhesive: Recommended by the anchor pin manufacturer as appropriate for surface temperatures of ducts, plenums, and breechings; and to achieve a holding capacity of 100 lb for direct pull perpendicular to the adhered surface.
- E. Self-Adhesive Anchor Pins and Speed Washers: Galvanized steel plate, pin, and washer manufactured for attachment to duct and plenum with adhesive. Pin length sufficient for insulation thickness indicated.

2.4 VAPOR RETARDERS

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

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 and fittings.
- B. Refer to schedules at the end of this Section for materials, forms, jackets, and thicknesses required for each duct 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.
- E. Seal joints and seams with vapor-retarder mastic on insulation indicated to receive a vapor retarder.
- F. Keep insulation materials dry during application and finishing.
- G. Apply insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by the insulation material manufacturer.
- H. Apply insulation with the least number of joints practical.
- I. Apply insulation over fittings and specialties, with continuous thermal and vapor-retarder integrity, unless otherwise indicated.
- J. Hangers and Anchors: Where vapor retarder is indicated, seal penetrations in insulation at hangers, supports, anchors, and other projections with vapor-retarder mastic. Apply insulation continuously through hangers and around anchor attachments.
- K. 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.
- L. 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 duct flanges and fittings.
- M. Cut insulation according to manufacturer's written instructions to prevent compressing insulation to less than 75 percent of its nominal thickness.
- N. Install vapor-retarder mastic on ducts and plenums scheduled to receive vapor retarders.
1. Ducts 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. Ducts without Vapor Retarders: Overlap insulation facing at seams and secure with outward clinching staples and pressure-sensitive tape having same facing as insulation.
- O. 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.
- P. Interior Wall and Partition Penetrations: Apply insulation continuously through walls and partitions, except fire-rated walls and partitions.
- Q. Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire/smoke damper sleeves for fire-rated wall and partition penetrations.
- R. 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 and Plenums: Secure blanket 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 and plenum surfaces.
 2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
 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 overcompress insulation during installation.
 - 4. Impale insulation over anchors and attach speed washers.
 - 5. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
 - 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 rectangular duct elbows and transitions with a full insulation segment for each surface. Apply insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
 - 9. Insulate duct stiffeners, hangers, and flanges that protrude beyond the insulation surface with 6-inch wide strips of the same material used to insulate duct. 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 Ducts and Plenums: 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 and plenum surfaces.
 - 2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
 - 3. Space anchor pins 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 overcompress insulation during installation.
 - 4. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
 - 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 stiffeners, hangers, and flanges that protrude beyond the insulation surface with 6-inch wide strips of the same material used to insulate duct. 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 DUCT SYSTEM APPLICATIONS

- A. Insulation materials and thicknesses are specified in schedules at the end of this Section.
- B. Materials and thicknesses for systems listed below are specified in schedules at the end of this Section.
- C. Items Not Insulated: Unless otherwise indicated, do not apply insulation to the following systems, materials, and equipment:
 1. Metal ducts with duct liner. (When located in a conditioned space)
 2. Factory-insulated flexible ducts.
 3. Factory-insulated plenums, casings, terminal boxes, and filter boxes and sections.
 4. Flexible connectors.
 5. Vibration-control devices.
 6. Testing agency labels and stamps.
 7. Nameplates and data plates.
 8. Access panels and doors in air-distribution systems.

3.6 INDOOR DUCT AND PLENUM APPLICATION SCHEDULE

- A. Service: Round, supply-air ducts and return air ducts, concealed and exposed, located in a heated space.
 1. Material: Mineral-fiber blanket.
 2. Thickness: 2 inches.
 3. Number of Layers: One.
 4. Factory-Applied Jacket: Foil and paper.
 5. Vapor Retarder Required: Yes.
- B. Service: Round, outside-air ducts, concealed and exposed, located in a heated space.
 1. Material: Mineral-fiber blanket.
 2. Thickness: 2 inches.
 3. Number of Layers: One.
 4. Factory-Applied Jacket: Foil and paper.
 5. Vapor Retarder Required: Yes.
- C. Service: Rectangular, supply-air and return-air ducts, concealed and exposed, located in a heated space.

1. Material: Mineral-fiber blanket.
 2. Thickness: 2 inches.
 3. Number of Layers: One.
 4. Factory-Applied Jacket: Foil and paper.
 5. Vapor Retarder Required: Yes.
- D. Service: Rectangular, outside-air ducts, concealed and exposed, located in a heated space.
1. Material: Mineral-fiber blanket.
 2. Thickness: 2 inches.
 3. Number of Layers: One.
 4. Factory-Applied Jacket: Foil and paper.
 5. Vapor Retarder Required: Yes.
- E. Service: Exhaust plenums located outside building envelope and 24" of connecting ductwork.
1. Material: AP Armaflex Self-adhering.
 2. Thickness: 1 inch.
 3. Number of Layers: One.
 4. Factory-Applied Jacket: None.
 5. Vapor Retarder Required: Yes.
- F. Service: Entire Grease exhaust ductwork from point of connection of hood to sidewall mounted exhaust fan.
1. Material: 3M Firemaster Duct Wrap.
 2. Thickness: 3"
 3. Number of Layers: 1
 4. Rating: 2 hours.
- G. Service: All moisture laden (including dishwasher) exhaust ducts:
1. Material: Mineral-fiber blanket.
 2. Thickness: 2 inches.
 3. Number of Layers: One.
 4. Factory applied jacket: Foil and paper.
 5. Vapor Retarder Required: Yes.

END OF SECTION 230700

SECTION 230710 – HVAC PIPE INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes preformed, rigid and flexible pipe insulation; insulating cements; field-applied jackets; accessories and attachments; and sealing compounds.
- B. Related Sections include the following:
 - 1. Division 07 Section "Penetration Firestopping" for firestopping materials and requirements for penetrations through fire and smoke barriers.
 - 2. Division 23 Section "Duct Insulation" for insulation for ducts and plenums.
 - 3. Division 23 Section "Hangers and Supports for HVAC Piping and Equipment" for pipe insulation shields and protection saddles.

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. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets with requirements indicated. Include dates of tests.

1.4 QUALITY ASSURANCE

- A. Fire-Test-Response Characteristics: As determined by testing materials identical to those specified in this Section according to ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and sealer and cement material containers with appropriate markings of applicable testing and inspecting agency. Revise subparagraphs below to suit Project and products selected.
 - 1. Insulation Installed Indoors: Flame-spread rating of 25 or less, and smoke-developed rating of 50 or less.
 - 2. Insulation Installed Outdoors: Flame-spread rating of 75 or less, and smoke-developed rating of 150 or less.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Packaging: Ship insulation materials in containers marked by manufacturer with appropriate ASTM specification designation, type and grade, and maximum use temperature.

1.6 COORDINATION

- A. Coordinate size and location of supports, hangers, and insulation shields specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."
- B. Coordinate clearance requirements with piping Installer for insulation application.
- C. Coordinate installation and testing of steam or electric heat tracing.

1.7 SCHEDULING

- A. Schedule insulation application after testing piping systems and, where required, after installing and testing heat-trace tape. Insulation application may begin on segments of piping that have satisfactory test results.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Mineral-Fiber Insulation:
 - a. CertainTeed Manson.
 - b. Knauf FiberGlass GmbH.
 - c. Owens-Corning Fiberglas Corp.
 - d. Schuller International, Inc.
 - e. Johns Manville.
 - 2. Flexible Elastomeric Thermal Insulation:
 - a. Armacell.
 - b. Rubatex Corp.

2.2 INSULATION MATERIALS

- A. Mineral-Fiber 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. U.L. 25/50 fire/smoke rating compliant, maximum 'k' value of 0.24 at 75 deg F.
 2. 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.
 3. Vapor-Retarder Mastics: Fire- and water-resistant, vapor-retarder mastic for indoor applications. Comply with MIL-C-19565C, Type II.
 4. Mineral-Fiber Insulating Cements: Comply with ASTM C 195.
- B. Flexible Elastomeric Thermal Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials, maximum 'k' value of 0.24 at 75 deg F.
1. Adhesive: As recommended by insulation material manufacturer.
 2. Ultraviolet-Protective Coating: As recommended by insulation manufacturer.
- C. 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. 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 Jacket Color: Color-code piping jackets based on materials contained within the piping system.
- C. Standard PVC Fitting Covers: Factory-fabricated fitting covers manufactured from 20-mil-thick, high-impact, ultraviolet-resistant PVC. U.L. 25/50 smoke/fire rating compliant.
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.
- D. Aluminum Jacket: Aluminum roll stock, ready for shop or field cutting and forming 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.

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, pre-sized, minimum 8 oz/sq. yd., tape width of 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.

2.5 VAPOR RETARDERS

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

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 pipe and fitting surfaces. 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; free of voids throughout the length of piping, including fittings, valves, and specialties.

- B. Refer to schedules at the end of this Section for materials, forms, jackets, and thicknesses required for each piping 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 insulation with longitudinal seams at top and bottom of horizontal pipe runs.
- E. Apply multiple layers of insulation with longitudinal and end seams staggered.
- F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
- G. Seal joints and seams with vapor-retarder mastic on insulation indicated to receive a vapor retarder.
- H. Keep insulation materials dry during application and finishing.
- I. Apply insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by the insulation material manufacturer.
- J. Apply insulation with the least number of joints practical.
- K. Apply insulation over fittings, valves, and specialties, with continuous thermal and vapor-retarder integrity, unless otherwise indicated. 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, taper insulation ends. Seal tapered ends with a compound recommended by the insulation material manufacturer to maintain vapor retarder.
- N. Apply adhesives and mastics at the manufacturer's recommended coverage rate.
- O. Apply insulation with integral jackets as follows:
 - 1. Pull jacket tight and smooth.

2. Circumferential Joints: Cover with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip and spaced 4 inches o.c.
 3. Longitudinal Seams: Overlap jacket seams at least 1-1/2 inches. Apply insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 4 inches o.c.
 - a. Exception: Do not staple longitudinal laps on insulation having a vapor retarder.
 4. Vapor-Retarder Mastics: Where vapor retarders are indicated, apply mastic on seams and joints and at ends adjacent to flanges, unions, valves, and fittings.
 5. At penetrations in jackets for thermometers and pressure gages, fill and seal voids with vapor-retarder mastic.
- P. 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. Extend metal jacket of exterior insulation outside roof flashing at least 2 inches below top of roof flashing.
 4. Seal metal jacket to roof flashing with vapor-retarder mastic.
- Q. Exterior Wall Penetrations: For penetrations of below-grade exterior walls, terminate insulation flush with mechanical sleeve seal. Seal terminations with vapor-retarder mastic.
- R. Interior Wall and Partition Penetrations: Apply insulation continuously through walls and floors.
- S. Fire-Rated Wall and Partition Penetrations: Apply insulation continuously through penetrations of fire-rated walls and partitions.
1. Firestopping and fire-resistive joint sealers are specified in Division 07 Section "Firestopping."
- T. Floor Penetrations: Apply insulation continuously through floor assembly.
1. For insulation with vapor retarders, seal insulation with vapor-retarder mastic where floor supports penetrate vapor retarder.
- 3.4 MINERAL-FIBER INSULATION APPLICATION
- A. Apply insulation to straight pipes and tubes as follows:
1. Secure each layer of pre-formed pipe insulation to pipe with wire, tape or bands without deforming insulation materials.
 2. Where pipe expansion is anticipated, detail expansion compensation for insulation on Drawings and indicate intervals for its occurrence. See MICA's "National Commercial & Industrial Insulation Standards," Plate No. 41A.

3. Where vapor retarders are indicated, seal longitudinal seams and end joints with vapor-retarder mastic. Apply vapor retarder to ends of insulation at intervals of 15 to 20 feet to form a vapor retarder between pipe insulation segments.
4. For insulation with factory-applied jackets, secure laps with outward clinched staples at 6 inches o.c.
5. For insulation with factory-applied jackets with vapor retarders, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by the insulation material manufacturer and seal with vapor-retarder mastic.

B. Apply insulation to flanges as follows:

1. Apply preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation segment the same as overall width of the flange and bolts, plus twice the thickness of the pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
4. Apply canvas jacket material with manufacturer's recommended adhesive, overlapping seams at least 1 inch, and seal joints with vapor-retarder mastic.

C. Apply insulation to fittings and elbows as follows:

1. Apply premolded insulation sections of the same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When premolded insulation elbows and fittings are not available, apply mitered sections of pipe insulation, or glass-fiber blanket insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire, tape, or bands.
3. Cover fittings with standard PVC fitting covers.

D. Apply insulation to valves and specialties as follows:

1. Apply premolded insulation sections of the same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When premolded insulation sections are not available, apply glass-fiber blanket insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation. For check valves, arrange insulation for access to strainer basket without disturbing insulation.
3. Apply insulation to flanges as specified for flange insulation application.
4. Use preformed standard or heavy PVC fitting covers for valve sizes where available. Secure fitting covers with manufacturer's attachments and accessories. Seal seams with tape and vapor-retarder mastic.
5. For larger sizes where PVC fitting covers are not available, seal insulation with canvas jacket and sealing compound recommended by the insulation material manufacturer.

3.5 FLEXIBLE ELASTOMERIC THERMAL INSULATION APPLICATION

A. Apply insulation to straight pipes and tubes as follows:

1. Follow 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 pipe surface.

B. Apply insulation to flanges as follows:

1. Apply pipe insulation to outer diameter of pipe flange.
2. Make width of insulation segment the same as overall width of the flange and bolts, plus twice the thickness of the pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of the same thickness as pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive. Cement to avoid openings in insulation that will allow passage of air to the pipe surface.

C. Apply insulation to fittings and elbows as follows:

1. Apply mitered sections of pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive. Cement to avoid openings in insulation that will allow passage of air to the pipe 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.

B. Apply PVC jacket where indicated, with 1-inch overlap at longitudinal seams and end joints. Seal with manufacturer's recommended adhesive.

C. Apply metal jacket where indicated, with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

3.7 FINISHES

A. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of the insulation manufacturer's recommended protective coating.

3.8 PIPING SYSTEM APPLICATIONS

A. Insulation materials and thicknesses are specified in schedules at the end of this Section.

B. Items Not Insulated: Unless otherwise indicated, do not apply insulation to the following systems, materials, and equipment:

1. Flexible connectors.
2. Vibration-control devices.

3. Fire-suppression piping.
4. Drainage piping located in crawl spaces, unless otherwise indicated.
5. Below-grade piping, unless otherwise indicated. See Section 15181 for below grade piping insulation requirements.
6. Chrome-plated pipes and fittings, unless potential for personnel injury.
7. Air chambers, unions, strainers, check valves, plug valves, and flow regulators.

3.9 FIELD QUALITY CONTROL

- A. Inspection: Perform the following field quality-control inspections, after installing insulation materials, jackets, and finishes, to determine compliance with requirements:
 1. Inspect fittings and valves randomly selected by Architect.
 2. Remove fitting covers from 20 elbows or 1 percent of elbows, whichever is less, for various pipe sizes.
 3. Remove fitting covers from 20 valves or 1 percent of valves, whichever is less, for various pipe sizes.
- B. Insulation applications will be considered defective if sample inspection reveals noncompliance with requirements. Remove defective Work and replace with new materials according to these Specifications.
- C. Reinstall insulation and covers on fittings and valves uncovered for inspection according to these Specifications.

3.10 INSULATION APPLICATION SCHEDULE, GENERAL

- A. Refer to insulation application schedules for required insulation materials, vapor retarders, and field-applied jackets.
- B. Application schedules identify piping system and indicate pipe size ranges and material, thickness, and jacket requirements.

3.11 INSULATION APPLICATION SCHEDULE

- A. Insulate the following piping systems with material and thickness as scheduled below:

Insulation Thickness In Inches for Pipe Sizes In Inches								
Interior Piping Service	Material	Less than 1"	1" to less than 1 ½"	1 ½" to less than 4"	4" to less than 8"	8" and larger	Notes	Vapor Barrier Yes/No
Chilled Water	Jacketed Fiberglass	1 ½	1 ½	2	2	2	2	Yes

(40-65° F)								
Heating Hot Water (100-200° F)	Jacketed Fiberglass	1 ½	1 ½	2	2	2	2	Yes
Condensate Drains	Jacketed Fiberglass or Flexible Elastomeric	1	1	1	1	1	2	Yes
Refrigerant Piping	Flexible Elastomeric	1	1	1	1	1	1	Yes

Notes:

1. All refrigerant piping to be insulated.
2. Where piping is installed exposed to view in finished spaces, cover with PVC or aluminum jacket. Piping installed in mechanical rooms expected to be exposed to impact or abuse shall be covered with a PVC or aluminum jacket.

B. Piping Exposed to Weather: Piping located outdoors and exposed to weather shall be insulated as indicated. The insulation shall then be protected with one of the following weatherproof finishes as indicated on contract drawings.

1. Metal jacketing shall be 0.016" (min.) aluminum or stainless steel with moisture barrier, secured in accordance with the jacket manufacturer's recommendations. Longitudinal joints shall be applied so they will shed water and shall be closed using pre-formed butt strips following manufacturer's recommendations for securement.
2. UV resistant PVC jacketing may be applied in lieu of metal jacketing for refrigerant piping provided jacketing manufacturer's limitations with regard to pipe size, surface temperature and thermal expansion and contraction are followed.
3. Fittings shall be insulated as prescribed above, jacketed with pre-formed fitting covers matching outer jacketing used on straight pipe sections, with all joints weather sealed.

END OF SECTION 230710

SECTION 230900 – HVAC INSTRUMENTATION AND CONTROLS

PART 1 - GENERAL

1.1 WORK INCLUDED:

A. Scope of Work

1. A fully integrated Building Automation System (BAS), incorporating direct digital control (DDC) for energy management, equipment monitoring and control, and subsystems with open communications capabilities as herein specified.
2. The BAS work shall consist of the provision of all labor, materials, tools, equipment, software, software licenses, software configurations and database entries, interfaces, wiring, tubing, installation, labeling, engineering, calibration, documentation, samples, submittals, testing, training services, permits and licenses, transportation, shipping, handling, administration, supervision, management, insurance, temporary protection, cleaning, cutting and patching, warranties, services, and items, even though these may not be specifically mentioned in this specification, which are required for the complete, fully functioned and commissioned BAS.
3. The existing BAS System currently serving Fair Acres Building 8 is CM3 Controls. The existing CM3 system shall remain in place and be expanded/modified to incorporate the proposed Renovations. Provide a fully operational system as defined within this specification. In addition, the following shall be provided:
 - a. New control panels and control module(s) as necessary to provide a fully operational system as outlined in this specification.
 - b. All cabling, wiring, hardware, and BAS network architecture infrastructure to connect all new BAS components to the existing BAS architecture and front end on campus. At the end of the project, all new equipment defined herein shall be seamlessly integrated into the existing Controls BAS system.
 - c. All existing sequences in place on campus shall remain as-is and operational at all times during renovations and additions.
 - d. Upgrade existing software as required so entire system is operating on same system.
4. Provide open communications system. The system shall be an open architecture with the capabilities to support a multi-vendor environment. The system shall not be limited to only use open communication protocols, but also be able to integrate a wide variety of third-party devices and applications via existing vendor protocols and through the latest software standards.
5. 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. All systems

and components shall have been thoroughly tested and proven in actual use for at least two years.

6. Provide system graphics for each controlled device and/or integrated systems specified herein. Origin of information shall be transparent to the operator and shall be controlled, displayed, trended, etc. as if the points were hardwired to the BAS.
7. The BAS Contractor is responsible for providing all wells, valves, dampers, flow stations, etc., for a complete and operable system. Devices shall be installed by mechanical contractor.
8. The BAS installation shall be performed by personnel directly employed by the manufacturer, or as a manufacturer's vendor (with the direct supervision of the controls manufacturer); with the shop drawings, flow diagrams, bill of materials, component designation, or identification number and sequence of operation all bearing the name of the manufacturer.
9. BAS manufacturer shall be responsible for all BAS and power wiring (line voltage and low voltage) for a complete and operable system. Refer to Part 1.2.B of this section for items provided by the electrical contractor. All wiring shall be done in accordance with all local and national codes. Refer to Division 26 for wire and conduit specifications. The BAS contractor shall wire all controls from the dedicated space provide by the Electrical Contractor in the dedicated electrical panels located in each facility:
 - a. All BAS Control Panels
 - b. Blower Coils
 - c. Electric Duct Heaters
 - d. Grease Exhaust Fans
 - e. Exhaust Fans

B. System Requirements

1. The system shall be scalable in nature and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, DDC Controllers, and operator devices.
2. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution. Each DDC Controller shall operate independently by performing its own specified control, alarm management, operator I/O, and data collection. The failure of any single component or network connection shall not interrupt the execution of any control strategy, reporting, alarming and trending function, or any function at any operator interface device.
3. The BAS shall use an open architecture and shall support a multi-vendor environment and be able to integrate a wide variety of third party devices and applications.

4. DDC Controllers shall be able to access any data from, or send control commands and alarm reports directly to, any other DDC Controller or combination of controllers on the network without dependence upon a central or intermediate processing device. DDC Controllers shall also be able to send alarm to multiple operator workstations without dependence upon a central or intermediate processing device.
5. DDC Controllers shall be able to assign password access and control priorities to each point individually. The Logon password (at any PC workstation or portable operator terminal) shall enable the operator to monitor, adjust or control only the points that the operator is authorized for. All other points shall not be displayed at the PC workstation or portable terminal. (e.g. all base building and all tenant points shall be accessible to any base building operators, but only certain base building and tenant points shall be accessible to tenant building operators). Passwords and priority levels for every point shall be fully programmable and adjustable.
6. All interface functions shall occur through a web-based browser based software for both local and remote access. Coordinate connection to each building network with owner's IT Department. Provide all components necessary for interface with building LAN.

1.2 RELATED SECTIONS

- A. The General Conditions of the Contract, Supplementary Conditions, and General Requirements are part of this specification and shall be used in conjunction with this section as part of the contract documents.
- B. Division 010000 – General and Special Conditions.
- C. Division 230000 – Mechanical
- D. Division 260000 – Electrical

1.3 WORK BY OTHERS

- A. Mechanical contractor installs all wells, valves, taps, dampers, flow stations, etc. furnished by BAS manufacturer.
- B. Electrical Contractor provides:
 1. Dedicated spaces in 120V panels for power source to all BAS control panels.
 2. Wiring of all power feeds through all disconnect starters to electrical motors. Including variable frequency controllers.
 3. Monitored fire alarm.

1.4 QUALITY ASSURANCE

- A. The BAS system shall be designed and installed, commissioned and serviced by factory trained personnel. BAS contractor shall have an in-place support facility within 100 miles of the site with

technical staff, spare parts inventory and necessary test and diagnostic equipment. The BAS contractor shall provide full time, on site, experienced project manager for this work, responsible for direct supervision of the design, installation, start up and commissioning of the B.M.S. The Bidder shall be regularly engaged in the installation and maintenance of BAS systems and shall have a minimum of ten (10) years of demonstrated technical expertise and experience in the installation and maintenance of B.M.S. systems similar in size and complexity to this project.

- B. Materials and equipment shall be the catalogued products of manufacturers regularly engaged in production and installation of automatic temperature control systems and shall be manufacturer's latest standard design that complies with the specification requirements.
- C. All electronic equipment shall conform to the requirements of FCC Regulation, Part 15, Governing Radio Frequency Electromagnetic Interference and be so labeled.
- D. All wireless devices shall conform to:
 - 1. The requirements of Title 47 of the Code of Federal Regulations, FCC Part 15, governing radio frequency intentional radiating devices and be issued a FCC user identification and be so labeled. CE Directive 1999/5/EC (Radio Equipment and Telecommunications Terminal Equipment and the Mutual Recognition of their Conformity).

1.5 CODES AND STANDARDS

- A. Work, materials, and equipment shall comply with the most restrictive of local, state, and federal authorities' codes and ordinances or these plans and specifications. As a minimum, the installation shall comply with current editions in effect 30 days prior to receipt of bids of the additional following codes and standards:
 - 1. National Electric Code (NEC).
 - 2. Federal Occupation, Safety, and Health Act (OSHA).

1.6 SYSTEM PERFORMANCE

- A. Performance Standards. System shall conform to the following minimum standards over network connections. Systems shall be tested using manufacturer's recommended hardware and software for operator workstation (server and browser for web-based systems).
 - 1. Graphic Display. A graphic with 20 dynamic points shall display with current data within 10 sec.
 - 2. Graphic Refresh. A graphic with 20 dynamic points shall update with current data within 8 sec. and shall automatically refresh every 15 sec.
 - 3. Alarm Response Time. An object that goes into alarm shall be annunciated within 15 sec. See Alarm Management section below for alarm routing and annunciation.

4. Performance. Programmable controllers shall be able to completely execute DDC control loops at a frequency adjustable down to once per sec. Select execution times consistent with the mechanical process under control.
5. Multiple Alarm Annunciations. Each workstation on the network shall receive alarms within 5 sec of other workstations.

1.7 SUBMITTALS

- A. Product Submittal Requirements: Provide drawings as hard copies on 11" x 17" prints of each drawing. When manufacturer's cutsheets apply to a product series rather than a specific product, clearly indicate applicable data by highlighting or by other means. Clearly reference covered specification and drawing on each submittal. General catalogs shall not be accepted as cut sheets to fulfill submittal requirements. Select and show submittal quantities appropriate to scope of work.
- B. Submittal data shall consist of the following:
 1. Direct Digital Control System Hardware:
 - a. Complete bill of materials indicating quantity, manufacturer, model number, and relevant technical data of equipment to be used.
 - b. Manufacturer's description and technical data, such as product specification sheets, installation and maintenance instructions for items listed below and for relevant items not listed below:
 - 1) Direct Digital Controllers (controller panels).
 - 2) Control Panels
 - 3) Power Supplies
 - 4) Operator Interface Equipment
 - c. Wiring diagrams and layouts for each control panel. Show all termination numbers.
 2. Central System Hardware and Software:
 - a. Complete bill of material indicating quantity, manufacturer, model number, and relevant technical data of equipment used.
 - b. Manufacturer's description and technical data such as product specifications for items listed below and for relevant items furnished under this contract not listed below:
 - 5) Operator Interface Software
 - 6) Color Graphic Software

- c. Schematic diagrams of all control, communication, and power wiring for central system installation. Show interface wiring to control system.
 - d. Provide a list of BAS point naming convention. Indicate the format, structure and standards of typical point names. Provide a list of point names for typical equipment and functions with specific examples.
- 3. Controlled Systems:
 - a. Riser diagrams showing control network layout, communication protocol, and wire types.
 - b. Schematic diagram of each controlled system. Label control points with point names. Graphically show locations of control elements.
 - c. Schematic wiring diagram of each controlled system. Label control elements and terminals. Where a control element is also shown on control system schematic use the same name.
 - d. Complete description of control system operation including sequences of operation. Include and reference schematic diagram of controlled system.
 - e. Point list for each system controller including both inputs and outputs (I/O), point numbers, controlled device associated with each I/O point, and location of I/O device.
- C. After completion of installation, and prior to submitting O & M Manuals, the BAS contractor shall submit in writing that the installation is complete, the system is functioning, the system graphics are complete, and that all sequences have been tested and are operational and that all initial set points have been set.
- D. Project Record Documents: Submit record (as-built) documents upon completion of installation. Submittal shall consist of:
 - 1. Project Record Drawings. As-built versions of the submittal shop drawings provided as 11" x 17" prints.
 - 2. Operation and Maintenance (O & M) Manual.
 - a. As-built versions of the submittal product data.
 - b. Names, addresses, and 24-hour telephone numbers of installing contractors and service representatives for equipment and control systems.
 - c. Operator's Manual with procedures for operating control systems, logging on and off, handling alarms, producing point reports, trending data, overriding computer control, and changing set points and variables.
 - d. Graphic files, programs, and database on magnetic or optical media.

1.8 WARRANTY

- A. Warrant labor and materials for specified control system free from defects for a period of 12 months after final acceptance. Failures on control systems that include all computer equipment, transmission equipment and all sensors and control devices during warranty period shall be adjusted, repaired, or replaced at no additional cost or reduction in service to Owner. Respond during normal business hours within next business day of Owner's warranty service request.
- B. Work shall have a single warranty date, even if Owner receives beneficial use due to early system start-up. If specified work is split into multiple contracts or a multi-phase contract, each contract or phase shall have a separate warranty start date and period.

1.9 OWNERSHIP OF PROPRIETARY MATERIAL

- A. Project specific software and documentation shall become Owner's property. This includes, but not limited to:
 - 1. Graphics
 - 2. Record drawings
 - 3. Database
- B. Operating manual to serve as training and reference manual for all aspects of day-to-day operation of the system. As a minimum include the following:
 - 1. Sequence of operation for automatic and manual operating modes for all building systems. The sequences shall cross reference the system point names.
 - 2. BAS system manufacturers complete operating manuals.
- C. Provide maintenance manual to serve as training and reference manual for all aspects of day-to-day maintenance and major system repairs. As a minimum include the following:
 - 1. Complete as-built installation drawings for each building system.
 - 2. Manufacturer's operation, set-up, maintenance and catalog literature for each piece of equipment.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. All products used in this project installation shall be new and currently manufactured and shall have been applied in similar installations. Do not use this installation as a product test site unless explicitly approved in writing by Owner or Owner's representative. Spare parts shall be available for at least five years after completion of this contract.

2.2 COMMUNICATIONS

- A. The design of the BAS shall support networking of operator workstations and Building Controllers. The network architecture shall consist of two levels, an Ethernet based primary network for all operator workstations, servers, and primary DDC controllers along with secondary Floor Level Networks (FLN) for terminal equipment application specific controllers.
- B. Access to system data shall not be restricted by the hardware configuration of the building management system. The hardware configuration of the BAS network shall be totally transparent to the user when accessing data or developing control programs.
- C. Operator Workstation Communication:
 - 1. All color graphic operator workstations shall reside on the Ethernet network and the consoles shall be set up in a client/server configuration.
 - 2. Network shall allow concurrent use of multiple BAS software licenses.
- D. Management Level Network Communication (MLN)
 - 1. Any controller residing on the primary network shall connect to Ethernet network without the use of a PC or a gateway with a hard drive.
 - 2. Any PC on the Primary Network shall have transparent communication with controllers on the building level networks connected via Ethernet.
 - 3. Any break in Ethernet communication from the PC to the controllers on the Primary Network shall result in a notification at the PC.
 - 4. System software applications will run as a service to allow communication with Primary Network Controllers without the need for user log in. Closing the application or logging off shall not prevent the processing of alarms, network status, panel failures, and trend information.
- E. Primary Network – Panel to Panel Communication:
 - 1. All Building Controllers shall directly reside on the primary Ethernet network such that communications may be executed directly between Building Controllers, directly between server and Building Controllers on a peer-to-peer basis.
 - 2. Systems that operate via polled response or other types of protocols that rely on a central processor, file server, or similar device to manage panel-to-panel or device-to-device communications shall not be acceptable.
 - 3. All operator interfaces shall have the ability to access all point status and application report data or execute control functions for any and all other devices. Access to data shall be based upon logical identification of building equipment. No hardware or software limits shall be imposed on the number of devices with global access to the network data.
 - 4. The primary network shall use TCP/IP over Ethernet. All devices must:

- a. Auto-sense 10/100 Mbps networks.
 - b. Allow MMI access to an individual Primary Network Controller using industry standard Telnet software to view and edit entire Primary Network.
- 5. The primary network shall provide the following minimum performance:
 - a. Provide high-speed data transfer rates for alarm reporting, report generation from multiple controllers and upload/download efficiency between network devices. System performance shall insure that an alarm occurring at any Building Controller is displayed at any PC workstations, all Building controllers, and other alarm printers within 15 seconds.
 - b. Message and alarm buffering to prevent information from being lost.
 - c. Error detection, correction, and re-transmission to guarantee data integrity.
 - d. Synchronization of real-time clocks between Building Controllers, including automatic daylight savings time corrections.
 - e. The primary network shall allow the Building Controllers to access any data from, or send control commands and alarm reports directly to, any other Building Controller or combination of controllers on the network without dependence upon a central or intermediate processing device. Building Controllers shall send alarm reports to multiple operator workstations without dependence upon a central or intermediate processing device. The network shall also allow any Building controller to access, edit, modify, add, delete, back up, restore all system point database and all programs.
 - f. The primary network shall allow the Building Controllers to assign password access and control priorities to each point individually. The logon password (at any PC workstation or portable operator terminal) shall enable the operator to monitor, adjust and control only the points that the operator is authorized for. All other points shall not be displayed at the PC workstation or portable terminal. (e.g. all base building and all tenant points shall be accessible to any base building operators, but only certain base building and tenant points shall be accessible to tenant building operators). Passwords and priorities for every point shall be fully programmable and adjustable.
 - g. Devices containing custom programming must reside on the Primary Network.
- F. Secondary Network – Application Specific Controller Communication:
 - 1. Communication over the secondary network shall be the manufacturer's standard protocol.
 - 2. This level communication shall support a family of application specific controllers for terminal equipment.
 - 3. The Application Specific Controllers shall communicate bi-directionally with the primary network through Building Controllers for transmission of global data.

4. A maximum of 30 terminal equipment controllers may be configured on individual secondary network trunks to insure adequate global data and alarm response times.

2.3 BUILDING CONTROLLER SOFTWARE

A. General

1. Furnish the following applications software to form a complete operating system for building and energy management as described in this specification.
2. The software programs specified in this Section shall be provided as an integral part of Building Controllers and shall not be dependent upon any higher level computer or another controller for execution.
3. All points, panels and programs shall be identified by a 30 character name. All points shall also be identified by a 16 character point descriptor. The same names shall be displayed at both Building Controller and the Operator Interface.
4. All digital points shall have a user defined two-state status indication with 8 characters minimum (e.g. Summer, Enabled, Disabled, Abnormal).
5. Building Controllers shall have the ability to perform energy management routines including but not limited to time of day scheduling, calendar-based scheduling, holiday scheduling, temporary schedule overrides, start stop time optimization, automatic daylight savings time switch over, night setback control, enthalpy switch over, peak demand limiting, temperature-compensated duty cycling, heating / cooling interlock, supply temperature reset, priority load shedding, and power failure restart.
6. The Building 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
 - f. Model-Free Adaptive Control
7. Building Controllers shall not be susceptible to Microsoft Windows operating systems based viruses.

B. System Security

1. User access shall be secured using individual security passwords and user names.

2. Passwords shall restrict the user to the objects, applications, and system functions as assigned by the system manager.
3. Building Controllers shall be able to assign a minimum of 50 passwords access and control priorities to each point individually. The logon password (at any Operator Interface or portable operator terminal) shall enable the operator to monitor, adjust and control only the points that the operator is authorized for. All other points shall not be displayed at the Operator Interface or portable terminal. Passwords and priorities for every point shall be fully programmable and adjustable.
4. User Log On / Log Off attempts shall be recorded.
5. The system shall protect itself from unauthorized use by automatically logging off following the last keystroke. The delay time shall be user-definable.
6. Use of workstation resident security as the only means of access control is not an acceptable alternative to resident system security in the field panel.

C. User Defined Control Applications

1. Controllers shall be able to execute custom, job-specific processes defined by the user, to automatically perform calculations and special control routines.
2. It shall be possible to use any system measured point data or status, any system calculated data, a result from any process, or any user-defined constant in any controller in the system.
3. Any process shall be able to issue commands to points in any and all other controllers in the system.
4. Processes shall be able to generate operator messages and advisories to other operator I/O devices. A process shall be able to directly send a message to a specified device or cause the execution of a dial-up connection to a remote device such as a printer or pager.
5. Each controller shall support plain language text comment lines in the operating program to allow for quick troubleshooting, documentation, and historical summaries of program development.

D. Alarm Management

1. Alarm management shall be provided to monitor and direct alarm information to operator devices. Each Building 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 Building 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.
2. Conditional alarming shall allow generation of alarms based upon user defined multiple criteria.
3. All alarm or point change reports shall include the point's user defined language description and the time and date of occurrence.

4. The user shall be able to define the specific system reaction for each point. Alarms shall be prioritized to minimize nuisance reporting and to speed operator response to critical alarms. A minimum of six priority levels shall be provided for each point. Point priority levels shall be combined with user definable destination categories (PC, printer, Building Controller, email, text message, etc.) to provide full flexibility in defining the handling of system alarms. Each Building Controller shall automatically inhibit the reporting of selected alarms during system shutdown and start-up. Users shall have the ability to manually inhibit alarm reporting for each point.
5. Alarm reports and messages shall be routed to user-defined list of operator workstations, or other devices based on time and other conditions. An alarm shall be able to start programs, print, be logged in the event log, generate custom messages, and display graphics.
6. In addition to the point's descriptor and the time and date, the user shall be able to print, display or store a 200 character alarm message to more fully describe the alarm condition or direct operator response.
 - a. Each Building Controller shall be capable of storing a library of at least 50 alarm messages. Each message may be assignable to any number of points in the Controller.

E. Scheduling

1. Provide a comprehensive menu driven program to automatically start and stop designated object or group of objects in the system according to a stored time.
2. Schedules shall reside in the building controller and shall not rely on external processing or network.
3. It shall be possible to define a group of objects as a custom event (i.e. meeting, athletic activity, etc.). Events can then be scheduled to operate all necessary equipment automatically.
4. For points assigned to one common load group, it shall be possible to assign variable time delays between each successive start and/or stop within that group.
5. The operator shall be able to define the following information.
 - a. Time, day
 - b. Commands such as on, off, auto, etc.
 - c. Time delays between successive commands.
 - d. There shall be provisions for manual overriding of each schedule by an authorized operator.
6. It shall be possible to schedule calendar-based events up to one year in advance based on the following:

- a. Weekly Schedule. Provide separate schedules for each day of the week. Each of these schedules should include the capability for start, stop, optimal start, optimal stop, and night economizer. When a group of objects are scheduled together as an Event, provide the capability to adjust the start and stop times for each member.
 - b. Exception Schedules. Provide the ability for the operator to designate any day of the year as an exception schedule. Exception schedules may be defined up to a year in advance. Once an exception schedule is executed, it will be discarded and replaced by the standard schedule for that day of the week.
 - c. Holiday Schedules. Provide the capability for the operator to define up to 99 special or holiday schedules. These schedules may be placed on the scheduling calendar and will be repeated each year. The operator shall be able to define the length of each holiday period.
- F. Automatic Daylight Savings Time Switchover: The system shall provide automatic time adjustment for switching to/from Daylight Savings Time.
- G. Night setback control. The system shall provide the ability to automatically adjust set points for night control.
- H. Loop Control. A Model-Free Adaptive Control algorithm or alternatively a PID (proportional-integral-derivative) closed-loop control algorithm with direct or reverse action and anti-windup shall be supplied. The algorithm shall calculate a time-varying analog value that is used to position an output or stage a series of outputs. The controlled variable, set point, and weighting parameters shall be user-selectable.
- I. Sequencing. Provide application software based upon the sequences of operation specified to properly sequence equipment.

2.4 BUILDING CONTROLLERS

- A. Building Controllers shall be 32 bit, multi-tasking, multi-user, real-time 48 MHz 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 this specification and the attached point list.
- B. Each Building Controller shall support a minimum of 3 directly connected Secondary Networks.
- C. Each Building Controller shall have sufficient memory, a minimum of 72 megabyte, to support its own operating system and databases, including control processes, energy management applications, alarm management applications, historical/trend data for points specified, maintenance support applications, custom processes, operator I/O, and dial-up communications.
- D. Building Controller shall have an integral real-time clock.
- E. Each Building Controller shall support firmware upgrades without the need to change hardware.
- F. Each Building Controller shall support.

1. Monitoring of industry standard analog and digital inputs, without the addition of equipment outside the Building Controller cabinet.
- G. Spare Point Capacity.
1. Provide all processors, power supplies, and communication controllers so that the implementation of adding a point to the spare point location only requires the addition of the appropriate.
 - a. Expansion modules
 - b. Sensor/actuator
 - c. Field wiring/tubing
- H. Manual Override. The operator shall have the ability to manually override automatic or centrally executed commands at the Building Controller via local, point discrete, integral hand/off/auto operator override switches for all digital control type points and gradual switches for all analog control type points. These override switches shall be operable whether the panel processor is operational or not. Each Building Controller shall monitor and alarm the hand, off and auto positions of integral HOA switches.
- I. I/O Status and Indication. Building Controllers shall provide local LED status indication for each digital input and output for constant, up-to-date verification of all point conditions without the need for an operator I/O device. Graduated intensity LEDs or analog indication of value shall also be provided for each analog output. All wiring connections shall be made to field-removable terminals.
- J. Self-Diagnostics. Each Building Controller shall continuously perform self-diagnostics, communication diagnosis, and diagnosis of all panel components. The Building Controller shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication for any system.
- K. Power loss. In the event of the loss of power, there shall be an orderly shutdown of all Building 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 hours.
- L. Environment.
1. Controller hardware shall be suitable for the anticipated ambient conditions.
 2. Controllers used outdoors and/or in wet ambient conditions shall be mounted within waterproof enclosures and shall be rated for operation at 0°C to 49°C (32°F to 120°F).
 3. Controllers used in conditioned space shall be mounted in dust-proof enclosures and shall be rated for operation at 0°C to 49°C (32°F to 120°F).
- M. Immunity to power and noise.

1. Controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage.
 - a. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 1 m (3 ft).

2.5 POWER SUPPLIES AND LINE FILTERING

- A. Control transformers shall be UL listed. Furnish Class 2 current-limiting type or furnish over-current protection in both primary and secondary circuits for Class 2 service in accordance with NEC requirements. Limit connected loads to 80% of rated capacity.

2.6 COMMUNICATION AND CONTROL WIRING

- A. General:
 1. Provide copper wiring, plenum cable, and raceways as specified in the applicable sections of Division 16 unless otherwise noted herein.
 2. All insulated wire to be copper conductors, UL labeled for 90°C minimum service.
 3. All wiring shall be in EMT or rigid conduit, as required by code. Open wiring will be accepted, where code permits, but must be installed in a neat, workmanlike manner in association with building contours. In all exposed areas, wiring shall be in EMT.
 4. Where feasible, existing wire & conduit for signal control & power circuits may be reused.
- B. Communication Wiring
 1. Ethernet Cable shall be minimum CAT5.
 2. Secondary level network shall be 24 gage, TSP, low capacitance cable.

2.7 INPUT/OUTPUT INTERFACE

- A. Hardwired inputs and outputs may tie into the system through building or application specific controllers.
- B. All input points and output points shall be protected such that shorting of the point to itself, to another point, or to ground will cause no damage to the controller. All input and output points shall be protected from voltage up to 24 V of any duration, such that contact with this voltage will cause no damage to the controller.
- C. Binary inputs shall allow the monitoring of On/Off signals from remote devices. The binary inputs shall provide a wetting current of at least 12 mA to be compatible with commonly available control devices and shall be protected against the effects of contact bounce and noise. Binary inputs shall sense “dry contact” closure without external power (other than that provided by the controller) being applied.

- D. Pulse accumulation input objects. This type of object shall conform to all the requirements of binary input objects and also accept up to 10 pulses per second for pulse accumulation.
- E. Analog inputs shall allow the monitoring of low-voltage (0 to 10 VDC), current (4 to 20 mA), or resistance signals (thermistor, RTD). Analog inputs shall be compatible with—and field configurable to—commonly available sensing devices.
- F. Binary outputs shall provide for On/Off operation or a pulsed low-voltage signal for pulse width modulation control. Binary outputs on building and custom application controllers shall have three-position (On/Off/Auto) override switches and status lights. Outputs shall be selectable for either normally open or normally closed operation.
- G. Analog outputs shall provide a modulating signal for the control of end devices. Outputs shall provide either a 0 to 10 VDC, 4 to 20 mA or 0-20 PSI signal as required to provide proper control of the output device. Analog outputs on building or custom application controllers shall have status lights and a two-position (AUTO/MANUAL) switch and manually adjustable potentiometer for manual override. Analog outputs shall not exhibit a drift of greater than 0.4% of range per year.
- H. System Object Capacity. The system size shall be expandable to at least twice the number of input/ output objects required for this project. Additional controllers (along with associated devices and wiring) shall be all that is necessary to achieve this capacity requirement. The operator interfaces installed for this project shall not require any hardware additions or software revisions in order to expand the system.

2.8 FIELD DEVICES

A. Input Control Devices

- 1. Current Switches shall have an internal transformer operating normally open and/or normally closed contacts through a trip point adjustment. As a minimum, current switches shall have a range of 1A to at least 120% of the full load current rating of the equipment to be monitored. Where the equipment current rating exceeds the range of the current switch, a current transformer shall be provided to “step down” the current within the range of the switch. The current transformer shall have a current ratio with an upper limit that is at least 120% of the full load current rating of the equipment to be monitored with accuracy equal to $\pm 5\%$ of the range. Switch contacts shall be rated for the loads to be switched.
- 2. Current Transducers/Sensors shall have solid state design with adjustable threshold. Current Transducers/Sensors shall have a built-in power supply and shall provide a signal compatible with controller inputs. As a minimum, current transducers/sensors shall have a range of 0 to at least 120% of the full load current rating of the equipment to be monitored with accuracy equal to $\pm 3\%$ of the range. Where the equipment current rating exceeds the range of the current transducer/sensor, a current transformer shall be provided to “step down” the current within the range of the transducer/sensor. The current transformer shall have a current ratio with an upper limit that is at least 120% of the full load current rating of the equipment to be monitored with accuracy equal to $\pm 5\%$ of the range. Current transducers/sensors for variable frequency drives shall have a polymer core and shall provide current sensing with accuracy equal to $\pm 0.5\%$ of the range.

3. Differential Pressure Switches shall have an internal diaphragm operating a snap-acting switch with normally open and/or normally closed contacts through a sensitivity (setpoint) adjustment screw. As a minimum, differential pressure switches shall have a range covering the upper and lower limits of the media to be sensed. Switch contacts shall be rated for the loads to be switched.
4. End Switches shall provide true mechanical operation of normally open and/or normally closed contacts. Switch contacts shall be rated for the loads to be switched.
5. Flow Switches shall have paddle segments, accommodating 1-inch diameter and larger pipes, operating a snap-acting switch with normally open and/or normally closed contacts through a sensitivity (setpoint) adjustment screw. Switch contacts shall be rated for the loads to be switched.
6. Flow Meters shall be insertion type with dual turbine rotors, a non-magnetic sensing mechanism, and shall provide a signal compatible with controller inputs. As a minimum, flow meters shall have a range of 0.4 to 30 feet/second with accuracy equal to $\pm 2\%$ of the range. Flow meters shall include a full port ball valve for installation and removal, and a local display.
7. Humidity Sensors shall have a capacitive sensing element and shall provide a signal compatible with controller inputs. As a minimum, humidity sensors shall have a range of 0 to 95% relative humidity (RH) between the upper and lower temperature limits of air to be sensed, accuracy equal to $\pm 3\%$ over the range of 20 to 90% RH, and stability as measured by no more than 1% drift per year. The following criteria shall be used for selecting humidity sensors:
 - a. Duct Sensors shall be used in all ductwork or for sensing outdoor air at intakes before any dampers when mounting of an outdoor sensor is not feasible, as approved by the Professional.
 - b. Outdoor Sensors shall be used when the North outdoor building exposure is available and accessible. Outdoor sensors shall be manufactured with a weatherproof enclosure.
 - c. Space Sensors shall be used in all open areas.
8. Pressure Sensors shall have a capacitive sensing element and shall provide a signal compatible with controller inputs. As a minimum, pressure sensors shall have a range of 0 to the upper limit of the media to be sensed with accuracy equal to $\pm 1\%$ of the range. Sensors for monitoring space static pressure shall be furnished with a range of -0.1 to +0.1-inches WC and shall include a minimum NEMA type 4 enclosure when mounted exposed. Sensors for monitoring water differential pressure shall be furnished with snubbers for protection against shocks and pulsations. Sensors for monitoring steam pressure shall be furnished with snubbers for protection against shocks and pulsations, and steam pigtail siphons for protection against high temperatures. Atmospheric pressure shall be sensed as required using an outdoor air static pressure sensor (reference).
9. Pressure-Electric Switches shall have an internal diaphragm operating a snap-acting switch with normally open and/or normally closed contacts through a sensitivity (setpoint) adjustment screw. As a minimum, pressure-electric switches shall have a range covering

the upper and lower limits of the media to be sensed. Switch contacts shall be rated for the loads to be switched.

10. Temperature Sensors shall be Resistance Temperature Detector (RTD) type of 500 ohm balco, 100 or 3000 ohm platinum and shall provide a signal compatible with controller inputs. As a minimum, temperature sensors shall have a range covering the upper and lower limits of the media to be sensed, accuracy equal to $\pm 0.36^{\circ}\text{F}$, and stability as measured by no more than 0.24°F drift over five years. The following criteria shall be used for selecting temperature sensors:
 - a. Duct Averaging Sensors shall be used where air stratification may be a problem, such as in mixed air.
 - b. Duct Probe Sensors shall be used where air temperature is consistent across ductwork, such as in supply or return air. Duct probe sensors may also be used for sensing outdoor air at intakes before any dampers when mounting of an outdoor sensor is not feasible, as approved by the Engineer. Duct probe sensors used for sensing outdoor air shall have an RTD sensing element only.
 - c. Immersion Sensors shall be used for sensing liquid temperature in pipes. Brass thermal wells shall be furnished for installation of immersion sensors in piping. Stainless steel thermal wells shall be furnished for installation of immersion sensors in piping.
 - d. Outdoor Sensors shall be used when the North outdoor building exposure is available and accessible. Outdoor sensors shall have an RTD sensing element only and shall be manufactured with a weatherproof enclosure.
 - e. Strap-On Sensors shall be used for sensing liquid temperature in pipes where the installation of thermal wells is not practical, as approved by the Professional.
11. Space Thermostats: All thermostats shall be digital with LCD display of space temperature. Thermostats shall have "up/down" buttons for adjustment of space temperature. Color shall be white. Slide-bar and thumbwheel style thermostats shall not be accepted. All thermostats shall interface with the DDC system to allow the BAS to limit local thermostat setpoint control range. Thermostats shall have occupied override button with adjustable time.

B. Output Control Devices

1. Relays shall be plug-in style with one or more sets of normally open and/or normally closed contacts and a snap-mount socket for panel mounting. Relays for field mounting may be a one-piece assembly. Relay contacts shall be rated for the loads to be switched.

C. Safety Control Devices

1. Freezestats shall have an extended sensing element, manual reset, and a temperature range down to at least 15°F . Freezestat contacts shall be rated for the loads to be switched. Freezestats with manual resets shall be provided where indicated. The sensing elements shall be not less than 20 feet long, and shall be installed to sense all representative temperatures across the entire duct or unit cross section.

D. Local Controls Devices

1. Electric Thermostats shall provide switching of electrical contacts in response to changes in temperature. Thermostats shall be heating and/or cooling as required, and shall be furnished with a setpoint adjustment over a range including all setpoints indicated. Thermostat contacts shall be rated for the loads to be switched. The following criteria shall be used for selecting thermostats:
 - a. Aquastats (Bulb Thermostats) shall be used for sensing liquid temperature in pipes where the installation of thermal wells is not practical.
 - b. Space Thermostats shall be used in all open areas and shall include a locking cover. Space thermostats shall be programmable or non-programmable as required.

E. Control Dampers

1. Control dampers shall be of the multi-louver type with adjacent blades rotating in opposite directions for proportional control and in parallel directions for 2-position control unless noted otherwise. Frames shall be constructed from hat-shaped channel and blades shall be a maximum of 6-inches wide. Axles shall be 1/2-inch diameter plated steel and bearings shall be either synthetic or oil-impregnated sintered bronze. A removable 6-inch x 1/2-inch diameter control shaft shall be provided for external mounting of actuator(s). Dampers shall have a mill finish and shall be furnished in the size required for installation. Linkage may be either exposed or concealed in the frame. Where damper size exceeds the maximum available for a single section, linkage shall be provided to allow multiple sections to operate as a single damper. All dampers shall be low-leakage, with 1% maximum leakage level per AMCA Standard 500. Dampers shall be fabricated of galvanized steel with airfoil blades, flexible metal or extruded silicone jamb seals, and rubber blade seals.

F. Control Valves

1. Control valves shall be 2-way sized for the required flow rates, as indicated on the contract drawings. All valves shall be globe style or characterized ball valves with a TEFZEL flow characterizing disc in the inlet of 2-way valves or in the control port of 3-way valves. 3-way valves shall be mixing type, unless noted otherwise. Flow type shall be equal percentage. Valves up to 2-inches in size shall have brass or bronze bodies, brass or stainless steel ball/trim, screwed ends, and ANSI Class 250 pressure rating. Valves 2-1/2-inches in size and larger shall have cast iron or cast carbon steel bodies, brass or stainless steel trim, flanged ends, and ANSI Class 125 pressure rating. All valves shall be rated for operation from 40°F to 250°F. The following criteria shall be used for sizing control valves:
 - a. Proportional valves in water lines shall be sized for a 3 to 5 psi pressure drop across the valve.
 - b. 2-position valves in water lines shall be line size or sized for a pressure drop across the valve equal to 10% of system water pressure.
 - c. Differential pressure valves across water lines shall be sized for a pressure drop equal to system water pressure at total system water flow.

- d. All control valves shall be modulating except hot water control valves for radiant ceiling panels, hot water cabinet heaters and hot water unit heaters.

G. Actuators

1. Actuators and linkage for control dampers shall meet the following criteria:
 - a. Actuators shall be proportional or 2-position type as required to achieve the sequence of operation.
 - b. Actuators shall be spring return or non-spring return type as required to achieve the sequence of operation. Normal positions for dampers with spring return actuators, determined by loss of power, are indicated on the contract drawings.
 - c. Actuators for single section dampers shall be sized using a minimum requirement of 5 in.-lb. torque (at the control shaft) per square foot of damper area. Actuators for multiple section dampers with a jackshaft linkage assembly shall be sized using a minimum requirement of 7 in.-lb. torque (at the control shaft) per square foot of damper area.
 - d. Actuators shall be direct coupled type.
 - e. Damper operators shall be designed for line voltage operation.
 - f. Provide smooth proportional control with sufficient power for air velocities 20 percent greater than maximum design velocity and to provide tight seal against maximum system pressures. Provide spring return for all actuators and for fail safe operation.
 - g. Electric Operators: Split phase type with oil immersed gear train.
 - h. Number: Sufficient to achieve unrestricted movement throughout damper range. Provide one damper operator for maximum 16 sq ft damper section.
2. Actuators and linkage for control valves shall meet the following criteria:
 - a. Actuators shall be proportional or 2-position type as required to achieve the sequence of operation.
 - b. Actuators shall be spring return or non-spring return type as required to achieve the sequence of operation. Normal positions for valves with spring return actuators, determined by loss of power, are indicated on the contract drawings.
 - c. Actuator/linkage assemblies shall be capable of closing valves against a minimum unbalanced pressure equal to total system pressure.
 - d. All control valves shall be modulating except hot water control valves for radiant ceiling panels and hot water unit heaters.
3. All actuators shall be rated for operation from -22°F to 122°F ambient. Actuators that are mounted outdoors shall be provided with a weatherproof cover/enclosure.

H. Control Panels

1. Enclosures for indoor mounting shall be NEMA Type 1, constructed of 16 or 14 gauge steel with hinged door, and painted both inside and outside. Enclosures for outdoor mounting shall be NEMA Type 3R, constructed of 16 or 14 gauge galvanized steel with drip shield top, seamfree front, back, and sides, hinged door, and painted both inside and outside. Sub-panels (backplates) shall be 14 or 12 gauge steel painted both sides, or perforated 16 gauge galvaneal steel. All enclosures/sub-panels shall be sized for 20% spare space and shall be furnished with door lock kits.
2. Transformers shall provide the AC voltage required, sized for the load to be served, and fused on the secondary for not more than 125% of transformer rating.
3. Power Supplies shall provide the DC voltage required, sized for the load to be served, and fused on the secondary.

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/Engineer.
 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.
- B. Project manager must have at least six years of experience installing systems specified in this section.
- C. Refer to Paragraph 1.1 of this specification for additional requirements

3.2 EXAMINATION:

- A. The project plans shall be thoroughly examined for control device and equipment locations. Any discrepancies, conflicts, or omissions shall be reported to the architect/engineer for resolution before rough-in work is started.
- B. The contractor shall inspect the site to verify that equipment may be installed as shown. Any discrepancies, conflicts, or omissions shall be reported to the engineer for resolution before rough-in work is started.

- C. The contractor shall examine the drawings and specifications for other parts of the work. If head room or space conditions appear inadequate—or if any discrepancies occur between the plans and the contractor’s work and the plans and the work of others—the contractor shall report these discrepancies to the engineer and shall obtain written instructions for any changes necessary to accommodate the contractor’s work with the work of others.

3.3 COORDINATION

A. Submittals:

1. Refer to the “Submittals” article in Part 1 of this specification for requirements.

3.4 INSTALLATION

- A. Provide direct digital electronic/electric operated systems of control. Provide all necessary relays, mounting brackets, gages, switches and accessories where required, even though not specifically called for, so as to result in complete workable systems.

B. General Notes:

1. Install specified temperature control equipment.
2. Install and properly support all duct stats, dial thermometers, thermostat bulbs, temperature and humidity controllers in the center of duct cross section, in a straight duct run.
3. Install separable well sockets for all capillary thermostats, thermometers, temperature controllers, sensors and transmitters for piping or tank insertion.
4. Provide averaging type elements for sensing mixed air temperatures in ductwork, with sufficient length or sufficient number of elements, so as to efficiently measure the air temperature through the entire cross section of duct.
5. Test all electric and electronic equipment provided under this Section.
6. All controllers shall be “panel mounted”.

- C. Check and verify location of thermostats, and other exposed control sensors with plans and room details before installation. Locate room thermostats 48 inches above floor. Align with lighting switches, and humidistats.

- D. Provide valves with position indicators and with pilot positioners where sequenced with other controls.

- E. After completion of installation, test and adjust control equipment. Submit data showing set points and final adjustments of controls.

3.5 GENERAL WORKMANSHIP

- A. Install equipment, piping, and wiring/raceway parallel to building lines (i.e., horizontal, vertical, and parallel to walls) wherever possible.
- B. Provide sufficient slack and flexible connections to allow for vibration of piping and equipment.
- C. Install all equipment in readily accessible locations as defined by Chapter 1, Article 100, Part A of the National Electrical Code (NEC).
- D. Verify integrity of all wiring to ensure continuity and freedom from shorts and grounds.
- E. All equipment, installation, and wiring shall comply with acceptable industry specifications and standards for performance, reliability, and compatibility and be executed in strict adherence to local codes and standard practices.

3.6 WIRING

- A. All control and interlock wiring shall comply with national and local electrical codes and Division 26 of this specification. Where the requirements of this section differ from those in Division 26, the requirements of this section shall take precedence.
- B. All NEC Class 1 (line voltage) wiring shall be UL Listed in approved conduit according to NEC and Division 26 requirements.
- C. All low-voltage wiring shall meet NEC Class 2 requirements. (Low-voltage power circuits shall be sub fused when required to meet Class 2 current limit.)
- D. Where NEC Class 2 (current-limited) wires are in concealed and accessible locations, including ceiling return air plenums, approved cables not in conduit may be used provided that cables are UL Listed for the intended application. For example, cables used in ceiling plenums shall be UL Listed specifically for that purpose.
- E. All wiring in mechanical, electrical, or service rooms—or where subject to mechanical damage—shall be installed in conduit.
- F. Do not install Class 2 wiring in conduit containing Class 1 wiring. Boxes and panels containing high voltage wiring and equipment may not be used for low-voltage wiring except for the purpose of interfacing the two (e.g., relays and transformers).
- G. Do not install wiring in conduit containing tubing.
- H. Where plenum rated cable is run exposed, wiring is to be run parallel along a surface or perpendicular to it and neatly tied at 3 m (10 ft) intervals.
- I. Where plenum rated cable is used without conduit, it shall be supported from or anchored to structural members. Cables shall not be supported by or anchored to ductwork, electrical conduits, piping, or ceiling suspension systems.
- J. All wire-to-device connections shall be made at a terminal block or wire nut. All wire-to-wire connections shall be at a terminal strip or wire nut.

- K. All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.
- L. Maximum allowable voltage for control wiring shall be 120 V. If only higher voltages are available, the contractor shall provide step-down transformers or interposing relays.
- M. All plenum rated wiring shall be installed as continuous lengths, with no splices permitted between termination points
- N. All wiring in conduit shall be installed as continuous lengths, with no splices permitted between termination points or junction boxes.
- O. Maintain fire rating at all penetrations. Install plenum wiring in sleeves where it passes through walls and floors.
- P. Size and type of conduit and size and type of wire shall be the responsibility of the contractor, in keeping with the manufacturer's recommendations and NEC requirements, except as noted elsewhere.
- Q. Include one pull string in each conduit 3/4 in. or larger.
- R. Control and status relays are to be located in designated enclosures only. These enclosures can include packaged equipment control panel enclosures unless they also contain Class 1 starters.
- S. Conceal all conduit, except within mechanical, electrical, or service rooms. Install conduit to maintain a minimum clearance of 15 cm (6 in.) from high-temperature equipment (e.g., steam pipes or flues).
- T. Secure conduit with conduit clamps fastened to the structure and spaced according to code requirements. Conduit and pull boxes may not be hung on flexible duct strap or tie rods. Conduits may not be run on or attached to ductwork.
- U. Adhere to this specification's Division 26 requirements where conduit crosses building expansion joints.
- V. The Contractor shall terminate all control and/or interlock wiring and shall maintain updated (as-built) wiring diagrams with terminations identified at the job site.
- W. Flexible metal conduits and liquid-tight, flexible metal conduits shall not exceed 1 m (3 ft) in length and shall be supported at each end. Flexible metal conduit less than 1/2 in. electrical trade size shall not be used. In areas exposed to moisture, including chiller and boiler rooms, liquid-tight, flexible metal conduits shall be used.
- X. Conduit must be adequately supported, properly reamed at both ends, and left clean and free of obstructions. Conduit sections shall be joined with couplings (according to code). Terminations must be made with fittings at boxes and ends not terminating in boxes shall have bushings installed.

3.7 COMMUNICATION WIRING

- A. The contractor shall adhere to the items listed in the “Wiring” article in Part 3 of the specification.
- B. All cabling shall be installed in a neat and workmanlike manner. Follow manufacturer’s installation recommendations for all communication cabling.
- C. Do not install communication wiring in raceway and enclosures containing Class 1 or other Class 2 wiring.
- D. Maximum pulling, tension, and bend radius for cable installation, as specified by the cable manufacturer, shall not be exceeded during installation.
- E. Contractor shall verify the integrity of the entire network following the cable installation. Use appropriate test measures for each particular cable.
- F. All runs of communication wiring shall be unsliced length when that length is commercially available.
- G. All communication wiring shall be labeled to indicate origination and destination data.

3.8 IDENTIFICATION OF HARDWARE AND WIRING

- A. All wiring and cabling, including that within factory-fabricated panels shall be labeled at each end within 5 cm (2 in.) of termination with the DDC address or termination number.
- B. Permanently label or code each point of field terminal strips to show the instrument or item served.

3.9 PROGRAMMING

- A. Provide sufficient internal memory for the specified sequences of operation and trend logging. There shall be a minimum of 25% of available memory free within the primary controller for future use.
- B. Point Naming: System point names shall be modular in design, allowing easy operator interface without the use of a written point index. Point Naming standard shall be agreed upon between owner and BAS contractor. Refer to Submittals section in the General Section.
- C. Software Programming
 - 1. Provide programming for the system and adhere to the sequences of operation provided. The contractor also shall provide all other system programming necessary for the operation of the system, but not specified in this document. Imbed into the control program sufficient comment statements to clearly describe each section of the program. The comment statements shall reflect the language used in the sequences of operation and be of different font and color in text editor. Use the appropriate technique based on one of the following programming types.
 - a. Test-based:
 - 1) Must provide actions for all possible situations

- 2) Must be modular and structured
- 3) Must be commented
- 4) Must provide line by line programming and compilation wizard to allow for ease of editing.

D. Operator Interface

1. Standard graphics—Provide graphics for all mechanical systems and floor plans of the building. This includes each chilled water system, hot water system, chiller, boiler, air handler, and all terminal equipment. Point information on the graphic displays shall dynamically update. Show on each graphic all input and output points for the system. Also show relevant calculated points such as set points.
2. The contractor shall provide all the labor necessary to install, initialize, start up, and troubleshoot all operator interface software and its functions as described in this section. This includes any operating system software, the operator interface database, and any third-party software installation and integration required for successful operation of the operator interface.

3.10 CONTROL SYSTEM DEMONSTRATION AND ACCEPTANCE

A. Demonstration

1. Prior to acceptance, the control system shall undergo a series of performance tests to verify operation and compliance with this specification. These tests shall occur after the Contractor has completed the installation, started up the system, and performed his/her own tests.

B. Acceptance

1. All tests described in this specification shall have been performed to the satisfaction of both the engineer and owner prior to the acceptance of the control system as meeting the requirements of completion. Any tests that cannot be performed due to circumstances beyond the control of the contractor may be exempt from the completion requirements if stated as such in writing by the engineer. Such tests shall then be performed as part of the warranty.

3.11 CLEANING

- A. The contractor shall clean up all debris resulting from their activities daily. The contractor shall remove all cartons, containers, crates, etc., under his/her control as soon as their contents have been removed. Waste shall be collected and placed in a designated location.

3.12 COMMISSIONING OF BUILDING AUTOMATION SYSTEM

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including piping and electrical connections.

Report results in writing.

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove malfunctioning units, replace with new units, and retest.
 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment, and retest.
 3. Calibration test pneumatic and electronic controllers by disconnecting input sensors and stimulating operation with compatible signal generator.
- B. Engage a factory-authorized service representative to perform startup service.
- C. Replace damaged or malfunctioning controls and equipment.
1. Start, test, and adjust control systems.
 2. Demonstrate compliance with requirements, including calibration and testing, and control sequences.
 3. Adjust, calibrate, and fine tune circuits and equipment to achieve sequence of operation specified.
- D. Verify DDC as follows:
1. Verify software including automatic restart, control sequences, scheduling, reset controls, and occupied/unoccupied cycles.
 2. Verify operation of operator workstation.
 3. Verify local control units including self-diagnostics.
 4. Verify interfaces between DDC system and building fire alarm system.
- E. Each phase of testing must be completed and accepted before proceeding to the next step of testing. It shall be the responsibility of this contract to coordinate and schedule the required trades and officials required to complete testing. Project completion delays caused by inadequate coordination and scheduling or delays caused by failure to meet test specifications shall be the responsibility of this contract.
1. Test plans shall be provided for each phase of testing and shall define all the tests required to ensure that the system meets technical, operational, and performance specifications. The test plans shall define milestones for the tests; identifying simulation programs, equipment, personnel, facilities, and supplies required. The test plans shall identify the capabilities and functions to be tested.
 2. Test procedures for each phase of testing shall be developed from the test plans and design documentation. The procedures shall consist of detailed instructions for test setup, execution and evaluation of test results. Test reports shall be used to document the results of each test.

3. Testing shall be performed in two basic steps. Step one shall include two phases of testing.
 - a. Phase One is a Test which verifies the accuracy of the sensors and end devices and general system operation, flexibility and response.
 - b. Phase Two is operational sequence testing which verifies the proper operation of control strategies to match the sequence of operation.
- F. Phase One Testing: Calibration of each instrumentation device connected to the DDC system shall be performed by making a comparison between the reading at the respective device and the display at the supervisory console or other operator's work station using a standard which is traceable to the national bureau of standards and shall be at least twice as accurate as the device to be calibrated. Written permission must be obtained from the Owner that this phase of testing has been successfully completed with the proper documentation before proceeding with the next phase of testing. All sensors/transducers, etc. shall be tested to verify that they meet the accuracy as specified.
1. The general performance tests shall be used to demonstrate the specified overall system performance and accuracy of the DDC system. System performance shall be verified on all systems on the specified failure modes upon DDC system failure or loss of power, and that all systems return to DDC system control automatically upon resumption of DDC system operation or return of power. Exercises shall be performed on the system according to the written test procedures in order to verify response time of all system activities (i.e., control loop response, alarm response, updating of temperatures, and other values).
 - a. Network:
 - 1) Controller to controller data transfer time.
 - 2) Supervisory console to controller transfer time.
 - 3) Network reconfiguration.
 - 4) Network error recovery.
 - b. Controller:
 - 1) Scan rate.
 - 2) Analog input/output accuracy.
 - 3) Battery back-up duration.
 - 4) Screen refresh rate.
 - c. Sensors:
 - 1) Visually inspect for proper installation and pneumatic or electrical connections.
 - 2) If the process variable can be simulated, input 0% range value and record the measured process variable, device output and displayed value at the DDC system terminal. Repeat this process for 50% and 100% of the process variable range.
 - 3) If the process variable can not be simulated, use the ambient value for the process variable and record the measured process variable, device output and displayed value at the DDC system terminal. Simulate the device output signal current/voltage for 0% and 100% of the process

variable range and record the measured device output signal and the displayed value at the DDC system terminal.

d. Transducers:

- 1) Visually inspect for proper installation and pneumatic or electrical connections.
- 2) Enter 0% range value at the DDC system terminal and measure and record the device's input and output signal values. Repeat for 50% and 100% of device's range.

e. Final Elements:

- 1) Visually inspect for proper installation and pneumatic or electrical connections.
- 2) Enter 0% range value at the DDC system terminal and measure and record the device's input and output signal values. Repeat for 50% and 100% of device's range.
- 3) Step the final element from 0% to 100% range value at the DDC system terminal and measure and record the device's 0% to 100% speed. Repeat for 100% to 0% of device's range.

G. Phase Two - Operational Sequence Testing: Operational sequence testing shall be performed to demonstrate compliance of the completed DDC system with the contract documents. Using approved test procedures, all physical and functional requirements of the project shall be demonstrated and shown. Provide and schedule operational testing for each season (winter, summer, etc.) applicable to specific control sequence. Operational sequence testing as specified shall not be started until after the receipt of written permission by the Owner, based on written certification of successful completion of the general performance testing as specified.

H. Documentation: The Operational Check Verification Form shall be completed for each control loop. Any deviations or unsatisfactory results shall be noted in the remarks and signed and dated by the field engineer.

3.13 TRAINING

A. The contractor shall provide factory trained instructor to give full instruction to designated personnel in the operation of the system installed. Instructors shall be thoroughly familiar with all aspects of the subject matter they are to teach. The contractor shall provide all students with a student binder containing product specific training modules for the system installed. All training shall be held during normal working hours of 8:00 am to 4:30 PM weekdays.

B. Provide 24 hours of training for Owner's designated operating personnel. Training shall include:

1. Explanation of drawings, operations and 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. Operation of portable operator's terminal
 7. Explanation of adjustment, calibration and replacement procedures
 8. Binder with training modules
- C. Since the Owner may require personnel to have more comprehensive understanding of the hardware and software, additional training must be available from the Contractor. If such training is required by the Owner, it will be contracted at a later date.

3.14 SEQUENCE DEVELOPMENT

- A. General: The Engineer shall review all sequences with the BAS contractor during development of the controls shop drawings. Sequences may be modified to optimize system performance during the review process; however, additional hard points and point to point programming will not be added as a result of sequence optimization.
- B. The control manufacturer shall provide all control devices required to provide the sequence of operation.
- C. All setpoints in all sequences shall be adjustable. Adjustability shall be directly from the graphical interface.

3.15 SEQUENCES OF OPERATION

- A. General:
1. All setpoints indicated in the sequence below shall be adjustable. Further they shall be adjustable by the Owner Operator at graphical interface without the need of special training and without reprogramming of the system software. Further the Owner Operator shall be able to reset all setpoints and change all schedules without the need to call the BAS manufacturer service for assistance or have to have BAS manufacturer service on site.
 2. Failure of or a fault at a piece of equipment shall result in an alarm being sent to the BAS. This is typical for all equipment in the sequences below.
- B. Existing Multi-zone Air Handling unit:
1. Existing controls to remain and be reused.
 2. Existing thermostats to be relocated as indicated on drawings. Provide new control wiring as required.
- C. Blower Coils, DDC Controlled:
1. General:

- a. A direct digital, terminal equipment controller will control the units. Refer to controls below Kitchen Exhaust and Make-up Air Systems.

D. Kitchen Exhaust and Make-up Air Systems:

1. General

- a. Provide BAS connection to the three new exhaust hood controllers.
 - a. Hood 8C119: Exhaust fan to be controlled by hood controller. BAS is read only.
 - b. Hood 8K168 and 8K145: Two exhaust fans (one exhaust fan for each hood) to be controlled by hood controller. BAS system to control MAU blower coil supply fans and supply temperatures. Hood 8K168 to have two blower coil makeup air units. Hood 8K145 to have one blower coil makeup air unit. Makeup air supply fan control signal (0-10v) for each hood from hood controller shall be used for blower coil makeup air unit supply fan variable speed control for each unit. BAS controller to provide discharge air control.
 - c. Hood 8K180: Recirc unit to be controlled by hood controller. BAS is read only.
- b. Food service exhaust hood controller is provided with exhaust fan control interlock. Refer to food service exhaust hood drawings for additional information. Exhaust Fan to operate on variable speed once enabled via exhaust hood controls. Blower Coil Makeup air unit(s) to operate on variable speed control to track the exhaust fan operation.
- c. Food service exhaust hood controller is provided with BAS connection. Hood controller to provide 0-10v signal for modulation of the supply fans in the makeup air blower coils. Blower coil makeup air supply fans to operate on variable speed once enabled via exhaust hood controls. Blower Coil Makeup air unit(s) to operate on variable speed control to track the exhaust fan operation.
 - a. Hood 8C119: Exhaust fan to be controlled by hood controller. BAS is read only.
 - b. Hood 8K168 and 8K145: Exhaust fans (one exhaust fan for each hood) to be controlled by hood controller. BAS system to control MAU unit supply fans and supply temperatures. Hood 8K168 to have two makeup air units. Hood 8K145 to have one makeup air unit. Makeup air supply fan control signal (0-10v) for each hood from hood controller shall be used for makeup air unit supply fan variable speed control for each unit. BAS controller to provide discharge air control.
 - c. Hood 8K180: Recirc unit to be controlled by hood controller. BAS is read only.

- d. The grease exhaust fan shall be started automatically via a heat detection device mounted in the grease exhaust hood and manually with a single switch at the kitchen hood to initiate operation. The automatic operation via the heat detector will override the manual switch at the hood.
 - e. BAS interlock shall be provided to activate the blower coil make-up air unit(s) operation automatically upon operation of the grease exhaust fan. When the kitchen grease exhaust fan is automatically or manually started at the hood, the associated supply-air fan in blower coil makeup air shall energize and motorized intake damper will open. When the intake damper is proven open by an electric end-switch the supply fan will start.
 - f. A signal from the building fire alarm system shall de-energize the supply fan via the hood controller upon an alarm condition.
 - g. A low temperature detector on the heating coil discharge will de-energize the supply fan should a temperature below 36 deg. F (adj.) be sensed. During either a fire alarm condition or freeze-stat condition the outside air damper shall close and the unit shall terminate operation. The exhaust fan shall continue to operate in both conditions.
 - h. When the kitchen exhaust fan is manually stopped at the hood the exhaust fan shall stop and the associated blower coil make-up air unit(s) supply fan and intake damper will close and the supply fan will stop.
2. Blower Coil Make-up Air Unit Control: The unit shall include factory mounted control panel for operation of all internal components.
- a. The makeup unit shall operate to deliver “space neutral” air (68 degrees adjustable) with space temperature and humidity override, to the kitchen hood using the most energy efficient energy management sequence possible. The system shall modulate hot water and chilled water valve to dehumidify and temper the 100% outside air stream to the facility. The factory mounted control panel shall provide (at a minimum) the following command, status and alarm control points: System Enable (on/off); Setpoint Adjustment (Discharge Air and Discharge Humidity); Fan Status; Fan Speed (Hz); Discharge Air Temperature; Discharge Air Humidity; Outside Air Temperature; Return Air Humidity; Stages of Cooling Operating; Reheat Operating Point; Dirty Filter; and General Unit Alarm.
 - b. The Unit shall operate with on-off-auto DDC controls. The unit will be energized after opening the outdoor air damper 100%. The damper end switch will allow the unit fan to run.
 - c. The outside air temperature (OAT) shall be used to index the system between four operating modes: Heating, Cooling, Economizer and Dehumidification. During operation the unit shall operate on discharge air temperature with space temperature and space dehumidification override.
 - d. Heating Mode
 - 1) On an OAT of 62 deg. F or lower (adj.), heating mode shall be enabled.
 - 2) On an OAT of 64 deg. F or higher (adj.), heating mode shall be disabled.

- 3) During the Dehumidification and Cooling Modes the heating coil shall be Disabled.
 - 4) The hot water heat valve shall modulate to maintain the discharge air temperature (DAT) setpoint of 68 deg. F (adj.).
 - 5) The discharge air temperature setpoint shall be compared to the discharge air temperature to reset the gas heater control valve.
- e. Cooling Mode
- 1) On an OAT of 78 deg. F or higher (adj.), cooling mode shall be enabled.
 - 2) On an OAT of 76 deg. F or lower (adj.), cooling mode shall be disabled.
 - 3) During the Heating Mode the cooling functions shall be disabled.
 - 4) The chilled water valve shall modulate to maintain the discharge air temperature (DAT) setpoint of 68 deg. F (adj.).
- f. Economizer Mode
- 1) On an OAT from 62 deg. F to 78 deg. F (adj.), economizer mode shall be enabled. During this operation the wheel speed shall be varied to maintain the discharge air temperature of 68 deg. F (adj.).
 - 2) On an outside relative humidity of 50% or higher (adj.), economizer mode shall be disabled.
 - 3) During Economizer Mode both the Heating Mode and Cooling Mode functions shall be disabled.
- g. Dehumidification Mode
- 1) Dehumidification mode shall override Heating Mode, Cooling Mode and Economizer Mode.
 - 2) The chilled water and hot water valves shall be modulated to maintain a space setpoint of 55% RH (adj.).
- h. Remote setpoint adjustment of the discharge air temperature shall be provided via a space temperature and space humidity override function. Temperature and humidity sensors shall be located in the area adjacent to respective kitchen hood. These sensors shall provide feedback to the unit controller to adjust the leaving air temperature setpoint based on the desired space temperature setpoint.
- i. Outside Air Damper Control
- 1) When the unit is commanded to run, the controller will command the outside air damper to open. The supply fan will not be permitted to operate until the outside air damper end switch indicates the damper open.
 - 2) If a damper proof indicates the damper command and the damper end switch status have not matched for at least 150 seconds (adj.), the controller will generate an alarm and disable the unit. The unit will remain disabled until a manual reset has been initiated by the end-user.
 - 3) If a damper open command is on and the damper status has indicated that the damper is open for 5 seconds (adj.), the controller will indicate that the damper is open.

- 4) The controller will generate a hand operation alarm if the damper is commanded closed and the damper status indicates the damper is open.
 - 5) The controller will require that both the damper open command and the damper status indicate that the damper is operating normally for 10 seconds (adj.), before cleaning the alarm.
- j. Outside Air Preheat Electric Coil – Refer to Section 238216. Provide discharge air controller to maintain an adjustable (50 Degree) discharge air temperature from heating coil. Controller to have SCR output for modulation control. When outside air is above setpoint (50 Degree), coil shall be locked out. Each electric coil to have own controller. Coil to be provide with airflow switch.
- k. Supply Fan Control – Variable speed operation via 0-10v signal from hood controller.
- 1) When the unit is commanded to run and the outside air damper end switch indicates the damper is open, the controller will command the supply fan to start.
 - 2) If a fan proof indicates the signal to the fan and the fan status feedback from the fan has not matched for at least 30 seconds (adj.), the controller will generate an alarm and disable the unit. The unit will remain disable the unit. The unit will remain disabled until a manual reset has been initiated by the end-user.
 - 3) If a run signal is on and the fan status has indicated that the unit has air flow for 5 seconds (adj.), the controller will indicate that the fan has flow.
 - 4) The controller will generate a hand operation alarm if the run signal commands the fan off and the fan status indicates the fan is running.
 - 5) The controller will require that both the fan enable signal and the fan status indicate that the fan is operating normally for 10 seconds (adj.) before clearing an alarm.
- l. Safeties:
- 1) If a low temperature thermostat, located on inlet side of the coil is in alarm (temperature falls below 36 deg F) the controller will generate an alarm and, via hard wire interlock, shut down the supply fan and position all damper actuators to their fail safe positions. This safety sequence will also be commanded in the unit's controller software. An alarm will be sent to the remote panel.
 - 2) If the duct smoke detector is in alarm, the controller will generate the respective alarm and, via hardwire interlock, shut down the supply air fan. The controller will also position all damper actuators to their fail safe positions.
 - 3) If the condensate pan level switch is in alarm, the controller will generate an alarm and, via hard wire interlock, disable cooling.
3. Motorized Control Dampers in Exhaust System: Provide interlock with new motorized control dampers in ductwork as noted on drawings. Motorized control dampers shall close when respective exhaust fan is energized.

E. VRF System and Terminal FCUs:

1. Systems shall operate on manufacturer provided unit mounted controls and BAS shall be networked into a single system controller provided by the VRF system manufacturer. Refer to Specification 238120 - Variable Refrigerant Flow System for system control information.
2. The factory system controller shall provide (at a minimum) the following command, status and alarm control points to the BAS: System Enable (on/off); Setpoint Adjustment (Discharge Air Temperature); Fan Status; Discharge Air Temperature; VRF operating mode and General Unit Alarm.
3. Condensate overflow switch activation shall terminate system operation and send an alarm to the BAS.
4. Time of Day Schedules shall be coordinated with the Owner during construction and submitted to the engineer for review.
5. Refrigerant detection sensors shall be provided in each occupied room that is 400 square feet or smaller (within the areas served by a VRF system) for detection of a leak within the building from the VRF system. Upon detection an alarm shall annunciate at the BAS, a trouble alarm signal shall be sent to the BAS and system shall be automatically shutdown.

F. Stand-alone Ductless Split System

1. Unit to be connected to VRF main control panel.

G. Cabinet Ceiling Heater:

1. Ceiling heaters shall operate with an integral line voltage thermostat as specified. Upon a drop below setpoint, 68°F (adj.), the heater, and fan when applicable, shall engage to meet the space setpoint.

H. Existing Electric Unit Heaters:

1. Existing control shall be relocated and reused.

I. Existing Dishwasher Exhaust Fan: Reconnect to existing controls.

J. Miscellaneous:

1. BAS shall monitor temperature in walk-in refrigeration and freezers and provide a high limit alarm.

END OF SECTION 230900

SECTION 232113 - HYDRONIC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes:

1. Piping
2. Special-duty valves
3. Hydronic specialties for hot-water heating and chilled water systems
4. Condensate drain piping.
5. Pipe Testing

- B. Related Sections include the following:

1. Division 07 Section "Penetration Firestopping" for materials and methods for sealing pipe penetrations through fire and smoke barriers.
2. Division 07 Section "Joint Sealants" for materials and methods for sealing pipe penetrations through exterior walls.
3. Division 23 Section "Common Work Results for HVAC" for general piping materials and installation requirements.
4. Division 23 Section "Hangers and Supports for HVAC Piping and Equipment" for pipe supports, product descriptions, and installation requirements. Hanger and support spacing is specified in this Section.
5. Division 23 Section "General Duty Valves for HVAC" for general-duty gate, globe, ball, butterfly, and check valves.
6. Division 23 Section "Meters and Gages for HVAC Piping" for thermometers, flow meters, and pressure gages.
7. Division 23 Section "Identification for HVAC Piping and Equipment" for labeling and identifying hydronic piping.
8. Division 23 Section "HVAC Instrumentation and Controls" for temperature-control valves and sensors.

1.3 DEFINITIONS

- A. CPVC: Chlorinated polyvinyl chloride.
- B. PVC: Polyvinyl chloride.

1.4 SUBMITTALS

- A. Product Data: For each type of special-duty valve indicated. Include flow and pressure drop curves based on manufacturer's testing for diverting fittings, balancing valves, and automatic flow-control valves.
- B. Welding Certificates: Copies of certificates for welding procedures and personnel.
- C. Field Test Reports: Written reports of tests specified in Part 3 of this Section. Include the following:
 - 1. Test procedures used.
 - 2. Test results that comply with requirements.
 - 3. Failed test results and corrective action taken to achieve requirements.
- D. Maintenance Data: For hydronic specialties and special-duty valves to include in maintenance manuals specified in Division 01.
- E. Water Analysis: Submit a copy of the water analysis to illustrate water quality available at Project site.

1.5 QUALITY ASSURANCE

- A. Welding: Qualify processes and operators according to the ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications." Coordinate welding with Indoor Air Quality Policy Requirements.
- B. 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 01.

1.6 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 07 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 03 Sections.
- F. Coordinate installation of pipe sleeves for penetrations through exterior walls and floor assemblies. Coordinate with requirements for firestopping specified in Division 07 Section "Penetration Firestopping" for fire and smoke wall and floor assemblies.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Grooved Mechanical-Joint Fittings and Couplings:
 - a. Central Sprinkler Company; Central Grooved Piping Products.
 - b. Grinnell Corporation.
 - c. Victaulic Company of America.
 - 2. Automatic Flow Balancing Valves:
 - a. Flow Design, Inc.
 - b. Griswold Controls.
 - c. Nexus Valves
 - d. Hays Fluid Control

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, ASTM B 88, Type M.
- B. Annealed-Temper Copper Tubing: ASTM B 88, Type K.
- C. DWV Copper Tubing: ASTM B 306, Type DWV.
- D. Wrought-Copper Fittings: ASME B16.22.
- E. Wrought-Copper Unions: ASME B16.22.
- F. Solder Filler Metals: ASTM B 32, 95-5 tin antimony.
- G. Brazing Filler Metals: AWS A5.8, Classification BAg-1 (silver).

2.4 STEEL PIPE AND FITTINGS

- A. Steel Pipe, NPS 2 and Smaller: ASTM A 53, Type S (seamless) or Type F (furnace-butt welded), Grade B, Schedule 40, black steel, plain ends.
- B. Steel Pipe, NPS 2-1/2 through NPS 12: ASTM A 53, Type E (electric-resistance welded), Grade B, Schedule 40, black steel, plain ends.

- C. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250.
- D. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300.
- E. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300.
- F. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced.
- G. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.
- H. 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.
- I. Grooved Mechanical-Joint Fittings: ASTM A 536, Grade 65-45-12 ductile iron; ASTM A 47, Grade 32510 malleable iron; ASTM A 53, Type F, E, or S, Grade B fabricated steel; or ASTM A 106, Grade B steel fittings with grooves or shoulders designed to accept grooved end couplings.
- J. Grooved Mechanical-Joint Couplings: Ductile- or malleable-iron housing and synthetic rubber gasket of central cavity pressure-responsive design; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.
- K. Welding Materials: Comply with Section II, Part C, of the ASME Boiler and Pressure Vessel Code for welding materials appropriate for wall thickness and for chemical analysis of pipe being welded.
- L. Gasket Material: Thickness, material, and type suitable for fluid to be handled; and design temperatures and pressures.

2.5 VALVES

- A. Check, ball, and butterfly valves are specified in Division 23 Section "General Duty Valves for HVAC."
- B. Refer to Part 3 "Valve Applications" Article for applications of each valve.
- C. Automatic Flow-Control Valves:
 - 1. Body: Bronze or Brass.
 - 2. Piston and Spring Assembly: Stainless steel Corrosion resistant, tamper proof, self-cleaning, and removable.
 - 3. Combination Assemblies: Include bronze ball valve.
 - 4. Identification Tag: Marked with zone identification, valve number, and flow rate.
 - 5. Size: Same as pipe in which installed.
 - 6. Performance: Maintain constant flow, plus or minus 5 percent over system pressure fluctuations.

7. Minimum CWP Rating: 175 psig.
 8. Maximum Operating Temperature: 250 deg F.
 9. Provide isolation valve and unions to enable replacement and servicing of each valve.
- D. Safety Valves: Diaphragm-operated, bronze or brass body with brass and rubber, wetted, internal working parts; shall suit system pressure and heat capacity and shall comply with the ASME Boiler and Pressure Vessel Code, Section IV.

2.6 HYDRONIC SPECIALTIES

- A. Manual Air Vent: Bronze body and nonferrous internal parts; 150-psig working pressure; 225 deg F operating temperature; manually operated with screwdriver or thumbscrew; with NPS 1/8 discharge connection and NPS 1/2 inlet connection.
- B. Automatic Air Vent: Designed to vent automatically with float principle; bronze body and nonferrous internal parts; 150-psig working pressure; 240 deg F operating temperature; with NPS 1/4 discharge connection and NPS 1/2 inlet connection.
- C. Diverting Fittings: 125-psig working pressure; 250 deg F maximum operating temperature; cast-iron body with threaded ends or wrought copper with soldered ends. Indicate flow direction on fitting.
- D. Y-Pattern Strainers: 125-psig working pressure; cast-iron body (ASTM A 126, Class B), flanged ends for NPS 2-1/2 and larger, threaded connections for NPS 2 and smaller, bolted cover, perforated stainless-steel basket, and bottom drain connection.
- E. 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.
- F. 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. (Use on all base mounted pumps)
- G. Packed, Slip, Expansion Joints: 150-psig minimum working pressure, steel pipe fitting consisting of telescoping body and slip-pipe sections, packing ring, packing, limit rods, flanged ends, and chrome-plated finish on slip-pipe telescoping section.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

- A. Heating Water, NPS 2 and Smaller: Aboveground, use Type L drawn-temper copper tubing with soldered joints.
- B. Heating Water, NPS 2-1/2 and Larger: Schedule 40 steel pipe with grooved mechanical-joint couplings.

- C. Chilled Water, NPS 2 and Smaller: Aboveground, use Type L drawn-temper copper tubing with soldered joints.
- D. Chilled Water, NPS 2-1/2 and Larger: Schedule 40 steel pipe with grooved mechanical-joint couplings.
- E. Condensate Drain Lines: Type M drawn-temper copper tubing with soldered joints. Use copper piping for condensate drain lines located in return air plenums and exposed to exterior.

3.2 VALVE APPLICATIONS

- A. General-Duty Valve Applications: Unless otherwise indicated, use the following valve types:
 - 1. Shutoff Duty:
 - a. Ball valves: 3" and smaller
 - b. Butterfly valves: 4" and larger
 - 2. Throttling Duty:
 - a. Ball valves: 3" and smaller
 - b. Butterfly valves: 4" and larger
 - 3. Balancing valves at blower coils and unit heaters:
 - a. Automatic Flow-Control Valves – Provide additional spring to provide additional 10% flow.
- B. Install shutoff duty valves at each branch connection to supply mains, at supply connection to each piece of equipment, unless only one piece of equipment is connected in the branch line. Install throttling duty valves at each branch connection to return mains, at return connections to each piece of equipment, and elsewhere as indicated.
- C. Install balancing valves in the return water line of each heating or cooling element and elsewhere as required to facilitate system balancing. Provide isolation valve and unions on both sides of balancing valves for future replacement.
- D. Install safety valves on hot-water generators and elsewhere as required by the ASME Boiler and Pressure Vessel Code. Install safety-valve discharge piping, without valves, to floor. Comply with the ASME Boiler and Pressure Vessel Code, Section VIII, Division 01, for installation requirements.
- E. Install pressure-reducing valves on hot-water generators and elsewhere as required to regulate system pressure.

3.3 PIPING INSTALLATIONS

- A. Refer to Division 23 Section "Common Work Results for HVAC" for basic piping installation requirements.

- B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
- C. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- F. Install piping to permit valve servicing.
- G. Install piping at indicated slopes.
- H. Install piping free of sags and bends.
- I. Install fittings for changes in direction and branch connections.
- J. Install piping to allow application of insulation.
- K. Select system components with pressure rating equal to or greater than system operating pressure.
- L. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.
- M. Install drains, consisting of a tee fitting, NPS 3/4 ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.
- N. Reduce pipe sizes using concentric reducer or eccentric reducer fitting installed with level side up.
- O. Install strainers on supply side of each control valve, pressure-reducing valve, solenoid valve, in-line pump, and elsewhere as indicated. Install NPS 3/4 nipple and ball valve in blowdown connection of strainers NPS 2 and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2.
- P. Anchor piping for proper direction of expansion and contraction.
- Q. Extruded-Tee and drilled fittings with brazed joints are not approved for use.
- R. Mechanical Tee and Mechanical-Joint Tee Fittings are not approved for use.

3.4 HANGERS AND SUPPORTS

- A. Hanger, support, and anchor devices are specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment." Comply with requirements below for maximum spacing of supports.

B. Install the following pipe attachments:

1. Trapeze hangers for multiple horizontal pipes.
2. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.
3. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet or longer.
4. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
5. Spring hangers to support vertical runs.
6. On plastic pipe, install pads or cushions on bearing surfaces to prevent hanger from scratching pipe.

C. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:

1. NPS 3/4: Maximum span, 7 feet; minimum rod size, 1/4 inch.
2. NPS 1: Maximum span, 7 feet; minimum rod size, 1/4 inch.
3. NPS 1-1/2: Maximum span, 9 feet; minimum rod size, 3/8 inch.
4. NPS 2: Maximum span, 10 feet; minimum rod size, 3/8 inch.
5. NPS 2-1/2: Maximum span, 11 feet; minimum rod size, 3/8 inch.
6. NPS 3: Maximum span, 12 feet; minimum rod size, 3/8 inch.
7. NPS 4: Maximum span, 14 feet; minimum rod size, 1/2 inch.
8. NPS 6: Maximum span, 17 feet; minimum rod size, 1/2 inch.
9. NPS 8: Maximum span, 19 feet; minimum rod size, 5/8 inch.
10. NPS 10: Maximum span, 20 feet; minimum rod size, 3/4 inch.
11. NPS 12: Maximum span, 23 feet; minimum rod size, 7/8 inch.

D. Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:

1. NPS 3/4: Maximum span, 5 feet; minimum rod size, 1/4 inch.
2. NPS 1: Maximum span, 6 feet; minimum rod size, 1/4 inch.
3. NPS 1-1/2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
4. NPS 2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
5. NPS 2-1/2: Maximum span, 9 feet; minimum rod size, 3/8 inch.
6. NPS 3: Maximum span, 10 feet; minimum rod size, 3/8 inch.

E. Install hangers for plastic piping, with maximum horizontal spacing and minimum rod diameters, to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

F. Support vertical runs at roof, at each floor, and at 10-foot intervals between floors.

3.5 PIPE JOINT CONSTRUCTION

- A. Refer to Division 23 Section "Common Work Results for HVAC" for joint construction requirements for soldered and brazed joints in copper tubing; threaded, welded, and flanged joints in steel piping; and solvent-welded joints for PVC and CPVC piping.

3.6 HYDRONIC SPECIALTIES INSTALLATION

- A. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.
- B. Install automatic air vents in mechanical equipment rooms only at high points of system piping, at heat-transfer coils, and elsewhere as required for system air venting.
- C. Install expansion tanks on floor. Vent and purge air from hydronic system, and ensure tank is properly charged with air to suit system design requirements.

3.7 TERMINAL EQUIPMENT CONNECTIONS

- A. Install control valves in accessible locations close to connected equipment.
- B. Where indicated on drawings, install bypass piping with globe valve around control valve. If multiple, parallel control valves are installed, only one bypass is required.
- C. Install ports for pressure and temperature gages at coil inlet connections.

3.8 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 test.
 - 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 hydronic piping systems with clean water; then remove and clean or replace strainer screens.
 - 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. Install blinds in flanged joints to isolate equipment.
 - 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 both existing and new 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. Verify that stress due to pressure at bottom of vertical runs does not exceed either 90 percent of specified minimum yield strength or 1.7 times "SE" value in Appendix A of ASME B31.9, "Building Services Piping."

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.

3.9 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 are calling for full flow.
 6. Check operation of automatic bypass valves.
 7. Check and set operating temperatures of boilers, chillers, and cooling towers to design requirements.
 8. Lubricate motors and bearings.

3.10 CLEANING (Both Existing and New Piping)

- A. Flush system with fresh water and add liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products from piping. Circulate solution for a minimum of 24 hours, drain, clean strainer screens, and flush again with fresh water, drain, clean strainer screens, and refill with fresh water. After cleaning and flushing hydronic piping systems, but before balancing, remove disposable fine-mesh strainers in pump suction diffusers.

END OF SECTION 232113

SECTION 233113 - METAL DUCTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes metal ducts for supply, return, outside, and exhaust air-distribution systems in pressure classes from minus 2 to plus 10-inch wg. Metal ducts include the following:
 - 1. Rectangular ducts and fittings.
 - 2. Single-wall, round, and flat-oval ducts and formed fittings.
 - 3. Duct liner.
- B. Related Sections include the following:
 - 1. Division 23 Section "HVAC Casings" for factory- and field-fabricated casings for mechanical equipment.
 - 2. Division 23 Section "Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.3 DEFINITIONS

- A. NUSIG: National Uniform Seismic Installation Guidelines.

1.4 SYSTEM DESCRIPTION

- A. Duct system design, as indicated, has been used to select size and type of air-moving and -distribution equipment and other air system components. Changes to layout or configuration of duct system must be specifically approved in writing by Architect. Accompany requests for layout modifications with calculations showing that proposed layout will provide original design results without increasing system total pressure.

1.5 SUBMITTALS

- A. Coordination Drawings: Refer to Section 23 requirements.
- B. Welding certificates.
- C. Field quality-control test reports.

1.6 QUALITY ASSURANCE

- A. Welding: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code--Steel," for hangers and supports, AWS D1.2, "Structural Welding Code--Aluminum," for aluminum supporting members and AWS D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.
- B. NFPA Compliance:
 - 1. NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."
 - 2. NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."
- C. Comply with NFPA 96, "Ventilation Control and Fire Protection of Commercial Cooking Operations," Ch. 3, "Duct System," for range hood ducts, unless otherwise indicated.
- D. Welding certificates.
- E. Field quality-control reports.

PART 2 - PRODUCTS

2.1 SHEET METAL MATERIALS

- A. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods, unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
- B. Galvanized Sheet Steel: Lock-forming quality; complying with ASTM A 653/A 653M and having G60 coating designation; ducts shall have mill-phosphatized finish for surfaces exposed to view.
- C. Carbon-Steel Sheets: ASTM A 366/A 366M, cold-rolled sheets; commercial quality; with oiled, matte finish for exposed ducts.
- D. Stainless Steel: ASTM A480/A 480M. Type 316 and having a No. 2D finish for concealed ducts and a premium finish for exposed ducts.
- E. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
 - 1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.
- F. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.2 DUCT LINER

- A. Fibrous-Glass Liner: Comply with NFPA 90A or NFPA 90B and with NAIMA AH124.
1. Manufacturers:
 - a. CertainTeed Corp.; Insulation Group.
 - b. Johns Manville International, Inc.
 - c. Knauf Fiber Glass GmbH.
 - d. Owens Corning.
 2. Fibrous glass duct liners shall resist fungal and bacterial growth as defined and in accordance with ASTM C 1338, required for airstream surfaces per ASHRAE 62.1-2001; and additionally, ASTM G 21-96 (fungus test) required by ASTM C 1071.
 3. Materials: ASTM C 1071; surfaces exposed to airstream shall be coated to prevent erosion of glass fibers.
 - a. Thermal Conductivity (k-Value): 0.26 at 75 deg F mean temperature.
 - b. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
 - c. Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.
 - d. Mechanical Fasteners: Galvanized steel suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in duct.
 - 1) Tensile Strength: Indefinitely sustain a 50-lb- tensile, dead-load test perpendicular to duct wall.
 - 2) Fastener Pin Length: As required for thickness of insulation and without projecting more than 1/8 inch into airstream.
 - 3) Adhesive for Attaching Mechanical Fasteners: Comply with fire-hazard classification of duct liner system.
- B. Adhesive for Attaching Mechanical Fasteners: Comply with fire-hazard classification of duct liner system.
- C. Fire and Smoke Performance:
1. The rigid insulation panels used in the fabrication of the Duct system shall achieve the following fire and smoke performance requirements:
 - a. ASTM E 84—low contribution to fire growth not exceeding 25 Flame Spread and 50 Smoke Developed indices;
 - b. UL 723 —low contribution to fire growth not exceeding 25 Flame Spread and 50 Smoke Developed indices; and
 - c. UL 181 – UL/ULC classification as a Class 1 Air Duct to NFPA Standards 90A & 90B.
- D. Sealant Materials:
1. All internal seams must be fully sealed with an unbroken layer of Pal Phenolic sealant.

2. Each ductwork section must be duly connected with an inter-locking, double sealed jointing system. Sufficient sealant should be applied to each layer in order to seal the rigid Phenolic insulation panels and ensure minimum air leakage.
3. Ductwork reinforcement, if necessary, shall be applied to protect against side deformation from both positive and negative pressure.
4. All external seams where two separate panels join must be tiger clipped, taped and jacketed in watershed fashion whenever possible to achieve a permanent bond with weather protection and a smooth appearance.

2.3 SEALANT MATERIALS

- A. Joint and Seam Sealants, General: The term "sealant" is not limited to materials of adhesive or mastic nature but includes tapes and combinations of open-weave fabric strips and mastics. All sealant materials shall be low VOC type with a rating of 30 grams per liter or less.
- B. Tape Sealing System: Woven-fiber tape impregnated with gypsum mineral compound and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
- C. Water-Based Joint and Seam Sealant: Flexible, adhesive sealant, resistant to UV light when cured, UL 723 listed, and complying with NFPA requirements for Class 1 ducts.
- D. Solvent-Based Joint and Seam Sealant: One-part, nonsag, solvent-release-curing, polymerized butyl sealant formulated with a minimum of 75 percent solids.
- E. Flanged Joint Mastic: One-part, acid-curing, silicone, elastomeric joint sealant complying with ASTM C 920, Type S, Grade NS, Class 25, Use O.
- F. Flange Gaskets: Butyl rubber or EPDM polymer with polyisobutylene plasticizer.

2.4 HANGERS AND SUPPORTS

- A. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
 1. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
 2. Exception: Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
- B. Hanger Materials: Galvanized sheet steel or threaded steel rod.
 1. Hangers Installed in Corrosive Atmospheres: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
 2. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for steel sheet width and thickness and for steel rod diameters.
 3. Galvanized-steel straps attached to aluminum ducts shall have contact surfaces painted with zinc-chromate primer.

- C. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
- D. Trapeze and Riser Supports: Steel shapes complying with ASTM A 36/A 36M.
 - 1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
 - 2. Supports for Stainless-Steel Ducts: Stainless-steel support materials.
 - 3. Supports for Aluminum Ducts: Aluminum support materials unless materials are electrolytically separated from ducts.

2.5 RECTANGULAR DUCT FABRICATION

- A. General: Fabricate ducts, elbows, transitions, offsets, branch connections, and other construction with galvanized, sheet steel, according to SMACHNA's "HVAC Duct Construction Standards—Metal and Flexible." Comply with requirements for metal thickness, reinforcing types and intervals, tie-rod applications, and joint types and intervals.
 - 1. Lengths: Fabricate rectangular ducts in lengths appropriate to reinforcement and rigidity class required for pressure class.
 - 2. Materials: Free from visual imperfections such as pitting, seam marks, roller marks, stains, and discolorations.
- B. Static-Pressure Classifications and Construction Schedule:

Duct System	Material	Pressure Class (WC)	Seal Class	Liner
Multizone Supply Air Mains	Galvanized Steel	+3.0"	A	None
Multizone – Supply Branch Ducts	Galvanized Steel	+3.0"	A	None
Multizone - Return Air Mains	Galvanized Steel	-3.0"	A	None
Multizone – Return Branch Ducts	Galvanized Steel	-3.0"	A	None
Round Branch Ductwork to Air Devices	Galvanized Steel	+2.0"	B	None
Supply Air Main from Unit to Last Branch Duct	Galvanized Steel	+2.0"	B	None
Return Air main and Branches	Galvanized	-2.0"	B	None

	Steel			
Rectangular Supply Air Branch from Main Duct to Air Outlets	Galvanized Steel	+2.0"	B	None
Round SA and RA Branch Ductwork to Air Devices	Galvanized Steel	+1.0"	C	None
Blower Coils Makeup Supply Air – Supply Air	Galvanized Steel	+2.0"	A	None
Blower Coils Makeup Supply Air – Outside Air	Galvanized Steel	-2.0"	B	None
Kitchen Grease Exhaust	Carbon Steel	-5.0"	A	None
Dishwasher Hood	Stainless Steel	-3.0"	A	None
Transfer Air	Galvanized Steel	-0.5"	C	1"
General Exhaust Air	Varies	-3.0"	B	NONE

- C. Cross Breaking or Cross Beading: Cross break or cross bead duct sides 19 inches and larger and 0.0359 inch thick or less, with more than 10 sq. ft. of unbraced panel area, unless ducts are lined.
- D. Transverse Joints: Prefabricated slide-on joints and components constructed using manufacturer's guidelines for material thickness, reinforcement size and spacing, and joint reinforcement.

2.6 APPLICATION OF LINER IN DUCTS

- A. 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.
- B. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.
- C. Butt transverse joints without gaps and coat joint with adhesive.

- D. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.
- E. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and standard liner product dimensions make longitudinal joints necessary.
- F. Apply adhesive coating on longitudinal seams in ducts with air velocity of 2500 fpm.
- G. 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.
- H. 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:
 - 1. Fan discharges.
 - 2. Intervals of lined duct preceding unlined duct.
 - 3. Upstream edges of transverse joints in ducts where air velocities are greater than 2500 fpm (12.7 m/s) or where indicated.
- I. 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.

2.7 ROUND AND FLAT-OVAL DUCT AND FITTING FABRICATION

- A. Diameter as applied to flat-oval ducts in this Article is the diameter of a round duct with a circumference equal to the perimeter of a given size of flat-oval duct.
- B. Round Ducts: Fabricate supply ducts of galvanized steel according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."
- C. Flat-Oval Ducts: Fabricate supply ducts according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."
 - 1. Manufacturers:
 - a. ACME.
 - b. McGill AirFlow Corporation.
 - c. SEMCO Incorporated.
- D. Duct Joints:
 - 1. Ducts up to 20 Inches in Diameter: Interior, center-beaded slip coupling, sealed before and after fastening, attached with sheet metal screws.
- E. 90-Degree Tees and Laterals and Conical Tees: Fabricate to comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," with metal thicknesses specified for longitudinal-seam straight ducts.

- F. Diverging-Flow Fittings: Fabricate with reduced entrance to branch taps and with no excess material projecting from fitting onto branch tap entrance.
- G. Fabricate elbows using die-formed, gored, pleated, or mitered construction. Bend radius of die-formed, gored, and pleated elbows shall be 1-1/2 times duct diameter. Unless elbow construction type is indicated, fabricate elbows as follows:
1. Mitered-Elbow Radius and Number of Pieces: Welded construction complying with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," unless otherwise indicated.
 2. Round Mitered Elbows: Welded construction with the following metal thickness for pressure classes from minus 2- to plus 2-inch wg:
 - a. Ducts 3 to 36 Inches in Diameter: 0.034 inch.
 3. Round Mitered Elbows: Welded construction with the following metal thickness for pressure classes from 2- to 10-inch wg:
 - a. Ducts 3 to 26 Inches in Diameter: 0.034 inch.
 4. Flat-Oval Mitered Elbows: Welded construction with same metal thickness as longitudinal-seam flat-oval duct.
 5. 90-Degree, 2-Piece, Mitered Elbows: Use only for supply systems or for material-handling Class A or B exhaust systems and only where space restrictions do not permit using radius elbows. Fabricate with single-thickness turning vanes.
 6. Round Elbows 8 Inches and Less in Diameter: Fabricate die-formed elbows for 45- and 90-degree elbows and pleated elbows for 30, 45, 60, and 90 degrees only. Fabricate nonstandard bend-angle configurations or nonstandard diameter elbows with gored construction.
 7. Round Elbows 9 through 14 Inches in Diameter: Fabricate gored or pleated elbows for 30, 45, 60, and 90 degrees unless space restrictions require mitered elbows. Fabricate nonstandard bend-angle configurations or nonstandard diameter elbows with gored construction.
 8. Round Elbows Larger than 14 Inches in Diameter and All Flat-Oval Elbows: Fabricate gored elbows unless space restrictions require mitered elbows.
 9. Die-Formed Elbows for Sizes through 8 Inches in Diameter and All Pressures 0.040 inch thick with 2-piece welded construction.
 10. Round Gored-Elbow Metal Thickness: Same as non-elbow fittings specified above.
 11. Flat-Oval Elbow Metal Thickness: Same as longitudinal-seam flat-oval duct specified above.
- H. Fabricate dryer exhaust from all residential dryers and all 14# and smaller light commercial dryers from aluminum or as required by dryer manufacturer with smooth interior finish.
1. Dryer exhaust ducts shall be minimum 4" diameter.
 2. The dryer exhaust duct system shall be secured in place with male end duct at overlapped joints shall extend in the direction of airflow.
 3. Overlapped joints shall be secured with band clamps in lieu of sheet metal screws.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

- A. Construct and install ducts according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," unless otherwise indicated.
- B. Install round and flat-oval ducts in lengths not less than 12 feet unless interrupted by fittings.
- C. Install ducts with fewest possible joints.
- D. Install fabricated fittings for changes in directions, size, and shape and for connections.
- E. Install couplings tight to duct wall surface with a minimum of projections into duct. Secure couplings with sheet metal screws. Install screws at intervals of 12 inches, with a minimum of 3 screws in each coupling.
- F. Install ducts, unless otherwise indicated, vertically and horizontally and parallel and perpendicular to building lines; avoid diagonal runs.
- G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
- H. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.
- I. Conceal ducts from view in finished spaces. Do not encase horizontal runs in solid partitions unless specifically indicated.
- J. Coordinate layout with suspended ceiling, fire- and smoke-control dampers, lighting layouts, and similar finished work.
- K. Seal all joints and seams. Apply sealant to male end connectors before insertion, and afterward to cover entire joint and sheet metal screws.
- L. Electrical Equipment Spaces: Route ducts to avoid passing through transformer vaults and electrical equipment spaces and enclosures.
- M. Non-Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls and are exposed to view, conceal spaces between construction openings and ducts or duct insulation with sheet metal flanges of same metal thickness as ducts. Overlap openings on 4 sides by at least 1-1/2 inches.
- N. Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls, install appropriately rated fire dampers, sleeves, and firestopping sealant. Fire and smoke dampers are specified in Division 23 Section "Duct Accessories." Firestopping materials and installation methods are specified in Division 07 Section "Through-Penetration Firestop Systems."
- O. Protect duct interiors from the elements and foreign materials until building is enclosed. Follow SMACNA's "Duct Cleanliness for New Construction."

3.2 SEAM AND JOINT SEALING

- A. Seal duct seams and joints according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for duct pressure class indicated.
 - 1. For pressure classes lower than 2-inch wg, seal transverse joints.
- B. Seal ducts before external insulation is applied.

3.3 HANGING AND SUPPORTING

- A. Support horizontal ducts within 24 inches of each elbow and within 48 inches of each branch intersection.
- B. Support vertical ducts at maximum intervals of 16 feet and at each floor.
- C. Install upper attachments to structures with an allowable load not exceeding one-fourth of failure (proof-test) load.
- D. Install concrete inserts before placing concrete.
- E. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
 - 1. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.

3.4 CONNECTIONS

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

3.5 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections according to SMACNA's "HVAC Air Duct Leakage Test Manual" and prepare test reports:
 - 1. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
 - 2. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If pressure classes are not indicated, test entire system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure. Give seven days' advance notice for testing.
 - 3. Maximum Allowable Leakage: Comply with requirements for Leakage Class 3 for round and flat-oval ducts, Leakage Class 12 for rectangular ducts in pressure classes lower than and equal to 2-inch wg (both positive and negative pressures), and Leakage Class 6 for pressure classes from 2- to 10-inch wg.
 - 4. Remake leaking joints and retest until leakage is equal to or less than maximum allowable.

3.6 CLEANING NEW SYSTEMS

- A. All duct systems shall be protected during construction using industry defined methods for protecting openings during construction and storing materials in clean, dry environments.
- B. Mark position of dampers and air-directional mechanical devices before cleaning, and perform cleaning before air balancing.
- C. Use service openings, as required, for physical and mechanical entry and for inspection.
 - 1. Create other openings to comply with duct standards.
 - 2. Disconnect flexible ducts as needed for cleaning and inspection.
 - 3. Remove and reinstall ceiling sections to gain access during the cleaning process.
- D. Vent vacuuming system to the outside. Include filtration to contain debris removed from HVAC systems, and locate exhaust down wind and away from air intakes and other points of entry into building.
- E. Clean the following metal duct systems by removing surface contaminants and deposits:
 - 1. Air outlets and inlets (registers, grilles, and diffusers).
 - 2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
 - 3. Air-handling equipment internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
 - 4. Return-air ducts, dampers, and actuators except in ceiling plenums and mechanical equipment rooms.
 - 5. Supply-air ducts and accessories.
- F. Mechanical Cleaning Methodology:
 - 1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
 - 2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
 - 3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
 - 4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet.
 - 5. Biocidal Agents and Coatings: Upon verification of fungus contact the Architect for system review. Apply biocidal agents according to manufacturer's instructions after reviewed and scheduled with the Architect.
- G. Cleanliness Verification:
 - 1. Visually inspect metal ducts for contaminants.
 - 2. Where contaminants are discovered, re-clean and re-inspect ducts.

3. Inspection and re-reclean shall be performed as needed until the system is cleaned in accordance with this Specification.

END OF SECTION 233113

SECTION 233300 – AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:

1. Backdraft dampers.
2. Volume dampers.
3. Motorized control dampers.
4. Fire and Radiation dampers.
5. Turning vanes.
6. Duct-mounting access doors.
7. Flexible connectors.
8. Flexible ducts.
9. Duct accessory hardware.

- B. Related Sections include the following:

1. Division 28 Section "Fire Alarm" for duct-mounting fire and smoke detectors.
2. Division 23 Section "Instrumentation and Control for HVAC" for electric and pneumatic damper actuators.

1.3 SUBMITTALS

- A. Product Data: For the following:

1. Backdraft dampers.
2. Volume dampers.
3. Motorized control dampers.
4. Fire dampers.
5. Radiation dampers.
6. Flexible ducts.
7. Flexible connectors.

1.4 QUALITY ASSURANCE

- A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

2.2 SHEET METAL 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.
- B. Galvanized Sheet Steel: Lock-forming quality; complying with ASTM A 653/A 653M and having G coating designation; ducts shall have mill-phosphatized finish for surfaces exposed to view.
- C. Aluminum Sheets: ASTM B 209, alloy 3003, temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.
- D. Extruded Aluminum: ASTM B 221, alloy 6063, temper T6.
- E. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.
- 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.

2.3 BACKDRAFT DAMPERS

- A. Manufacturers:
 - 1. Air Balance, Inc.
 - 2. American Warming and Ventilating.
 - 3. CESCO Products.
 - 4. Duro Dyne Corp.
 - 5. Greenheck.
 - 6. Penn Ventilation Company, Inc.
 - 7. Ruskin Company.
- B. Description: Multiple-blade, parallel action gravity balanced, with center-pivoted blades of maximum 6-inch width, with sealed edges, assembled in rattle-free manner with 90-degree stop, steel ball bearings, and axles; adjustment device to permit setting for varying differential static pressure.

- C. Frame: 0.063-inch- thick extruded aluminum, with welded corners and mounting flange.
- D. Blades: 0.050-inch- thick aluminum sheet.
- E. Blade Seals: Vinyl or Neoprene.
- F. Blade Axles: Nonferrous.
- G. Tie Bars and Brackets: Aluminum.
- H. Return Spring: Adjustable tension.

2.4 VOLUME DAMPERS

- A. Manufacturers:
 - 1. Air Balance, Inc.
 - 2. American Warming and Ventilating.
 - 3. Flexmaster U.S.A., Inc.
 - 4. McGill AirFlow Corporation.
 - 5. METALAIRE, Inc.
 - 6. Nailor Industries Inc.
 - 7. Penn Ventilation Company, Inc.
 - 8. Ruskin Company.
- B. General Description: Factory fabricated, with required hardware and accessories. Stiffen damper blades for stability. Include locking device to hold single-blade dampers in a fixed position without vibration. Close duct penetrations for damper components to seal duct consistent with pressure class.
 - 1. Pressure Classes of 3-Inch wg or Higher: End bearings or other seals for ducts with axles full length of damper blades and bearings at both ends of operating shaft.
- C. Standard Volume Dampers: Multiple- or single-blade, parallel or opposed-blade design as indicated, standard leakage rating, with linkage outside airstream, and suitable for horizontal or vertical applications.
 - 1. Steel Frames: Hat-shaped, galvanized sheet steel channels, minimum of 0.064 inch thick, with mitered and welded corners; frames with flanges where indicated for attaching to walls and flangeless frames where indicated for installing in ducts.
 - 2. Roll-Formed Steel Blades: 0.064-inch- thick, galvanized sheet steel.
 - 3. Aluminum Frames: Hat-shaped, 0.10-inch- thick, aluminum sheet channels; frames with flanges where indicated for attaching to walls; and flangeless frames where indicated for installing in ducts.
 - 4. Roll-Formed Aluminum Blades: 0.10-inch thick aluminum sheet.
 - 5. Extruded-Aluminum Blades: 0.050-inch thick extruded aluminum.
 - 6. Blade Axles: Galvanized steel.
 - 7. Tie Bars and Brackets: Galvanized steel.

- D. Low-Leakage Volume Dampers: Multiple- or single-blade, parallel or opposed-blade design as indicated, low-leakage rating, with linkage outside airstream, and suitable for horizontal or vertical applications.
1. Steel Frames: Hat-shaped, galvanized sheet steel channels, minimum of 0.064 inch thick, with mitered and welded corners; frames with flanges where indicated for attaching to walls and flangeless frames where indicated for installing in ducts.
 2. Roll-Formed Steel Blades: 0.064-inch- thick, galvanized sheet steel.
 3. Blade Axles: Galvanized steel.
 4. Bearings: Oil-impregnated bronze thrust or ball.
 5. Blade Seals: Neoprene.
 6. Jamb Seals: Cambered aluminum.
 7. Tie Bars and Brackets: Galvanized steel.
- E. Jackshaft: 1-inch- diameter, galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
1. Length and Number of Mountings: Appropriate to connect linkage of each damper in multiple-damper assembly.
- F. Damper Hardware: Zinc-plated, die-cast core with dial and handle made of 3/32-inch- thick zinc-plated steel, and a 3/4-inch hexagon locking nut. Include center hole to suit damper operating-rod size. Include elevated platform for insulated duct mounting.
- G. Provide Ruskin, Young Regulator or Metropolitan Air electric zone damper remote adjustment system for system balancing. Include damper, actuator, wiring, terminal blocks and controller for locations where dampers are not accessible for balancing and as indicated on drawings.

2.5 FIRE AND RADIATION DAMPERS

- A. Fire Rating: 1-1/2 and 3 hours s required for each application. UL 555 listed for dynamic dampers.
- B. Frame: SMACNA Type 'B' with blades outside airstream; fabricated with roll-formed, 0.034-inch thick galvanized steel; with mitered and interlocking corners.
- C. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.
1. Minimum Thickness: 0.052 or 0.138 inch thick as indicated and of length to suit application.
 2. Exceptions: Omit sleeve where damper frame width permits direct attachment of perimeter mounting angles on each side of wall or floor, and thickness of damper frame complies with sleeve requirements.
- D. Mounting Orientation: Vertical or horizontal as indicated.
- E. Blades: Roll-formed, interlocking, 0.034-inch- thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch- thick, galvanized-steel blade connectors.
- F. Horizontal Dampers: Include blade lock and stainless-steel closure spring.

- G. Fusible Links: Replaceable, 165 deg F or 212 deg F rated as required by fire rating.

2.6 TURNING VANES

- A. Fabricate to comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for vanes and vane runners. Vane runners shall automatically align vanes.
- B. Manufactured Turning Vanes: Fabricate 1-1/2-inch- wide, double-vane, curved blades of galvanized sheet steel set 3/4 inch o.c.; support with bars perpendicular to blades set 2 inches o.c.; and set into vane runners suitable for duct mounting.
- C. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.

2.7 DUCT-MOUNTING ACCESS DOORS

- A. General Description: Fabricate doors airtight and suitable for duct pressure class.
- B. Door: Double wall, duct mounting, and round; fabricated of galvanized sheet metal with insulation fill and 1-inch thickness. Include cam latches.

2.8 FLEXIBLE CONNECTORS

- A. General Description: Flame-retardant or noncombustible fabrics, coatings, and adhesives complying with UL 181, Class 1.
- B. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches wide attached to two strips of 2-3/4-inch- wide, 0.028-inch- thick, galvanized sheet steel or 0.032-inch- thick aluminum sheets. Select metal compatible with ducts.

2.9 FLEXIBLE DUCTS

- A. General: Comply with UL 181, Class 1.
- B. Flexible Ducts, Insulated: Factory-fabricated, insulated, round duct, with an outer jacket enclosing 1-1/2-inch thick, glass-fiber insulation around a continuous inner liner.
 - 1. Reinforcement: Steel-wire helix encapsulated in inner liner.
 - 2. Outer Jacket: Glass-reinforced, silver Mylar with a continuous hanging tab, integral fibrous-glass tape, and nylon hanging cord.
 - 3. Inner Liner: Polyethylene film.
- C. Pressure Rating: 6-inch wg positive, 1/2-inch wg negative.

2.10 DUCT ACCESSORY HARDWARE

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

PART 3 - EXECUTION

3.1 APPLICATION AND INSTALLATION

- A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for metal ducts.
- B. Provide duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel; stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.
- C. Install backdraft dampers on exhaust fans or exhaust ducts nearest to outside.
- D. Install volume dampers in ducts with liner; avoid damage to and erosion of duct liner.
- E. Provide balancing dampers at points on supply, return, and exhaust systems where branches lead from larger ducts as required for air balancing. Install at a minimum of two duct widths from branch takeoff.
- F. Provide test holes at fan inlets and outlets and elsewhere as indicated.
- G. Provide turning vanes in all supply and return air ductwork.
- H. Install fire and smoke dampers, with fusible links, according to manufacturer's UL-approved written instructions.
- I. Install duct access doors to allow for inspecting, adjusting, and maintaining accessories and terminal units as follows:
 - 1. On both sides of duct coils.
 - 2. Adjacent to fire or smoke dampers, providing access to reset or reinstall fusible links.
 - 3. To interior of ducts for cleaning; before and after each change in direction, at maximum 50-foot spacing.
 - 4. On sides of ducts where adequate clearance is available.
- J. Install the following minimum sizes for duct-mounting, rectangular access doors and access panels:
 - 1. Inspection Access: 8 by 5 inches.
 - 2. Two-Hand Access: 12 by 12 inches.
 - 3. Head and Hand Access: 18 by 10 inches.
 - 4. Head and Shoulders Access: 21 by 14 inches.
 - 5. Body Access: 25 by 14 inches.

6. Body Plus Ladder Access: 25 by 17 inches.

- K. Label access doors according to Division 23 Section "Identification for HVAC Piping and Equipment."
- L. Install flexible connectors immediately adjacent to equipment in ducts associated with fans and motorized equipment supported by vibration isolators.
- M. Connect terminal units to supply ducts with maximum 12-inch lengths of flexible duct. Do not use flexible connector to change directions.
- N. Connect diffusers to low pressure ducts with maximum 96-inch lengths of flexible duct clamped or strapped in place.
- O. Connect flexible ducts to metal ducts with draw bands and adhesive.
- P. Install duct test holes where indicated and required for testing and balancing purposes.

3.2 ADJUSTING

- A. Adjust duct accessories for proper settings.
- B. Adjust fire and smoke dampers for proper action.
- C. Final positioning of manual-volume dampers is specified in Division 23 Section "Testing, Adjusting, and Balancing."

END OF SECTION 233300

SECTION 233416 - CENTRIFUGAL FANS

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 centrifugal fans.

1.3 PERFORMANCE REQUIREMENTS

- A. Project Altitude: Base air ratings on standard air conditions.
- B. Operating Limits: Classify according to AMCA 99.

1.4 SUBMITTALS

- A. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated and include the following:
 - 1. Certified fan performance curves with system operating conditions indicated.
 - 2. Certified fan sound-power ratings.
 - 3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
 - 4. Material gages and finishes, including color charts.
 - 5. Dampers, including housings, linkages, and operators.
- B. Maintenance Data: For centrifugal fans to include in maintenance manuals specified in Division 01.

1.5 QUALITY ASSURANCE

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

1.6 DELIVERY, STORAGE, AND HANDLING

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

1.7 COORDINATION

- A. Coordinate size and location of structural-steel support members.
- B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section "Cast-in-Place Concrete."
- C. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

1.8 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Belts: One set for each belt-driven unit.
 - 2. Grease Absorber: One for each grease fan.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Greenheck Fan Corp.
 - 2. Cook, Loren Company.
 - 3. PennBarry

2.2 UPBLAST/SIDEWALL KITCHEN HOOD EXHAUST FANS

- A. Furnish and install exhaust fans of model, size and capacity as shown on drawings.
 - 1. Kitchen hood exhaust fans shall be UL listed for kitchen hood exhaust (UL 762).

- B. Housings shall be of contour type, circular, aluminum, circumferential air discharge, upblast.
- C. Fan shall be the backwardly inclined type with centrifugal wheel that has been statically and dynamically balanced at the factory.
- D. Motor shall be installed in a totally enclosed weather-proof housing outside of the air stream. Provide outside air cooling tube and wiring conduit into motor enclosure.
- E. Drives shall be belt driven. Belt shall be oil resistant. An adjustable sheave on the motor shall be provided to allow changes in the fan speed. Drives sized for 150% of motor horsepower. Provide pillow-bearings.
- F. Ventilators shall be installed on the roof on a pre-fabricated, self-flashing aluminum curb. Provide vented extension on curb to meet NFPA 96D and to meet discharge height required by code.
- G. Fan shall be provided with a factory-mounted grease drain and removable container for field cleaning of accumulated grease.
- H. Sidewall mounted fan shall not carry the UL 762 designation or grease exhaust accessories.
- I. Provide the following accessories:
 - 1. Disconnect switch, NEMA 3R.
 - 2. Hinge kit for tilt-up access to fan parts and ducts. (Not provided with sidewall mounting fan)
 - 3. UL 762 Grease Trap
 - 4. Variable Frequency Drive

2.3 MOTORS

- A. Refer to Division 23 Section "Common Motor Requirements for HVAC Equipment" for general requirements for factory-installed motors.
- B. Motor Construction: NEMA MG 1, general purpose, continuous duty, high efficiency, Design B rated for variable frequency drive.
- C. Enclosure Type: Open dripproof or totally enclosed, fan cooled as required for fan style.

2.4 SOURCE QUALITY CONTROL

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

2.5 VARIABLE FREQUENCY CONTROLLERS

- A. Description: NEMA ICS 2, IGBT, PWM, VFC; listed and labeled as a complete unit and arranged to provide variable speed of an NEMA MG 1, Design B, 3-phase induction motor by adjusting output voltage and frequency.
 - 1. Provide unit suitable for operation of standard-efficiency motor as defined by NEMA MG 1.
 - 2. Provide a filter on the incoming power to each variable frequency controller matched to the controller style and operating characteristics to prevent passage of any harmonics through any building electrical systems.
- B. Design and Rating: Match load type to fans and type of connection used between motor and load such as direct or through a power-transmission connection.
- C. Output Rating: 3-phase; 0 to 150 Hz.
- D. Unit Operating Requirements:
 - 1. Input ac voltage tolerance of 208 V, plus or minus 10 percent and 380 to 480 V, plus or minus 10 percent.
 - 2. Input frequency tolerance of 47 Hz to 63 Hz.
 - 3. Minimum Efficiency: 96 percent at 60 Hz, full load.
 - 4. Minimum Displacement Primary-Side Power Factor: 98 percent.
 - 5. Overload Capability: 1.0 times the base load current for 60 seconds; 1.5 times the base load current for 3 seconds.
 - 6. Starting Torque: 100 percent of rated torque or as indicated.
 - 7. Speed Regulation: Plus or minus 1 percent.
- E. Isolated control interface to allow controller to follow control signal over an 11:1 speed range.
 - 1. Electrical Signal: 4 to 20 mA at 24 V.
- F. Internal Adjustability Capabilities:
 - 1. Minimum Speed: 5 to 25 percent of maximum rpm.
 - 2. Maximum Speed: 80 to 100 percent of maximum rpm.
 - 3. Acceleration: 2 to a minimum of 22 seconds.
 - 4. Deceleration: 2 to a minimum of 22 seconds.
 - 5. Current Limit: 50 to a minimum of 110 percent of maximum rating.
- G. Self-Protection and Reliability Features:
 - 1. Input transient protection by means of surge suppressors.
 - 2. Under- and overvoltage trips; inverter overtemperature, overload, and overcurrent trips.
 - 3. Motor Overload Relay: Adjustable and capable of NEMA 250 performance.
 - 4. Notch filter to prevent operation of the controller-motor-load combination at a natural frequency of the combination.
 - 5. Instantaneous line-to-line and line-to-ground overcurrent trips.
 - 6. Loss-of-phase protection.

7. Reverse-phase protection.
 8. Short-circuit protection.
 9. Motor overtemperature fault.
- H. Automatic Reset/Restart: Attempts three restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction. Bidirectional autospeed search shall be capable of starting into rotating loads spinning in either direction and returning motor to set speed in proper direction, without damage to controller, motor, or load.
- I. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped.
- J. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.
- K. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.
- L. Status Lights: Door-mounted LED indicators shall indicate the following conditions:
1. Power on.
 2. Run.
 3. Overvoltage.
 4. Line fault.
 5. Overcurrent.
 6. External fault.
- M. Panel-Mounted Operator Station: Start-stop and auto-manual selector switches with manual speed control potentiometer.
- N. Indicating Devices: Meters or digital readout devices and selector switch, mounted flush in controller door and connected to indicate the following controller parameters:
1. Output frequency (Hz).
 2. Motor speed (rpm).
 3. Motor status (running, stop, fault).
 4. Motor current (amperes).
 5. Motor torque (percent).
 6. Fault or alarming status (code).
 7. PID feedback signal (percent).
 8. DC-link voltage (VDC).
 9. Set-point frequency (Hz).
 10. Motor output voltage (V).
- O. Control Signal Interface:
1. Electric Input Signal Interface: A minimum of 2 analog inputs (0 to 10 V or 0/4-20 mA) and 6 programmable digital inputs.

2. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the BAS or other control systems:
 - a. 0 to 10-V dc.
 - b. 0-20 or 4-20 mA.
 - c. Potentiometer using up/down digital inputs.
 - d. Fixed frequencies using digital inputs.
 - e. RS485.
 - f. Keypad display for local hand operation.
3. Output Signal Interface:
 - a. A minimum of 1 analog output signal (0/4-20 mA), which can be programmed to any of the following:
 - 1) Output frequency (Hz).
 - 2) Output current (load).
 - 3) DC-link voltage (VDC).
 - 4) Motor torque (percent).
 - 5) Motor speed (rpm).
 - 6) Set-point frequency (Hz).
4. Remote Indication Interface: A minimum of 2 dry circuit relay outputs (120-V ac, 1 A) for remote indication of the following:
 - a. Motor running.
 - b. Set-point speed reached.
 - c. Fault and warning indication (overtemperature or overcurrent).
 - d. PID high- or low-speed limits reached.
- P. Communications: Provide an RS485 interface allowing VFC to be used with an external system within a multidrop LAN configuration. Interface shall allow all parameter settings of VFC to be programmed via BAS control. Provide capability for VFC to retain these settings within the nonvolatile memory.
- Q. Manual Bypass: Magnetic contactor arranged to safely transfer motor between controller output and bypass controller circuit when motor is at zero speed. Controller-off-bypass selector switch sets mode, and indicator lights give indication of mode selected. Unit shall be capable of stable operation (starting, stopping, and running), with motor completely disconnected from controller (no load).
- R. Integral Disconnecting Means: NEMA AB 1, instantaneous-trip circuit breaker with lockable handle.
- S. Isolating Switch: Non-load-break switch arranged to isolate VFC and permit safe troubleshooting and testing, both energized and de-energized, while motor is operating in bypass mode.
- T. NEMA 250, Type 1 enclosure.
- U. Historical Logging Information and Displays:

1. Real-time clock with current time and date.
 2. Running log of total power versus time.
 3. Total run time.
 4. Fault log, maintaining last four faults with time and date stamp for each.
- V. Current-Sensing, Phase-Failure Relays for Bypass Controller: Solid-state sensing circuit with isolated output contacts for hard-wired connection; arranged to operate on phase failure, phase reversal, current unbalance of from 30 to 40 percent, or loss of supply voltage; with adjustable response delay.
- W. Provide factory start-up and perform all tests stated in NETA ATS.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install centrifugal fans level and plumb.
- B. Install units with clearances for service and maintenance.
- C. Label fans according to requirements specified in Division 23 Section "Identification for HVAC Piping and Equipment."

3.2 CONNECTIONS

- A. Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Division 23 Section "Duct Accessories."
- B. Install ducts adjacent to fans to allow service and maintenance.
- C. Ground equipment.
- D. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.3 FIELD QUALITY CONTROL

- A. Equipment Startup Checks:
 1. Verify that shipping, blocking, and bracing are removed.
 2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
 3. Verify that cleaning and adjusting are complete.

4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
5. Verify lubrication for bearings and other moving parts.
6. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.

B. Starting Procedures:

1. Energize motor and adjust fan to indicated rpm.
2. Measure and record motor voltage and amperage.

C. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Remove malfunctioning units, replace with new units, and retest.

D. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

E. Shut unit down and reconnect automatic temperature-control operators.

F. Refer to Division 23 Section "Testing, Adjusting, and Balancing" for testing, adjusting, and balancing procedures.

G. Replace fan and motor pulleys as required to achieve design airflow.

H. Repair or replace malfunctioning units. Retest as specified above after repairs or replacements are made.

3.4 ADJUSTING

- A. Adjust damper linkages for proper damper operation.
- B. Adjust belt tension.
- C. Lubricate bearings.

3.5 CLEANING

- A. On completion of installation, internally clean fans according to manufacturer's written instructions. Remove foreign material and construction debris. Vacuum fan wheel and cabinet.
- B. After completing system installation, including outlet fitting and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes.

3.6 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain centrifugal fans.

1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment and schedules.
2. Review data in maintenance manuals. Refer to Division 01 Section "Operation and Maintenance Data."
3. Schedule training with Owner, through Architect, with at least seven days of advance notice.

END OF SECTION 233416

SECTION 233713 - DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes ceiling- and wall-mounted diffusers, registers, and grilles.
- B. Related Sections include the following:
 - 1. Division 10 Section "Louvers and Vents" for fixed and adjustable louvers and wall vents, whether or not they are connected to ducts.
 - 2. Division 23 Section "Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers, registers, and grilles.
 - 3. Division 23 Section "Testing, Adjusting, and Balancing" for balancing diffusers, registers, and grilles.

1.3 DEFINITIONS

- A. Diffuser: Circular, square, or rectangular air distribution outlet, generally located in the ceiling and comprised of deflecting members discharging supply air in various directions and planes and arranged to promote mixing of primary air with secondary room air.
- B. Grille: A louvered or perforated covering for an opening in an air passage, which can be located in a sidewall, ceiling, or floor.
- C. Register: A combination grille and damper assembly over an air opening.

1.4 SUBMITTALS

- A. Product Data: For each model indicated, include the following:
 - 1. Data Sheet: For each type of air outlet and inlet, and accessory furnished; indicate construction, finish, and mounting details.
 - 2. Performance Data: Include throw and drop, static-pressure drop, and noise ratings for each type of air outlet and inlet.
 - 3. Schedule of diffusers, registers, and grilles indicating drawing designation, room location, quantity, model number, size, and accessories furnished.
 - 4. Assembly Drawing: For each type of air outlet and inlet; indicate materials and methods of assembly of components.

1.5 QUALITY ASSURANCE

- A. Product Options: Drawings and schedules indicate specific requirements of diffusers, registers, and grilles and are based on the specific requirements of the systems indicated. Other manufacturers' products with equal performance characteristics materials, size and aesthetics may be considered. Refer to Division 01 Section "Substitutions." NC levels must be equal to or less than those produced by the scheduled air device at the same design conditions.
- B. NFPA Compliance: Install diffusers, registers, and grilles according to NFPA 90A, "Standard for the Installation of Air-Conditioning and Ventilating Systems."

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

- A. Diffusers, registers, and grilles are scheduled on Drawings.
- B. Manufacturers:
 - 1. Tuttle & Bailey.
 - 2. Nailor Industries Inc.
 - 3. Price.
 - 4. Titus.
- C. Provide ceiling radiation dampers as noted on drawings. Dampers required at all rated ceiling, refer to architectural drawings for all locations.
- D. Provide opposed blade dampers as noted on drawings.

2.2 SOURCE QUALITY CONTROL

- A. Testing: Test performance according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install diffusers, registers, and grilles level and plumb, according to manufacturer's written instructions, Coordination Drawings, original design, and referenced standards.
- B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practicable. For units installed in lay-in ceiling panels, locate units in the center of the panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.
- C. Install diffusers, registers, and grilles with airtight connection to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.3 ADJUSTING

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

3.4 CLEANING

- A. After installation of diffusers, registers, and grilles, inspect exposed finish. Clean exposed surfaces to remove burrs, dirt, and smudges. Replace diffusers, registers, and grilles that have damaged finishes.

END OF SECTION 233713

SECTION 238120 – VARIABLE REFRIGERANT FLOW 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 split-type variable refrigerant flow systems and controls. The system shall utilize indoor terminal units with a refrigerant management system and outdoor air-cooled condenser to provide simultaneous heating and cooling to all terminal units within the system.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.
- B. Shop Drawings for Refrigerant Piping System: Include plans, elevations, sections, details, and attachments to other work.
 - 1. Detail all piping and accessories including equipment assemblies and indicate dimensions, components, and location and size of each field connections.
- C. Delegated-Design Submittals:
 - 1. Include design calculations with corresponding diagram of refrigerant piping and tubing sizing for each system installed.
 - 2. Include design calculations with corresponding floor plans indicating that refrigerant concentration limits are within allowable limits of ASHRAE 15 and governing codes.
 - 3. Include calculations showing that system travel distance for refrigerant piping and controls cabling are within horizontal and vertical travel distances set by manufacturer. Provide a comparison table for each system installed.
- D. Operation and Maintenance Data: For split-system air-conditioning units to include in emergency, operation, and maintenance manuals.
- E. Warranty: Sample of special warranty.

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. VRF systems and components shall be UL 1995 compliant.
- C. ASHRAE Compliance:
 - 1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."
 - 2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - "Procedures," and Section 7 - "Construction and System Start-Up."
- D. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2007.

1.5 INSTALLATION REQUIREMENTS

- A. The system must be installed by factory trained contractor/dealer. The bidders shall be required to submit training certification proof with bid documents. The mechanical contractor's installation price shall be based on the systems installation requirements. The mechanical contractor bids with complete knowledge of the HVAC system requirements.
- B. The installing contractor shall notify the local representative of the VRF manufacturer mid-way through the project to inspect all VRF evaporator units, branch controllers, refrigerant piping, and heat recovery / condensing units installed. The local representative of the VRF manufacturer shall confirm that the already installed VRF components meet the manufacturer's requirements for installation quality and for maintenance and service access. A written report of all installation errors or other faults which could affect the performance of the system or its future maintenance and service shall be documented and the contractor shall perform all steps that are required from this written report to properly complete the installation of the VRF system per plans and specifications.
- C. At the end of construction and prior to substantial completion, the installing contractor shall notify the local representative of the VRF manufacturer to inspect all VRF evaporator units, branch controllers, refrigerant piping, and heat recovery / condensing units installed. The local representative of the VRF manufacturer shall confirm that the installed VRF components meet the manufacturer's requirements for installation quality and for maintenance and service access. A written report of all installation errors or other faults which could affect the performance of the system or its future maintenance and service shall be documented and the contractor shall perform all steps that are required from this written report to properly complete the the VRF system per plans and specifications.

1.6 COORDINATION

- A. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.7 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of variable refrigerant air handling units and outdoor heat recovery units that fail in materials or workmanship within specified warranty period.

1. Warranty Period:

- a. For Compressor: Six years from date of Substantial Completion.
- b. For Parts: One year from date of Substantial Completion.
- c. For Labor: One year from date of Substantial Completion.

1.8 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 for each air-handling unit.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Trane
2. Mitsubishi
3. Samsung
4. Approved Equal.

2.2 SYSTEM DESCRIPTION

- A. The variable capacity, multi-zone heat pump system shall consist of multiple evaporators, system compatible refrigerant joints and headers, a two or three pipe refrigeration distribution system and a direct expansion (DX), air-cooled heat recovery condensing units with variable speed inverter driven compressors using R-410A refrigerant.
- B. Operation of the system shall permit either individual cooling or heating of each indoor unit simultaneously or all of the indoor units associated with one branch cool/heat selector box.
- C. Manufacturer is responsible for the entire refrigerant piping system design in accordance with the specified materials and installation requirements listed in Section 232300.
- D. The VRF system scope shall consist of the provision of all labor, materials, piping, equipment, controls and appurtenances, even though these may not be specifically mentioned in this specification or on the drawings, which are required for a complete and fully functional variable refrigerant flow air conditioning and heating system.

- E. All systems shall have published performance ratings certified by AHRI and listed in AHRI Standard 1230.

2.3 OUTDOOR HEAT RECOVERY UNITS

- A. General: 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 scroll compressors, motors, fans, condenser coil, electronic expansion valves, solenoid valves, 4-way valve, distribution headers, capillaries, filters, strainers, check valves, shut off valves, oil separators, service ports and refrigerant regulator. Dual and Triple Frame configurations shall be field piped using the manufacturer's designed and supplied Y-branch kit and field provided interconnecting pipe to form a common refrigerant circuit.
 - 1. The following safety devices shall be included on the condensing unit: high pressure switch, control circuit fuses, crankcase heaters, fusible plug, high pressure switch, overload relay, inverter overload protector, thermal protectors for compressor and fan motors, over current protection for the inverter, anti-recycling timers, oil management system, and automatic defrost cycles.
 - 2. Units shall be provided with factory installed microprocessor-based controls to efficiently operate the VRF system. The unit shall have the following sensors as standard:
 - a. Suction temperature sensor.
 - b. Discharge temperature sensor.
 - c. High pressure sensor.
 - d. Low pressure sensor.
 - e. Outdoor temperature sensor.
 - f. Outdoor unit heat exchanger temperature sensor.
 - 3. Units shall be provided with low ambient cooling kits to all cooling down to -4 degrees F.
 - 4. Units shall be capable of cooling in ambient conditions up to 122 degrees F.
 - 5. Units shall be capable of heating in ambient conditions between -13 degrees F to 61 degrees F.
 - 6. Units shall be capable of synchronous cooling between 14 degrees F and 81 degrees F.
 - 7. Units shall be capable of synchronous cooling between 14 degrees F and 61 degrees F.
- B. Unit Cabinet:
 - 1. The outdoor unit shall be completely weatherproof and corrosion resistant. The unit shall be constructed from galvanized steel panels coated with a baked enamel finish and salt spray tested in accordance with ASTM B-117 for a minimum of 1000 hours. The unit panels shall be removable for access.
- C. Fan:
 - 1. The condensing unit shall consist of one or more vertical discharge propeller type, direct-drive fan motors that have multiple speed operation via a DC (digitally commutating) inverter.
 - 2. The fan motor shall have inherent thermal overload protection and permanently lubricated bearings.
 - 3. The fan motor shall be provided with a fan guard.

D. Condenser Coil:

1. The condenser coil shall be manufactured from internally enhanced copper tubes expanded into aluminum fins to form a mechanical bond.

E. Compressor:

1. Hermetically sealed scroll type compressors. Compressors shall be inverter type, variable speed control and operation.
2. Each compressor shall be equipped with a crankcase heater, high pressure safety switch, over and under current protection, phase failure and phase reversal protection, and internal thermal overload protector.
3. Oil separators shall be standard with the equipment together with an intelligent oil management system.
4. Compressors shall be spring mounted to avoid the transmission of vibration.

F. Electrical:

1. The control voltage between the indoor and outdoor unit shall be 16VDC non-shielded, stranded 2 conductor cable.
2. The control wiring shall be a two-wire multiplex transmission system.

2.4 INDOOR UNITS

A. General: All indoor units shall be factory assembled, wired, piped and run tested. All indoor units shall be capable to be installed with heat pump or heat recovery or cooling VRF system. All units shall operate on R-410A refrigerant. All units shall be equipped with the following:

1. Factory installed thermistors for return air, refrigerant entering coil, and refrigerant leaving coil.
2. Electronic thermal expansion valve.
3. Evaporator Coil: copper tubing with mechanically bonded aluminum fins, factory pressure tested to a minimum of 550 psig.
4. Integral condensate drain pan.
5. Factory installed microprocessor control panel to communicate with other indoor units and the outdoor unit.
6. All indoor units shall have the following functions as standard:
 - a. Self-diagnostic function
 - b. Auto restart function
 - c. Auto changeover function (Heat Recovery system only)
 - d. Auto operation function
 - e. Auto clean function
 - f. Child lock function
 - g. Forced operation
 - h. Dual thermistor control
 - i. Sleep mode
7. Filter: Integral filter rack.

B. Ceiling Cassette Unit

1. Indoor Unit: The indoor unit shall be completely factory assembled and tested. Included in the unit is factory wiring, piping, electronic proportional expansion valve, control circuit board, fan motor thermal protector, flare connections, condensate drain pan, condensate drain pump, self-diagnostics, auto-restart function, 3-minute fused time delay, and test run switch. The indoor units shall be equipped with a return air thermistor. The cabinet shall be constructed with sound absorbing foamed polystyrene and polyethylene insulation.
2. The fan shall be direct-drive fan type with statically and dynamically balanced impeller with high and low fan speeds available. The fan motor shall contain thermal overload protection.
3. Filter: Provide high efficiency filters.
4. Coils shall be of the direct expansion type constructed from copper tubes expanded into aluminum fins to form a mechanical bond. The coil shall be of a waffle louver fin and high heat exchange, rifled bore tube design. The coil shall be a cross fin copper evaporator coil with 17 FPI design completely factory tested.
5. A condensate pump with a 24 inch lift shall be located below the coil in the condensate pan with a built in safety alarm. Include a condensate overflow switch in unit.
6. A thermistor will be located on the liquid and gas line

2.5 CONTROLS

A. Individual Unit Control:

1. All indoor terminal units shall be provided with a wall mounted, backlight LCD display, auto-changeover, 7-day programmable thermostat. Deluxe Wired MA controller, model TAR-40MAAU.
2. Thermostats shall have independent cooling and heating set-point with adjustable deadband. The heat pump shall automatically switch between heating and cooling modes to meet the setpoint. The Thermostat display shall have indicate the following functions:
 - a. On/off
 - b. Operation mode
 - c. Fan speed
 - d. Set point
 - e. Current room temperature

B. Central System Controller:

1. This controller shall be wall mounted and hard wired to each of the terminal heat pump units and outdoor condensing units. Mitsubishi Model AE-200A with expansion controller and BACnet interface and license. It will be manufactured with color LCD touch panel display and will be the manufacturer's standard color. The controller shall be capable of connecting all of the individual indoor units and all of the outdoor units with the following functions:
 - a. ON/OFF selection for each indoor unit.
 - b. Space temperature for each indoor unit
 - c. Temperature set point adjustment for each indoor unit.
 - d. Fan speed adjustment for each indoor unit
 - e. Mode selection

- f. Forced shutdown of indoor units
 - g. Priority setting for restriction of local access to start/stop, heat/cool mode and set point adjustment functions.
 - h. Temperature limitations in both heating and cooling mode.
 - i. Schedule adjustments
 - j. Reset of error codes and filter replacement warning
- 2. Each Intelligent controller unit shall be accessed remotely via standard web browser. Real time status, operation, and history shall be accessible. Malfunction reports shall be able to be sent via email when connected to the building local area network.
 - 3. The controller shall include optional hardware for the addition of up to 8 digital inputs for the monitoring of other equipment located in the building.
 - 4. Connectivity:
 - a. One (1) RJ-45 Ethernet port to support interconnection with a network PC
 - b. One (1) RS 232C port
 - c. One (1) PCMCIA Card Slot
 - d. Terminal block for 24V power supply
 - e. Terminal block for communication with the indoor heat pump units and outdoor condensing units.
 - 5. Controller to be installed in centrally located Mechanical or Utility room.

2.6 SOURCE QUALITY CONTROL

- A. Verification of Performance: Rate compressor and condenser units according to ARI 210/240.
- B. Energy Efficiency: Equal to or greater than prescribed by ASHRAE/IESNA 90.1-2004, "Energy Efficient Design of New Buildings except Low-Rise Residential Buildings," Section 6, "Heating, Ventilating, and Air-Conditioning."
- C. Test and inspect shell and tube condensers according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
- D. Testing Requirements: Factory test sound-power-level ratings according to ARI 270.

2.7 ACCESSORIES

- A. Provide Web-enabled system controller with graphical interface for all system equipment, local digital thermostats, all accessories and interconnecting wiring for a complete operational system.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install unit level and plumb, firmly anchored in locations indicated; maintain manufacturer's recommended clearances.

- B. Vibration Isolation: Mount compressor and condenser units on spring isolators with a minimum deflection meeting manufacturer's requirement. Vibration isolation devices and installation requirements are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."
- C. Maintain manufacturer's recommended clearances for service and maintenance.
- D. Loose Components: Install electrical components, devices, and accessories that are not factory mounted.

3.2 CONNECTIONS

- A. Comply with requirements for piping in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.
- C. Connect precharged refrigerant tubing to unit's quick-connect fittings. Install tubing so it does not interfere with access to unit. Install furnished accessories.
- D. Connect refrigerant piping to air-cooled compressor and condenser units; maintain required access to unit. Install furnished field-mounted accessories. Refrigerant piping and specialties are specified in Division 23 Section "Refrigerant Piping."
- E. Duct Connections: Duct installation requirements are specified in Division 23 Section "Metal Ducts" Drawings indicate the general arrangement of ducts. Connect supply ducts to split-system air-conditioning units with flexible duct connectors. Flexible duct connectors are specified in Division 23 Section "Air Duct Accessories."

3.3 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections, and to assist in testing.
- B. Tests and Inspections:
 - 1. Perform each visual and mechanical inspection and electrical test. Certify compliance with test parameters.
 - 2. Leak Test: After installation, charge system with refrigerant and oil and test for leaks. Repair leaks replace lost refrigerant and oil, and retest until no leaks exist.
 - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor operation and unit operation, product capability, and compliance with requirements.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

- 5. Verify proper airflow over coils.
- C. Verify that vibration isolation and flexible connections properly dampen vibration transmission to structure.
- D. Compressor and condenser units will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports.

3.4 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 and perform the following:
 - a. Inspect for physical damage to unit casing.
 - b. Verify that access doors move freely and are weathertight.
 - c. Clean units and inspect for construction debris.
 - d. Verify that all bolts and screws are tight.
 - e. Adjust vibration isolation and flexible connections.
 - f. Verify that controls are connected and operational.
- B. Lubricate bearings on fan motors.
- C. Verify that fan wheel is rotating in the correct direction and is not vibrating or binding.
- D. Start unit according to manufacturer's written instructions and complete manufacturer's startup checklist. Measure and record airflow and air temperature rise over coils.
- E. Verify proper operation of condenser capacity control device.
- F. Verify that vibration isolation and flexible connections properly dampen vibration transmission to structure.
- G. After startup and performance test, lubricate bearings.

3.5 DEMONSTRATION

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

END OF SECTION 238120

SECTION 238216 – ELECTRIC AIR COILS

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 electric resistance air coils.

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 air coil.
 - 2. Include rated capacities, operating characteristics, and pressure drops for each air coil.
- B. Shop Drawings: Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which coil location and ceiling-mounted access panels are shown and coordinated with each other.
- B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For air coils to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 DESCRIPTION

- A. ASHRAE Compliance: Comply with applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

2.2 COILS

- A. Manufacturers:
 - 1. Qmark, Inc.
 - 2. Trane Company
 - 3. Berko, Inc.
 - 4. Stelpro
- B. Testing Agency Listing and Labeling: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Coil Assembly: Comply with UL 1995.
- D. Heating Elements: Coiled resistance wire of 80 percent nickel and 20 percent chromium; surrounded by compacted magnesium-oxide powder in tubular-steel sheath; with spiral-wound, copper-plated, steel fins continuously brazed to sheath.
- E. High-Temperature Coil Protection: Disk-type, automatically reset, thermal-cutout, safety device; serviceable through terminal box without removing heater from duct or casing.
 - 1. Secondary Protection: Load-carrying, manually reset or manually replaceable, thermal cutouts; factory wired in series with each heater stage.
- F. Frames: Galvanized-steel channel frame, minimum 0.079 inch thick for slip-in mounting.
- G. Control Panel: Unit mounted with disconnecting means and overcurrent protection. Include the following controls:
 - 1. SCR controller for modulating control.
 - 2. Time-delay relay.
 - 3. Pilot lights.
 - 4. Airflow proving switch.
- H. Controls:
 - 1. EDH: Provide discharge air controller to maintain an adjustable (50 Degree) discharge air temperature from heating coil. Controller to have SCR output for modulation control. When outside air is above setpoint, coil shall be locked out. Each electric coil to have own controller.
- I. Capacities and Characteristics: Refer to drawing schedule.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine ducts, plenums, and casings to receive air coils for compliance with requirements for installation tolerances and other conditions affecting coil performance.

- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install coils level and plumb.
- B. Install coils in metal ducts and casings constructed according to SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."
- C. Clean coils using materials and methods recommended in writing by manufacturers, and clean inside of casings and enclosures to remove dust and debris.

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."

3.4 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections.
 - 1. Operational Test: After electrical circuitry has been energized, operate electric coils to confirm proper unit operation.
 - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- B. Prepare test and inspection reports.

END OF SECTION 238216

SECTION 238219 - BLOWER COIL UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Blower coil units and accessories.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include rated capacities, operating characteristics, and furnished specialties and accessories.
 - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Include diagrams for power, signal, and control wiring.

1.4 CLOSEOUT SUBMITTALS

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

1.5 EXTRA 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. Blower Coil Unit Filters: Furnish one set spare filters for each unit installed.

1.6 QUALITY ASSURANCE

- A. Comply with NFPA 70.
- B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

- C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.7 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of fan coil units that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: One year from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 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. Factory-packaged and -tested units rated according to AHRI 440, ASHRAE 33, and UL 1995.

2.2 BLOWER COIL UNITS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Trane Company
 - 2. Carrier
 - 3. Johnson Controls
- B. Description: Factory-assembled and -tested, fan coils consisting of cabinet; heating coil; cooling coil supply fan; filters; dampers; and isolation valves to allow servicing of components.
- C. Unit Insulation: 1"-inch-thick, foil coated insulation complying with ASTM C 1071 and attached with adhesive complying with ASTM C 916.
 - 1. Surface-Burning Characteristics: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84 by a qualified testing agency.
 - 2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- D. Drain Pans: Double-sloped, insulated stainless steel. Fabricate pans and drain connections to comply with ASHRAE 62.1. Drain pan shall be removable for cleaning.
 - 1. Provide with condensate overflow switch.
- E. Casing: Galvanized steel with removable side panels for access.

- F. Filters: 1" filter rack with MERV 8 filters as scheduled with minimum arrestance and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2 and all addendums.
- G. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch, tested in accordance with AHRI Standard 410. Each coil shall be factory tested for leakage at 300 psig air pressure under water. Coils shall be rated for a minimum working pressure of 250 psig and a maximum entering-water temperature of 200 deg F. Include manual air vent and drain valve.
- H. Fan and Motor:
 - 1. Fan coil units: Fans: Direct driven, centrifugal fan with variable speed ECM motor.
 - 2. Bearings: permanently sealed and lubricated ball bearings.
 - 3. Motor: Open drip-proof, mounted on an adjustable base to allow for tensioning and alignment. Comply with requirements in Section 23 05 13 "Common Motor Requirements for HVAC Equipment."
 - 4. Wiring Termination: Connect motor to chassis wiring with plug connection.
- I. Control devices and operational sequences are specified in Section 23 09 00 "Instrumentation and Control for HVAC" and Section 23 09 93 "Sequence of Operations for HVAC Controls."
- J. Electrical Connection: Factory wire motors and controls for a single electrical connection.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas, with Installer present, to receive fan coil and blower coil units for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for piping and electrical connections to verify actual locations before fan coil and blower coil unit installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install blower coil units level and plumb.
- B. Install blower coil units to comply with NFPA 90A.
- C. Verify locations of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation.
- D. Install new filters in each fan coil and blower coil unit within two weeks after Substantial Completion.

- E. Suspend blower coil with spring isolators, refer to 230548 VIBRATION CONTROLS FOR HVAC PIPING & EQUIPMENT.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:
 - 1. Install piping adjacent to machine to allow service and maintenance.
 - 2. Connect piping to fan coil unit factory hydronic piping package. Install piping package if shipped loose.
 - 3. Install piping at blower coil units per details on the drawings.
 - 4. Connect condensate drain to indirect waste.
 - a. Install condensate trap of adequate depth to seal against fan pressure. Install cleanouts in piping at changes of direction.
- B. Connect supply-air and return-air ducts to units with flexible duct connectors specified in Section 23 33 00 "Air Duct Accessories." Comply with safety requirements in UL 1995 for duct connections.
- C. Ground equipment according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."
- D. Connect wiring according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test, start-up and inspect components, assemblies, and equipment installations, including connections.
- C. Perform the following tests and inspections:
 - 1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 2. Operate electric heating elements through each stage to verify proper operation and electrical connections.
 - 3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.
- D. Remove and replace malfunctioning units and retest as specified above.
- E. Prepare test and inspection reports.

3.5 ADJUSTING

- A. Adjust initial temperature and humidity set points.
- B. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

END OF SECTION 238219

SECTION 23 82 39 - ELECTRIC HEATERS

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. Forced Air Heaters.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, furnished specialties, and accessories.
- B. Samples for Initial Selection: For units with factory-applied color finishes.
- C. Field quality-control test reports.
- D. Operation and Maintenance Data: For electric heaters to include in maintenance manuals.
- E. Warranties: Special warranties specified in this Section.

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.

1.5 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of electric radiators that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: One year from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 FORCED AIR HEATERS

A. Manufacturers:

1. Chromalox; Division of Emerson Electric Company.
2. Marley Electric Heating; a United Dominion Company.
3. Qmark Electric Heating.
4. Trane.

B. Heating Elements: Enclosed in metallic sheath mechanically expanded into steel plate fins, with high-temperature cutout. Elements shall be of a non-glowing style. Element supports eliminate thermal expansion noise.

C. Enclosures: Steel with exposed corners rounded; removable front panels with tamperproof fasteners braced and reinforced for stiffness.

1. Front and Top: 0.0598-inch- thick steel.
2. Back and Ends: 0.0478-inch- thick steel.
3. Insulation: 1/2-inch- thick, fibrous glass on inside at front, sides, and back of enclosure.
4. Finish: Factory-applied baked enamel in color selected by Architect from manufacturer's custom colors.
5. Enclosure Style: Recessed
- 6.

D. Unit Controls (As Noted on drawings schedules):

1. Heater shall operate with an integral thermostat as specified. Upon a drop below setpoint, 68°F (adj.), the heater, and fan when applicable, shall engage to meet the space setpoint. No BAS connection.

E. Accessories:

1. Integral thermostat and disconnect switch.
2. Recessed Mounting Frame (ceiling heaters)

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in for electric radiators to verify actual locations of electrical connections before equipment installation.
- B. Examine walls for suitable conditions where electric radiators will be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install electric heater level and plumb and according to the following, unless otherwise indicated:
 - 1. Center units where shown on documents.

3.3 CONNECTIONS

- A. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- B. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors And Cables."
- C. 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. Testing: Perform the following field quality-control testing and prepare test reports:
 - 1. Operate electric heating elements through each stage to verify proper operation and electrical connections.
 - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

END OF SECTION 23 82 39

SECTION 260500 - COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

1. Electrical equipment coordination and installation.
2. Sleeves for raceways and cables.
3. Grout.
4. Common electrical installation requirements.

1.3 COORDINATION

- A. Coordinate arrangement, mounting, and support of electrical 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 electrical 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. 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 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 ELECTRICAL 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 electrical 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 ELECTRICAL PENETRATIONS

- A. Electrical penetrations occur when raceways, cables, wireways, cable trays, or busways 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.
- 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. Exterior-Wall Penetrations: 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."
- M. Air and Water Resistant Barrier Penetrations: Provide prefabricated flashing accessories as indicated in Division 7 Section Flexible Flashing Panels".

3.3 FIRESTOPPING

- A. Apply firestopping to penetrations of fire-rated floor and wall assemblies for electrical 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 260500

SECTION 260501 - EQUIPMENT CONNECTIONS AND COORDINATION

PART 1 - GENERAL

1.1 DESCRIPTION

- A. General: Provide final connections to equipment and coordinate same in accordance with the Contract documents.
- B. Equipment to receive final connections shall include but not be limited to the following:
 - 1. Motors and equipment.
 - 2. Appliances.
- C. Drawings and general provisions of the Contract, including general and supplementary conditions and Division 01 specification sections, apply to this section.
- D. Related work specified in Division 26.
- E. Related work specified in other division of these specifications:
 - 1. Motors.
 - 2. FF&E Package.
 - 3. Control Wiring.
 - 4. Appliances.
 - 5. Kitchen Equipment.

1.2 QUALITY ASSURANCE

- A. Prior to the submitting of bids, the Contractor shall familiarize himself with all conditions affecting the proposed installation of equipment requiring electrical connections and shall make provisions as to the cost thereof. Failure to comply with the intent of this paragraph shall in no way relieve the Contractor of performing all necessary work required for final electrical connections and equipment and the coordination thereof.
- B. Connections and overcurrent protection devices shall be in accordance with the manufacturer's recommendations and approved shop drawings.

PART 2 - PRODUCTS

- 2.1 Only those products listed in Division 26 shall be employed.

PART 3 - EXECUTION

3.1 EQUIPMENT

- A. Connections for and coordination of motors and equipment requiring electrical connections shall include but not be limited to the following:
 - 1. Provide a disconnect switch for each motor and each piece of equipment, except where combination starter/disconnects or disconnects integral to equipment are provided by Mechanical or Plumbing Contractor. Provide disconnects where required by Code.
 - 2. Verify that the motor rotation is correct and reconnect if necessary.
 - 3. Provide separate ground wires in flexible, metal conduit and non-metallic conduit so as to provide an electrically continuous ground path. Ground all equipment.
 - 4. Provide motor branch circuit conductors and connections to each individual motor controller and from each controller to the motor through an approved disconnect switch. Make final connection per Division 26 Section "Raceways and Boxes for Electrical Systems".
 - 5. Where equipment is fed from branch circuit routed in or under the slab, terminate branch circuit at junction box on 2 foot rigid conduit stub-up and make final connection to equipment per Division 26 Section "Raceways and Boxes for Electrical Systems". Provide suitable knee brace on conduit stub-up.
 - 6. Where equipment is fed from overhead support conduit feeder descending from ceiling on flanged floor fitting with conduit type fitting connecting to motor. Make connection per Division 26 Section "Raceways and Boxes for Electrical Systems".
 - 7. Where nameplate on equipment indicates fuse protection the disconnecting means shall be equipped with dual element fuses.

3.2 APPLIANCES

- A. Connections for and coordination of appliances shall include but not be limited to the following:
 - 1. The basic requirements for motors and equipment specified above shall apply where applicable.
 - 2. Where cord and plugs are provided with the appliances this Contractor shall coordinate the receptacle installation to match.
 - 3. Direct connected equipment shall be serviced by disconnecting means.
- B. Where cord and plug connections are required but not provided with the appliance this Contractor shall coordinate the cord and plug and receptacle installation with General Contractor and appliance supplier.

3.3 KITCHENS

- A. The Contractor shall make final electrical connections to all kitchen equipment.

3.4 ELECTRICAL/MECHANICAL COORDINATION

- A. Furnish electrical services to Division 23 equipment as outlined below.

- B. Unless otherwise indicated, all mechanical equipment motors and controls shall be furnished, set in place and wired by the Division 23 Contractor. Contractor should note that the intent of this wiring schedule is to have the Division 23 Contractor responsible for coordinating all control wiring as outlined, whether or not specifically called for by the mechanical or electrical drawings and specification. Comply with the applicable requirements of Division 23 for electrical work of this Division 26 which is not otherwise specified. No extras will be allowed for Contractor's failure to provide for these required items. The Division 26 Contractor shall refer to the Division 23 specifications and plans for all power wiring and shall advise the Architect/Engineer of any discrepancies prior to bidding.

Item	Furnished By	Set By	Power Wiring	Control Wiring
Equipment Motors	MC	MC	EC	---
Motor Starters and Overload Heaters (See Note 1)	MC	EC	EC	MC
Fused & Unfused Disconnect Switches, Thermal Overload Heaters (if not integral to equipment)	EC	EC	EC	---
Manual Operating & Speed Switches (carrying load currents) (See Notes 3 & 4)	MC	MC	MC	MC
Control Relays & Transformer (See Note 2)	MC	MC	MC	MC
Thermostats (Line Voltage)	MC	MC	MC	MC
Temperature Control Panels	MC	MC	EC	MC
Building Fire Alarm System Fire & Smoke Detectors, including Relays for Fan Shutdown	EC	EC	EC	EC
Motor & Solenoid Valves, Damper Motors, PE & EP Switches, Control Valves, Fan Interlocking Wiring, Low Voltage Thermostats	MC	MC	---	MC
Duct Detection (See Note 6)	EC	MC	---	EC
Pilot Lights and Manually Operated Switches Not Carrying Load Currents (See Note 3)	MC	MC	---	MC
Boiler Controls including Gas Train	MC	MC	MC	MC

Item	Furnished By	Set By	Power Wiring	Control Wiring
Fire Sprinkler System Alarms, Tamper Switches, Flow Switches and Fire Alarm Systems Tie-ins to provide a complete Fire Protection System	FPC	FPC	---	EC
Temporary Heating Connections	MC	MC	MC	MC
HVAC Water Treatment Interlocks	MC	MC	---	MC

MC = Mechanical Contractor under Division 23 of the work.

EC = Electrical Contractor under Division 26 of the work.

FPC = Fire Protection Contractor

Notes for the Electrical/Mechanical Coordination Schedule:

1. All starters, other than those noted on the Drawings, shall be furnished under Division 23. All starters furnished under Division 23 shall be complete with three overload heaters and shall conform to NEC and NEMA requirements. All starters shall have 65,000 AIC rating.
 2. Control relays and control transformers shall be furnished under Division 23 except where furnishing such items are specifically required under Division 26 Specifications and/or Drawings.
 3. Switches carrying full load current are to be wired under Division 26 of the work.
 4. Exhaust Fans: The Electrical Contractor under Division 26 of the work shall furnish and install circuits, feeders and disconnect switches, and make all connections to motors and controls unless interlocked with other mechanical equipment or lights in locations indicated. Where exhaust fans are switched with lights, a two-pole toggle switch will be provided under Division 26. Where exhaust fans are interlocked with other mechanical equipment, the interlock wiring will be furnished by the Mechanical Contractor under Division 23.
 5. Electrical Contractor shall provide disconnects for all starters and variable frequency drives. Electrical Contractor shall provide disconnects at the equipment if it is not in line of sight of starter disconnect.
 6. Electrical Contractor provides control wiring to fire alarm panel and from fire alarm panel to mechanical unit.
- C. All temperature control conduit and wiring shall be furnished and installed under Division 23. All motorized damper equipment shall be furnished and installed under Division 23. 120 volt power wiring shall be by Division 26.

END OF SECTION 260501

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 2000 V and less.
 - 2. Connectors, splices, and terminations rated 2000 V and less.

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Alpha Wire Company.
 - 2. Belden Inc.
 - 3. Encore Wire Corporation.
 - 4. General Cable Technologies Corporation.
 - 5. Southwire Company.
 - 6. WESCO.
- 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. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."
- D. Conductors: Copper, complying with NEMA WC 70/ICEA S-95-658.
 - 1. Conductor Insulation: Comply with NEMA WC 70/ICEA S-95-658 for Type THHN/THWN-2.
- E. Cable: Comply with NEMA WC 70/ICEA S-95-658 for metal-clad cable, Type MC.

2.2 CONNECTORS AND SPLICES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. 3M Electrical Products.
 - 2. AFC Cable Systems; a part of Atkore International.
 - 3. Hubbell Power Systems, Inc.
 - 4. Ideal Industries, Inc.
 - 5. O-Z/Gedney; a brand of Emerson Industrial Automation.
 - 6. TE Connectivity Ltd.
- B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated; listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

- A. Feeders: Copper. Conductors shall be 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. Minimum wire size shall be No. 12 AWG.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

- A. Feeders: Type THHN/THWN-2, single conductors in raceway.
- B. Branch Circuits: Type THHN/THWN-2, single conductors in raceway or metal-clad cable, Type MC.
- C. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.
- D. Feeders have been sized to limit voltage drop to 3%. The Contractor shall increase branch circuit conductors, as required, to limit voltage drop in each branch circuit to 2%.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

- A. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.
- B. Install wires and cables as indicated, according to manufacturer's written instructions and NECA's "Standard of Installation."
- C. Complete raceway installation between conductor and cable termination points according to Section 26 05 33 "Raceways and Boxes for Electrical Systems" prior to pulling conductors and cables.

- D. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
- E. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.
- F. Install exposed cables parallel and perpendicular to surfaces of exposed structural members and follow surface contours where possible.
- G. Support cables according to Section 26 05 29 "Hangers and Supports for Electrical Systems."

3.4 CONNECTIONS

- A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.
- B. Make splices, terminations, and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.
- C. Wiring at Outlets: Install conductor at each outlet, with at least 12 inches of slack.
- D. All wiring connections made at or below grade shall be waterproof with UL listed waterproof connectors.

3.5 IDENTIFICATION

- A. Identify and color-code conductors and cables according to Section 26 05 53 "Identification for Electrical Systems."
- B. Identify each spare conductor at each end with identity number and location of other end of conductor and identify as spare conductor.

3.6 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 26 05 00 "Common Work Results for Electrical."

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 Division 07 Section "Penetration Firestopping."

3.8 FIELD QUALITY CONTROL

A. 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 of the following visual and electrical tests:
 - a. Inspect exposed sections of conductor and cable for physical damage and correct connection according to the one-line diagram.
 - b. Inspect compression applied connectors for correct cable match and indentation.
 - c. Inspect for correct identification.
 - d. Inspect cable jacket and condition.
 - e. Insulation-resistance test on each conductor with respect to ground and adjacent conductors. Apply a potential of 500-V dc for 300-V rated cable and 1000-V dc for 600-V rated cable for a one-minute duration.
 - f. Continuity test on each conductor and cable.
 - g. Uniform resistance of parallel conductors.

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

C. Prepare test and inspection reports to record the following:

1. Procedures used.
2. Results that comply with requirements.
3. Results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

END OF SECTION 260519

SECTION 260526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Burndy; Part of Hubbell Electrical Systems.
 - 2. ERICO International Corporation.
 - 3. Galvan Industries, Inc.; Electrical Products Division, LLC.
 - 4. Harger Lightning & Grounding.
 - 5. ILSCO.
 - 6. O-Z/Gedney; a brand of Emerson Industrial Automation.
 - 7. Siemens Power Transmission & Distribution, Inc.

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 or tinned-copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.
- B. Equipment Grounding Conductors: Insulated with green-colored insulation.
- C. 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. 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.
7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

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. Bus-Bar Connectors: Compression type, copper, or copper alloy, with two wire terminals.
- C. Beam Clamps: Mechanical type, terminal, ground wire access from four directions, with dual, tin-plated or silicon bronze bolts.
- D. Cable-to-Cable Connectors: Compression type, copper or copper alloy.
- E. Conduit Hubs: Mechanical type, terminal with threaded hub.
- F. U-Bolt Clamps: Mechanical type, copper or copper alloy, terminal listed for direct burial.

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. Conductor Terminations and Connections:
 1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
 2. Underground Connections: Welded connectors except as otherwise indicated.
 3. Connections to Structural Steel: Welded connectors.

3.2 EQUIPMENT GROUNDING

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

3.3 INSTALLATION

- A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.
- B. 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.

3.4 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
 - 1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
 - 2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
- C. Grounding system will be considered defective if it does not pass tests and inspections.

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. Section Includes:
 - 1. Hangers and supports for electrical equipment and systems.
 - 2. Construction requirements for concrete bases.

1.3 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, with a minimum structural safety factor of five times the applied force.

1.4 QUALITY ASSURANCE

- A. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

- A. Steel Slotted Support Systems: Comply with MFMA-4 factory-fabricated components for field assembly.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Allied Tube & Conduit; a part of Atkore International.
 - b. B-line, an Eaton business.

- c. ERICO International Corporation.
 - d. Flex-Strut Inc.
 - e. GS Metals Corp.
 - f. G-Strut.
 - g. Thomas & Betts Corporation; A Member of the ABB Group.
 - h. Unistrut; Part of Atkore International.
 - i. Wesanco, Inc.
- 2. Material: Galvanized steel.
 - 3. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
 - 4. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
 - 5. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
 - 6. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
 - 7. Channel Dimensions: Selected for applicable load criteria.
- B. Conduit and Cable Support Devices: Steel and malleable-iron hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.
 - C. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M steel plates, shapes, and bars; black and galvanized.
 - D. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:
 - 1. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) B-line, an Eaton business.
 - 2) Empire Tool and Manufacturing Co., Inc.
 - 3) Hilti, Inc.
 - 4) ITW Ramset/Red Head; Illinois Tool Works, Inc.
 - 5) MKT Fastening, LLC.
 - 2. Concrete Inserts: Steel or malleable-iron, slotted support system units are similar to MSS Type 18 units and comply with MFMA-4 or MSS SP-58.
 - 3. Clamps for Attachment to Steel Structural Elements: MSS SP-58 units are suitable for attached structural element.
 - 4. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
 - 5. Toggle Bolts: All-steel springhead type.
 - 6. Hanger Rods: Threaded steel.

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 unless requirements in this Section are stricter.
- B. Comply with requirements for raceways and boxes specified in Section 26 05 33 "Raceways and Boxes for Electrical Systems."
- C. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMTs, IMCs, and RMCs as required by NFPA 70. Minimum rod size shall be 1/4 inch in diameter.
- D. 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.

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, EMTs, IMCs, and RMCs may be supported by openings through structure members, according to NFPA 70.
- C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.
- D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
 - 1. To Wood: Fasten with lag screws or through bolts.
 - 2. To Concrete: Bolt to concrete inserts.
 - 3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
 - 4. To Steel: Beam clamps (MSS SP-58, Type 19, 21, 23, 25, or 27), complying with MSS SP-69.
 - 5. To Light Steel: Sheet metal screws.
 - 6. 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 the need for reinforcing bars.

3.3 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 Division 03 Section "Cast-in-Place Concrete."
- C. Anchor equipment to concrete base as follows:
 - 1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 2. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - 3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.4 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 09 Sections "Exterior Painting" and "Interior Painting" for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.
- C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 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. IMC: Intermediate metal conduit.

PART 2 - PRODUCTS

2.1 METAL CONDUITS, TUBING, AND FITTINGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. AFC Cable Systems; a part of Atkore International.
 - 2. Allied Tube & Conduit; a part of Atkore International.
 - 3. Anamet Electrical, Inc.
 - 4. Calconduit.
 - 5. Electri-Flex Company.
 - 6. FSR Inc.
 - 7. O-Z/Gedney; a brand of Emerson Industrial Automation.
 - 8. Southwire Company.
 - 9. Thomas & Betts Corporation; A Member of the ABB Group.
 - 10. Western Tube and Conduit Corporation.
 - 11. Wheatland Tube Company.

- 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. IMC: Comply with ANSI C80.6 and UL 1242.
- E. EMT: Comply with ANSI C80.3 and UL 797.
- F. FMC: Comply with UL 1; zinc-coated steel.
- G. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.
- H. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.
 - 1. Fittings for EMT:
 - a. Material: Steel or die cast.
 - b. Fittings: Set-screw for conduits less than 2" and compression type for conduits 2" or larger.
 - 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.
- I. Joint Compound for IMC or 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, provide products by one of the following:
 - 1. AFC Cable Systems; a part of Atkore International.
 - 2. Anamet Electrical, Inc.
 - 3. Arnco Corporation.
 - 4. CANTEX INC.
 - 5. CertainTeed Corporation.
 - 6. Condux International, Inc.
 - 7. Electri-Flex Company.
 - 8. Kraloy.
 - 9. Lamson & Sessions.
 - 10. RACO; Hubbell.
 - 11. Thomas & Betts Corporation; A Member of the ABB Group.
- 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. ENT: Comply with NEMA TC 13 and UL 1653.

- D. RNC: Type EPC-40-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.
- E. LFNC: Comply with UL 1660.
- F. Fittings for RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.
- G. Fittings for LFNC: Comply with UL 514B.
- H. Solvents and Adhesives: As recommended by conduit manufacturer.

2.3 METAL WIREWAYS AND AUXILIARY GUTTERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. B-line, an Eaton business.
 - 2. Hoffman; a brand of Pentair Equipment Protection.
 - 3. MonoSystems, Inc.
 - 4. Square D.
- B. Description: Sheet metal, complying with UL 870 and NEMA 250, Type 1 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, provide products by one of the following:
 - 1. Crouse-Hinds, an Eaton business.
 - 2. EGS/Appleton Electric.
 - 3. Erickson Electrical Equipment Company.
 - 4. FSR Inc.
 - 5. Hoffman; a brand of Pentair Equipment Protection.
 - 6. Hubbell Incorporated.
 - 7. Kraloy.
 - 8. Milbank Manufacturing Co.
 - 9. O-Z/Gedney; a brand of Emerson Industrial Automation.
 - 10. RACO; Hubbell.

11. Spring City Electrical Manufacturing Company.
 12. Thomas & Betts Corporation; A Member of the ABB Group.
 13. Wiremold / Legrand.
- B. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.
- C. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.
- D. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, aluminum, Type FD, with gasketed cover.
- E. Nonmetallic Outlet and Device Boxes: Comply with NEMA OS 2 and UL 514C.
- F. Floor Boxes: As indicated on drawings.
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.
- 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. Device Box Dimensions: 4 inches square by 2-1/8 inches deep.
- J. Gangable boxes are allowed.
- K. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 1 with continuous-hinge cover with flush latch unless otherwise indicated.
1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
 2. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.
- L. 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.
- M. Exterior Building-Mounted Boxes: Arlington Industries InBox series with clear cover or approved equal flush-mounted box. Provide box type and depth appropriate for exterior cladding application.

2.5 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. Boxes and handholes shall be provided for utility lines as required by the respective utility companies. Dimensions and materials shall comply with utility company's current requirements.

B. Fiberglass Handholes and Boxes: Molded of fiberglass-reinforced polyester resin, with frame and covers of fiberglass.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Armorcast Products Company.
 - b. Carson Industries LLC.
 - c. NewBasis.
 - d. Nordic Fiberglass, Inc.
 - e. Oldcastle Precast, Inc.
 - f. Quazite: Hubbell Power Systems, Inc.
 - g. Synertech Moulded Products.
2. Standard: Comply with SCTE 77.
3. Color of Frame and Cover: Green.
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, "ELECTRIC" or "TELECOM".
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.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

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

1. Exposed Conduit: IMC.
2. Concealed Conduit, Aboveground: IMC.
3. Underground Conduit: RNC, Type EPC-40-PVC, direct buried unless otherwise indicated.

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 and Subject to Severe Physical Damage: IMC.
 3. Concealed in Ceilings and Interior Walls and Partitions: EMT.
 4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
 5. Damp or Wet Locations: 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 Raceway Size: 3/4-inch trade size.
- D. Raceway Fittings: Compatible with raceways and suitable for use and location.
1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
 2. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.
- E. 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 26 05 29 "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. Support conduit within 12 inches of enclosures to which attached.

- I. Stub-ups to Above Recessed Ceilings:
 - 1. Use EMT, IMC, or RMC for raceways.
 - 2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.
- J. 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.
- K. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors including conductors smaller than No. 4 AWG.
- L. 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.
- M. Install raceways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.
- N. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to assure a continuous ground path.
- O. Cut conduit perpendicular to the length. For conduits 2-inch trade size and larger, use roll cutter or a guide to make cut straight and perpendicular to the length.
- P. 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.
- Q. 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.
- R. Install devices to seal raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all raceways at the following points:
 - 1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated or aquatics spaces.
 - 2. Where an underground service raceway enters a building or structure.
 - 3. Where otherwise required by NFPA 70.
- S. Comply with manufacturer's written instructions for solvent welding RNC and fittings.
- T. 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.
- U. Flexible Conduit Connections: Comply with NEMA RV 3. Use a maximum of 72 inches of flexible conduit for recessed and semirecessed luminaires, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.
1. Use LFMC in damp or wet locations subject to severe physical damage.
 2. Use LFMC or LFNC in damp or wet locations not subject to severe physical damage.
- V. 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.
- W. 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.
- X. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.
- Y. Locate boxes so that cover or plate will not span different building finishes. Coordinate with elevations and finish drawings.
- 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. Where installed in fire-rated partitions, apply firestop putty pads or similar fire rated products on or around outlet boxes as required to maintain the fire rating of the partition. Follow manufacturer's instructions, including lapping putty over box edges before gypboard is installed on 2nd side of wall.
- DD. Support outlet boxes and switch boxes from two (2) adjacent studs. Outlet boxes designed to attach to one metal stud and be "sandwiched" between the front and back layers of Gypsum Wallboard are not allowed.
- EE. Back-to-back outlets in common walls are not permitted. Outlet boxes shall be separated by at least one stud wherever possible. In cases of outlet boxes of adjacent rooms in the same stud cavity at the same height, provide a layer of expandable spray foam insulation around each box in that cavity. There must be a minimum of a 1" horizontal separation space between boxes of adjacent rooms. If this condition occurs in a fire rated wall, provide a 1 hour fire rated putty pad to cover the back of outlets of one side of the partition. Other junction box installations on fire rated walls shall comply with UL requirements.
- FF. Where shown adjacent to receptacles, telephone, data and cable TV outlets shall be located no further than 6" on center from the center of the receptacle. Cable television outlets and data/telephone outlets shall be combined in a single faceplate in resident units.
- GG. Contractor shall not install conductors or cables in a building that is not completely waterproofed, unless the conductors or cable is rated for wet location installations.
- HH. Route circuit homeruns down corridors, above accessible ceilings.

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 "Earth Moving" for pipe less than 6 inches in nominal diameter.
2. Install backfill as specified in Division 31 Section "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 31 20 00 "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 26 05 53 "Identification for Electrical Systems."

- B. Minimum burial depth for underground conduit shall be 24", unless greater depth is required by the AHJ, local codes or utility companies.

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 FIRESTOPPING

- A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Division 07 Section "Penetration Firestopping."

3.6 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 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 of power and control cables.
 - 2. Identification for conductors.
 - 3. Underground-line warning tape.
 - 4. Warning labels and signs.
 - 5. Instruction signs.
 - 6. Equipment identification labels, including arc-flash warning labels.
 - 7. Miscellaneous identification products.
- B. This Section includes electrical identification materials and devices required to comply with ANSI C2, NFPA 70, OSHA standards, and authorities having jurisdiction.

1.3 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 PERFORMANCE REQUIREMENTS

- A. Comply with ASME A13.1.
- B. Comply with NFPA 70.

- C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.
- D. Comply with ANSI Z535.4 for safety signs and labels.
- E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

2.2 COLOR AND LEGEND REQUIREMENTS

- A. Warning labels and signs shall include, but are not limited to, the following legends:
 - 1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
 - 2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES."

2.3 LABELS

- A. Self-Adhesive Labels:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. A'n D Cable Products.
 - b. Brady Corporation.
 - c. Brother International Corporation.
 - d. emedco.
 - e. Grafoplast Wire Markers.
 - f. Ideal Industries, Inc.
 - g. LEM Products Inc.
 - h. Marking Services, Inc.
 - i. Panduit Corp.
 - j. Seton Identification Products.
 - 2. Write-on, 3-mil-thick, vinyl flexible label with acrylic pressure-sensitive adhesive.
 - 3. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
 - 4. Marker for Tags: Machine-printed, permanent, waterproof, black ink recommended by printer manufacturer.

2.4 TAPES AND STENCILS:

- A. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; not less than 3 mils thick by 1 to 2 inches wide; compounded for outdoor use.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Brady Corporation.

- b. Carlton Industries, LP.
 - c. emedco.
 - d. Marking Services, Inc.
- B. Floor Marking Tape: 2-inch-wide, 5-mil pressure-sensitive vinyl tape, with yellow and black stripes and clear vinyl overlay.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Carlton Industries, LP.
 - b. Seton Identification Products.
- C. Underground-Line Warning Tape
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Brady Corporation.
 - b. Ideal Industries, Inc.
 - c. LEM Products Inc.
 - d. Marking Services, Inc.
 - e. Reef Industries, Inc.
 - f. Seton Identification Products.
 - 2. Tape:
 - a. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications utility lines.
 - b. Printing on tape shall be permanent and shall not be damaged by burial operations.
 - c. Tape material and ink shall be chemically inert and not subject to degradation when exposed to acids, alkalis, and other destructive substances commonly found in soils.
 - 3. Color and Printing:
 - a. Comply with ANSI Z535.1, ANSI Z535.2, ANSI Z535.3, ANSI Z535.4, and ANSI Z535.5.
 - b. Inscriptions for Red-Colored Tapes: "ELECTRIC LINE, HIGH VOLTAGE".
 - c. Inscriptions for Orange-Colored Tapes: "TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE", as appropriate.
 - 4. Tag: (Label as required):
 - a. Detectable three-layer laminate, consisting of a printed pigmented polyolefin film, a solid aluminum-foil core, and a clear protective film that allows inspection of the continuity of the conductive core; bright colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
 - b. Width: 3 inches.
 - c. Overall Thickness: 5 mils.
 - d. Foil Core Thickness: 0.35 mil.

- e. Weight: 28 lb/1000 sq. ft..
- f. Tensile according to ASTM D 882: 70 lbf and 4600 psi.

2.5 Tags

A. Write-On Tags:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Carlton Industries, LP.
 - b. LEM Products Inc.
 - c. Seton Identification Products.
2. Polyester Tags: 0.010 inch thick, with corrosion-resistant grommet and cable tie for attachment to raceway, conductor, or cable.
3. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

2.6 Signs

A. Laminated Acrylic or Melamine Plastic Signs:

1. Engraved legend.
2. Thickness:
 - a. For signs up to 20 sq. inches, minimum 1/16-inch-.
 - b. For signs larger than 20 sq. inches, 1/8 inch thick.
 - c. Engraved legend with black letters on white face.
 - d. Punched or drilled for mechanical fasteners.
 - e. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.
3. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Brady Corporation.
 - b. Carlton Industries, LP.
 - c. Emedco.
 - d. Marking Services, Inc.

2.7 CABLE TIES

- ### A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. HellermannTyton.
 2. Ideal Industries, Inc.
 3. Marking Services, Inc.

4. Panduit Corp.
- B. General-Purpose Cable Ties: Fungus inert, self-extinguishing, one piece, self-locking, Type 6/6 nylon.
 1. Minimum Width: 3/16 inch.
 2. Tensile Strength at 73 deg F according to ASTM D 638: 12,000 psi.
 3. Temperature Range: Minus 40 to plus 185 deg F.
 4. Color: Black, except where used for color-coding.
- C. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self-extinguishing, one piece, self-locking, Type 6/6 nylon.
 1. Minimum Width: 3/16 inch.
 2. Tensile Strength at 73 deg F according to ASTM D 638: 12,000 psi.
 3. Temperature Range: Minus 40 to plus 185 deg F.
 4. Color: Black.
- D. Plenum-Rated Cable Ties: Self-extinguishing, UV stabilized, one piece, 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.

2.8 MISCELLANEOUS IDENTIFICATION PRODUCTS

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

PART 3 - EXECUTION

3.1 PREPARATION

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

3.2 INSTALLATION

- A. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings,

manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.

- B. Install identifying devices before installing acoustical ceilings and similar concealment.
- C. Verify identity of each item before installing identification products.
- D. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment. Install access doors or panels to provide view of identifying devices.
- E. Apply identification devices to surfaces that require finish after completing finish work.
- F. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
- G. Attach plastic raceway and cable labels that are not self-adhesive type with clear vinyl tape, with adhesive appropriate to the location and substrate.
- H. 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.
- I. Painted Identification: Comply with requirements in painting Sections for surface preparation and paint application.
- J. Aluminum Wraparound Marker Labels and Metal Tags: Secure tight to surface of conductor or cable at a location with high visibility and accessibility.
- K. During backfilling of trenches, install continuous underground-line warning tape directly above cable or raceway at 8 inches below finished grade. Use multiple tapes where width of multiple lines installed in a common trench exceeds 16 inches overall.

3.3 IDENTIFICATION SCHEDULE

- A. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits, More Than 50A and 120V to Ground: Identify with self-adhesive vinyl label. Install labels at 50-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 containing the wiring system legend and system voltage. System legends shall be as follows:
 - 1. "EMERGENCY POWER."
- 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 and feeder 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.
 - c. 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. Conductors to Be Extended in the Future: Attach write-on tags to conductors and list source.
- F. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical-fiber cable.
 - 1. Install underground-line warning tape for direct-buried cables and cables in raceways.
- G. Workspace Indication: Install floor marking tape to show working clearances in the direction of access to live parts. Workspace shall comply with NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.
- H. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Baked-enamel warning signs.
 - 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.
- I. Arc Flash Warning Labeling: Self-adhesive thermal transfer vinyl labels.
 - 1. Comply with NFPA 70E and ANSI Z535.4.
- J. 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.
- K. 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.

- L. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and operation and maintenance manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm unless equipment is provided with its own identification.

1. Labeling Instructions:

- a. Indoor Equipment: Engraved, laminated acrylic or melamine plastic label, punched or drilled for mechanical fasteners. 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 labels are provided with self-adhesive means of attachment, fasten them 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 in the form of an engraved, laminated acrylic or melamine label that is screwed or riveted to the enclosure.
- b. Enclosures and electrical cabinets.
- c. Access doors and panels for concealed electrical items.
- d. Switchboards, including all distribution breakers. Identification shall be in the form of an engraved, laminated acrylic or melamine label that is screwed or riveted to the enclosure.
- e. Emergency system boxes and enclosures.
- f. Enclosed switches.
- g. Enclosed circuit breakers.
- h. Enclosed controllers.
- i. Disconnect means for Equipment: Indicate the equipment being served (with appropriate equipment tag) and the panelboard and circuit number(s) that are being utilized. Identification shall be in the form of an engraved, laminated acrylic or melamine label that is screwed or riveted to the enclosure.

END OF SECTION 260553

SECTION 26 05 73 - OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes computer-based, fault-current and overcurrent protective device coordination studies to determine overcurrent protective device sizes, types and settings for selective tripping. Protective devices shall be set based on results of the protective device coordination study.

1.3 SUBMITTALS

- A. Product Data: For computer software program to be used for studies.
- B. Product Certificates: For coordination-study and fault-current-study computer software programs, certifying compliance with IEEE 399.
- C. Qualification Data: For coordination-study specialist.
- D. Other Action Submittals: The following submittals shall be made after the approval process for system protective devices has been completed. Submittals may be in digital form.
 - 1. Coordination-study input data, including completed computer program input data sheets.
 - 2. Study and Equipment Evaluation Reports.
 - 3. Coordination-Study Report.
 - a. Submit study report for action prior to receiving final approval of the distribution equipment submittals.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For the overcurrent protective devices to include in emergency, operation, and maintenance manuals.
 - 1. In addition to items specified in Division 01 "Operation and Maintenance Data," include the following:
 - a. The following parts from the Protective Device Coordination Study Report:
 - 1) One-line diagram.

- 2) Protective device coordination study.
- 3) Time-current coordination curves.

b. Power system data.

1.5 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 not acceptable.
- B. Coordination-Study Specialist Qualifications: An entity experienced in the application of computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.
 1. Professional engineer, licensed in the state where Project is located, shall be responsible for the study. All elements of the study shall be performed under the direct supervision and control of engineer.
- C. Comply with IEEE 242 for short-circuit currents and coordination time intervals.
- D. Comply with IEEE 399 for general study procedures.

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE DEVELOPERS

- A. Computer Software Developers: Subject to compliance with requirements, provide products by one of the following:
 1. EDSA Micro Corporation.
 2. ESA Inc.
 3. Operation Technology, Inc.
 4. SKM Systems Analysis, Inc.

2.2 COMPUTER SOFTWARE PROGRAM REQUIREMENTS

- A. Comply with IEEE 399.
- B. Analytical features of fault-current-study computer software program shall include "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.
- C. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output. Computer software program shall report device settings and ratings of all overcurrent protective devices and shall demonstrate selective coordination by computer-generated, time-current coordination plots.
 1. Optional Features:

- a. Arcing faults.
- b. Simultaneous faults.
- c. Explicit negative sequence.
- d. Mutual coupling in zero sequence.

2.3 PROTECTIVE DEVICE COORDINATION STUDY REPORT CONTENTS

- A. Executive summary.
- B. Study descriptions, purpose, basis and scope. Include case descriptions, definition of terms and guide for interpretation of the computer printout. Specify the appropriate NEC edition that was utilized.
- 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. Switchboard and panelboard designations.
- D. Protective Device Coordination Study:
 - 1. Report recommended settings of protective devices, ready to be applied in the field. Use manufacturer's data sheets for recording the recommended setting of overcurrent protective devices when available.
 - a. Phase and Ground Relays:
 - 1) Device tag.
 - 2) Relay current transformer ratio and tap, time dial, and instantaneous pickup value.
 - 3) Recommendations on improved relaying systems, if applicable.
 - b. Circuit Breakers:
 - 1) Adjustable pickups and time delays (long time, short time, ground).
 - 2) Adjustable time-current characteristic.
 - 3) Adjustable instantaneous pickup.
 - 4) Recommendations on improved trip systems, if applicable.
 - c. Fuses: Show current rating, voltage, and class.
- E. Time-Current Coordination Curves: Determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices installed in series. Prepare separate sets of curves for the switching schemes and for emergency periods where the power source is local generation. Show the following information:
 - 1. Device tag and title, one-line diagram with legend identifying the portion of the system covered.

2. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which the device is exposed.
3. Identify the device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.
4. Plot the following listed characteristic curves, as applicable:
 - a. Medium-voltage equipment overcurrent relays.
 - b. Medium- and low-voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands.
 - c. Low-voltage equipment circuit-breaker trip devices, including manufacturer's tolerance bands.
 - d. Transformer full-load current, magnetizing inrush current, and ANSI through-fault protection curves.
 - e. Cables and conductors damage curves.
 - f. Ground-fault protective devices.
 - g. Motor-starting characteristics and motor damage points.
 - h. Generator short-circuit decrement curve and generator damage point.
 - i. The largest feeder circuit breaker in each panelboard.
5. Series rating on equipment allows the application of two series interrupting devices for a condition where the available fault current is greater than the interrupting rating of the downstream equipment. Both devices share in the interruption of the fault and selectivity is sacrificed at high fault levels. Maintain selectivity for tripping currents caused by overloads.
6. Provide adequate time margins between device characteristics such that selective operation is achieved.
7. Comments and recommendations for system improvements.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Provide selective coordination study that shows complete coordination of all supply side overcurrent protection devices for all emergency and legally-required branch paths (normal and emergency sources) as per NEC-2020, Articles 620.62, 700.32 and 701.32. Coordination is required for all new equipment. Studies shall be signed, sealed and dated.
- B. Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance. Devices to be coordinated are indicated on Drawings.
 1. Proceed with coordination study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to coordination study may not be used in study.

3.2 POWER SYSTEM DATA

- A. Gather and tabulate the following input data to support coordination study:

1. Product Data for overcurrent protective devices specified in other Division 26 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. Impedance of pad-mounted transformer.
3. Electrical Distribution System Diagram: In hard-copy and electronic-copy formats, showing the following:
 - a. Circuit-breaker and fuse-current ratings and types.
 - b. Relays and associated power and current transformer ratings and ratios.
 - c. Transformer kilovolt amperes, primary and secondary voltages, connection type, impedance, and X/R ratios.
 - d. Cables: Indicate conduit material, sizes of conductors, conductor material, insulation, and length.
 - e. Motor horsepower and code letter designation according to NEMA MG 1.
4. Data sheets to supplement electrical distribution system diagram, cross-referenced with tag numbers on diagram, showing the following:
 - a. Special load considerations, including starting inrush currents and frequent starting and stopping.
 - b. Transformer characteristics, including primary protective device, magnetic inrush current, and overload capability.
 - c. Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.
 - d. Ratings, types, and settings of utility company's overcurrent protective devices.
 - e. Special overcurrent protective device settings or types stipulated by utility company.
 - f. Time-current-characteristic curves of devices indicated to be coordinated.
 - g. Manufacturer, frame size, interrupting rating in amperes rms symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.
 - h. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.
 - i. Panelboards, switchboards, and interrupting rating in amperes rms symmetrical.

3.3 FAULT-CURRENT STUDY

- A. Source Impedance: Utility company's fault-current contribution as indicated.
- B. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project and use approved computer software program to calculate values. Include studies of system-switching configurations and alternate operations that could result in maximum fault conditions.
- C. Calculate momentary and interrupting duties on the basis of maximum available fault current.
- D. Calculations to verify interrupting ratings of overcurrent protective devices shall comply with the following:

1. Low-Voltage Circuit Breakers: IEEE 1015 and IEEE C37.50.
 2. Circuit Breakers: IEEE C37.13.
- E. Study Report: Enter calculated X/R ratios and interrupting (5-cycle) fault currents on electrical distribution system diagram of the report. List other output values from computer analysis, including momentary (1/2-cycle), interrupting (5-cycle), and 30-cycle fault-current values for 3-phase, 2-phase, and phase-to-ground faults.
- F. Equipment Evaluation Report: Prepare a report on the adequacy of overcurrent protective devices and conductors by comparing fault-current ratings of these devices with calculated fault-current momentary and interrupting duties.

3.4 COORDINATION STUDY

- A. Perform coordination study using approved computer software program. Prepare a written report using results of fault-current study. Comply with IEEE 399.
1. Calculate the maximum and minimum 1/2-cycle short-circuit currents.
 2. Calculate the maximum and minimum interrupting duty (5 cycles to 2 seconds) short-circuit currents.
 3. Calculate the maximum and minimum ground-fault currents.
- B. Comply with IEEE 141 recommendations for fault currents and time intervals.
- C. Transformer Primary Overcurrent Protective Devices:
1. Device shall not operate in response to the following:
 - a. Inrush current when first energized.
 - b. Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.
 - c. Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.
 2. Device settings shall protect transformers according to IEEE C57.12.00, for fault currents.
- D. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and conductor melting curves in IEEE 242. Demonstrate that equipment withstands the maximum short-circuit current for a time equivalent to the tripping time of the primary relay protection or total clearing time of the fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short-circuit current.
- E. Emergency systems overcurrent protection devices shall be selectively coordinated with all supply side overcurrent protective devices, as required by the National Electrical Code.
- F. Coordination-Study Report: Prepare a written report indicating the following results of coordination study:
1. Tabular Format of Settings Selected for Overcurrent Protective Devices:

- a. Device tag.
 - b. Relay-current transformer ratios; and tap, time-dial, and instantaneous-pickup values.
 - c. Circuit-breaker sensor rating; and long-time, short-time, and instantaneous settings.
 - d. Fuse-current rating and type.
 - e. Ground-fault relay-pickup and time-delay settings.
2. Coordination Curves: Prepared to determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company's upstream devices. Prepare separate sets of curves for the switching schemes and for emergency periods where the power source is local generation. Show the following information:
- a. Device tag.
 - b. Voltage and current ratio for curves.
 - c. Three-phase and single-phase damage points for each transformer.
 - d. No damage, melting, and clearing curves for fuses.
 - e. Cable damage curves.
 - f. Transformer inrush points.
 - g. Maximum fault-current cutoff point.
- G. Completed data sheets for setting of overcurrent protective devices.

3.5 ARC FLASH HAZARD ANALYSIS

- A. The Arc-Flash Hazard Analysis shall be performed with the aid of computer software intended for this purpose in order to calculate Arc-Flash Incident Energy (AFIE) levels and flash protection boundary distances.
- B. The Arc-Flash Hazard Analysis shall be performed in conjunction with a short-circuit analysis and a time-current coordination analysis.
- C. Results of the Analysis shall be submitted in tabular form, and shall include device or bus name, bolted fault and arcing fault current levels, flash protection boundary distances, personal-protective equipment classes and AFIE levels.
- D. The analysis shall be performed under worst-case Arc-Flash conditions, and the final report shall describe, when applicable, how these conditions differ from worst-case bolted fault conditions.
- E. The Arc-Flash Hazard Analysis shall be performed by a registered professional engineer.
- F. The Arc-Flash Hazard Analysis shall be performed in compliance with IEEE Standard 1584-2018, the *IEEE Guide for Performing Arc-Flash Calculations*.
- G. The Arc-Flash Hazard Analysis shall include recommendations for reducing AFIE levels and enhancing worker safety.
- H. The proposed vendor shall demonstrate experience with Arc-Flash Hazard Analysis by submitting names of at least ten actual Arc-Flash Hazard Analyses it has performed in the past year.

- I. The proposed vendor shall demonstrate capabilities in providing equipment, services, and training to reduce Arc-Flash exposure and train workers in accordance with NFPA 70E and other applicable standards.
- J. The proposed vendor shall demonstrate experience in providing equipment labels in compliance with NEC-2017 section 110 and ANSI Z535.4 to identify AFIE and appropriate Personal Protective Equipment classes.
- K. Provide labeling at each piece of equipment to denote the arc flash hazard levels as per NFPA 70E-2018.

3.6 FIELD ADJUSTING

- A. Adjust relay and protective device settings according to the recommended settings provided by the coordination study. Field adjustments shall be completed by the engineering service division of the equipment manufacturer under the Startup and Acceptance Testing contract portion.
- B. Make minor modifications to equipment as required to accomplish compliance with protective device coordination studies

3.7 DEMONSTRATION

- A. Train Owner's maintenance personnel in the following:
 - 1. Acquaint personnel in the fundamentals of operating the power system in normal and emergency modes.
 - 2. Hand-out and explain the objectives of the coordination study, study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpreting the time-current coordination curves.
 - 3. Adjust, operate, and maintain overcurrent protective device settings.

END OF SECTION 26 05 73

SECTION 260923 –LIGHTING CONTROLS AND DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following lighting control devices:
 - 1. Analog (stand-alone) occupancy and vacancy sensors.
 - 2. Analog (stand-alone) wall-box dimmers.
 - 3. UL 924 Devices.
- B. Related Sections include the following:
 - 1. Section 26 0553 - Identification for Electrical Systems: Identification products and requirements.
 - 2. Section 26 2726 - Wiring Devices: line voltage switches and finish requirements for wall controls specified in this section.
 - 3. Section 26 5100 – Interior Lighting.

1.3 DEFINITIONS

- A. LED: Light-emitting diode.
- B. PIR: Passive infrared.

1.4 REFERENCES

- A. IEC – International Electrotechnical Commission.
- B. NECA 1 - Standard for Good Workmanship in Electrical Construction.
- C. NEMA - National Electrical Manufacturers Association.
- D. NFPA 70 - National Electrical Code; National Fire Protection Association.
- E. FCC emission standards.
- F. UL - Underwriters Laboratories, Inc. Listings.

- G. UL 2043 - Standard for Fire Test for Heat and Visible Smoke Release for Discrete Products Installed in Air-Handling Spaces.
- H. UL 924 - Standard for Emergency Lighting and Power Equipment.
- I. UL 8750 - Light Emitting Diode (LED) Equipment for Use in Lighting Products; Current Edition, including All Revisions.

1.5 SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for control modules, power distribution components, relays/power packs/room controllers/panels, manual switches and plates, and conductors and cables.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
 - 3. Engraving information.
- B. Shop Drawings:
 - 1. Provide scaled drawings of the entire project that indicate all lighting control equipment locations.
 - 2. Occupancy/vacancy sensors on drawings are shown to convey general intent for lighting control of spaces, based on a single manufacturer. Indicate the proper number and location(s) of occupancy/vacancy sensors, with coverage templates, to achieve desired control in each space shown with sensor(s). Typical coverage patterns for similar room sizes (for offices, bathrooms, storage rooms, etc.) will be acceptable but must be clearly marked "TYPICAL xxxxx SPACE".
 - 3. Show installation details for the following:
 - a. Occupancy sensors.
 - b. Vacancy sensors.
 - 4. Interconnection diagrams showing field-installed wiring.
 - 5. Include diagrams for power, signal, and control wiring.
 - 6. Drawings will detail all control scenarios included in the project.
 - 7. Provide switch schedules for all low voltage switches.
 - 8. Indicate a sequence of operation for all control scenarios, including manual on / auto off, auto on / auto off, sensor time delays, time schedules, and control zones.
- C. System Performance-Verification Documentation: Provide written report detailing start-up performance-verification procedures and functional tests performed along with test results including that the system operation matches the Lighting Control Schedule and Scene Schedules on the plans.
- D. Operation and Maintenance Data: For each type of lighting control device to include in operation and maintenance manuals.

1. Include as-built documentation of the system with a printout of plans that indication locations of power packs or room controllers, bridges, hubs, and any other lighting control equipment.
2. Record actual installed locations and settings for lighting control system components.
3. Spreadsheet noting each component and its warranty.

1.6 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use. All components shall be UL listed and meet all applicable state and local code requirements.
- B. Manufacturer shall substantiate conformance to this specification by supplying the necessary documents, performance data and wiring diagrams. Any deviations to this specification must be clearly stated by letter and submitted.

1.7 COORDINATION

- A. Pre-Install Meeting; Conduct on-site meeting prior to commencing work to review the following:
 1. Low voltage wiring requirements.
 2. Separation of power and low voltage/data wiring.
 3. Wire labeling.
 4. Control station locations.
 5. Load circuit wiring.
 6. Installer responsibilities.
- B. Coordination:
 1. Coordinate layout and installation of ceiling-mount devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression system, and partition assemblies.
 2. Coordinate the placement of sensors and wall controls with millwork, furniture, equipment, changes of wall finishes, etc. installed under other sections or by others.
 3. Coordinate the placement of wall controls with actual installed door swings.
 4. Coordinate the work to provide lighting controls compatible with the luminaires and lamps to be installed (reference approved lighting submittal(s)).
 5. Notify Architect of any conflicts or deviations from the contract documents to obtain direction prior to proceeding with work.
- C. Sequencing:
 1. Do not install sensors, wall controls, or other equipment that could be damaged, until final surface finishes and painting are complete.

1.8 WARRANTY

- A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace lighting control device that fails due to materials or installation within specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Faulty operation of lighting control software.
 - b. Faulty operation of lighting control devices.
 - 2. Warranty Period: Five (5) years from date of Substantial Completion.
- B. Contractor shall warrant all equipment furnished in accordance to this specification to be undamaged, free of defects in materials and workmanship, and in conformance with specifications. The supplier's obligation shall include repair/replacement and testing, without charge to the owner, for all or any parts of equipment which are found to be damaged, defective, or non-conforming and returned to the supplier. The warranty shall commence upon the owner's acceptance of the project. Warranty on labor shall be for the time period specified elsewhere in this specification.

PART 2 - PRODUCTS

2.1 INDOOR ANALOG OCCUPANCY/VACANCY SENSORS

- A. Manufacturers: Provide products by one of the following:
 - 1. Acuity Sensor Switch
 - 2. Lutron
 - 3. Wattstopper
 - 4. Leviton
- B. General Description: Wall- or ceiling-mounting, solid-state indoor occupancy and vacancy sensors.
 - 1. All sensors shall be occupancy type, field set to vacancy where noted.
 - 2. Provide occupancy/vacancy sensors to control lighting as indicated on the plans. Sensors shall be installed to meet or exceed requirements of the 2015 IECC.
 - 3. Sensors shall be listed and specifically designed for the application. Sensors shall provide full coverage of the intended area.
 - a. Sensor technology and coverage shall be as noted on the drawings.
 - b. Dual technology sensors shall be provided for all offices, conference rooms and occupied work space areas. Passive infrared sensors may be used in common and storage areas. Ultrasonic-only sensors may be used in corridors and restrooms.
 - 4. Connections: Hard Wired.
 - 5. Able to be locked to either Automatic-On or Manual-On mode.
 - 6. Relay/power pack/room controller will be plenum rated, zero-crossing 20 amp devices rated for the voltage of the lighting circuit.

7. Operation:
 - a. Occupancy Sensor (Bathrooms, corridors and public spaces where noted): Unless otherwise indicated, automatically 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 20 minutes.
 - b. Vacancy Sensor (All other areas): Unless otherwise indicated, lights are manually turned ON and sensor turns lights OFF when the room is unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 20 minutes.
 8. Sensor Output: Contacts rated to operate the connected relay/power pack/room controller, complying with UL 773A. Sensor shall be powered from the unit.
 9. Mounting:
 - a. Sensor: Suitable for mounting in any position on a standard outlet box.
 - b. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
 10. Indicator: LED, to show when motion is being detected during testing and normal operation of the sensor.
 11. Bypass Switch: Override the on function in case of sensor failure.
- C. PIR Type: Detect occupants in coverage area by their heat and movement.
1. 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.
 2. Detection Coverage: Detect occupancy anywhere in a pattern to meet or exceed product(s) listed on the drawings.
- D. Dual-Technology Type: Ceiling-mount or Aimable; detect occupancy by using a combination of PIR and ultrasonic/microphonic detection methods in area of coverage. Particular technology or combination of technologies that controls on-off functions shall be selectable in the field by operating controls on unit or via software.
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/second.
 3. Detection Coverage: Detect occupancy anywhere in a pattern to meet or exceed product(s) listed.
 4. Ceiling-Mount Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. when mounted on a 96-inch-high ceiling.
 - a. Unless otherwise noted on the drawings, provide Wattstopper DT-300 Series, Sensor Switch CM-PDT-9-P (500SF) or CM-PDT-10-P (2000SF), or approved equal.
 5. Aimable Detection Coverage (Standard Room): Detect occupancy anywhere within a 90° area of 1000 sq. ft. when mounted at 120 inches, 2000 sq. ft. of walking motion.

- a. Unless otherwise noted on the drawings, provide Wattstopper DT-200 Series, Sensor Switch WV16-KIT, or approved equal.
 - b. Ceiling- or wall-mount, provide mounting armature for each aimable sensor shown on plans.
- E. Ultrasonic Type: Ceiling mounting; detect occupancy by sensing a change in pattern of reflected ultrasonic energy in area of coverage.
 - 1. Detector Sensitivity: 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/second.
 - 2. Detection Coverage: Detect occupancy anywhere in a pattern to meet or exceed product(s) listed on the drawings.

2.2 ANALOG SWITCHBOX-MOUNT SENSORS

- A. Manufacturers: Provide products by one of the following:
 - 1. Acuity Sensor Switch
 - 2. Lutron
 - 3. Wattstopper
- B. General Requirements for Sensors: Automatic-wall-switch occupancy or manual vacancy sensor with manual on-off switch, 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. Sensor Operation: Unless otherwise indicated, manually turn lights on and turn lights off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 20 minutes.
 - 3. Operating Ambient Conditions: Dry interior conditions, 32 to 120 deg F.
- 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: PIR.
 - 3. Switch Type: SP, field-selectable automatic "on," or manual "on," automatic "off."
 - 4. Capable of controlling load in three-way application.
 - 5. Voltage: Match the circuit voltage.
 - 6. 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.
 - 7. Concealed, "off" time-delay selector at 30 seconds and 5, 10, and 20 minutes.
 - 8. Adaptive Technology: Turn this mode OFF.
 - 9. Color: Match wiring devices (as selected by Architect).
 - 10. Faceplate: Color matched to switch.
- D. Unless otherwise noted on the drawings, provide the following:

1. $\$OS / \VS (1-relay) – Wattstopper #DW100, Lutron #MS-A102, or Sensor Switch #WSX-PDT.
2. $\$OS2 / \$VS2$ (2-relay) – Wattstopper #DW200, Lutron #MS-A202, or Sensor Switch #WSX-PDT-2P.
3. $\$OS3 / \$VS3$ (three-way) – Wattstopper #DW103 or approved equal.
4. $\$OSD / \VSD (line-voltage dim) – Lutron #MSCL-OP153M or approved equal.
5. $\$OSV / \VSV (0-10v dim) – Lutron #MS-Z101, Sensor Switch #WSX-PDT-D, or approved equal.

2.3 ANALOG SWITCHBOX-MOUNT 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 Lamp Dimmer Switches: Modular; compatible with LED lamps; trim potentiometer to adjust low-end dimming; capable of consistent dimming with low end not greater than 20 percent of full brightness.
 1. Rocker style, provide Lutron “Diva” 150 watt unit (#D VWCL-153PH-color) unless otherwise noted.
- D. Magnetic Low-Voltage Dimmer Switches (up to 600 watts):
 1. Rocker style, provide Lutron “Diva” 600 watt unit (#DVLV-600P) or approved equal, unless otherwise noted.
- E. Electronic Low-Voltage Dimmer Switches (up to 300 watts):
 1. Rocker style, provide Lutron “Diva” 300 watt unit (#DVELV-300P) or approved equal, unless otherwise noted.
- F. 0-10v Dimmer, single pole or 3-way
 1. Rocker style, provide Lutron “Diva” 8A unit (#DVSTV-color) or approved equal, unless otherwise noted.
- G. High-Wattage Dimmer Switches (> 1000 watts): Unless otherwise noted, provide Lightolier “Vega” 2000 watt low-voltage dimmer (#V2000LV). Unit shall require special mounting to allow for full dimmer wattage.
- H. Contractor shall calculate wattage to be connected to each dimmer, based on maximum wattage of light fixture(s) as allowed by approved luminaire manufacturer(s).

2.4 MANUAL SWITCHES AND PLATES

- A. Push-Button Switches: Type as listed on the drawings or approved functional equivalent.

- B. Wall Plates: Single and multi-gang plates as specified in Section 26 27 26 "Wiring Devices."
- C. Legend: Engraved or permanently silk-screened on wall plate where indicated. Use designations indicated on Drawings.

2.5 EMERGENCY LIGHTING CONTROL DEVICES

- A. Emergency Lighting Control Unit - A UL 924 listed device that monitors a switched circuit providing normal lighting to an area. The unit provides normal ON/OFF control of emergency lighting along with the normal lighting. Upon normal power failure the emergency lighting circuit will close, forcing the emergency lighting ON until normal power is restored. Features include:
 - 1. 120/277 volts, 50/60 Hz, 20 amp ballast rating
 - 2. Push to test button
 - 3. Auxiliary contact for remote test or fire alarm system interface

2.6 CONDUCTORS AND CABLES

- A. Refer to manufacturer requirements.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Receive, inspect, handle, and store equipment according to NECA 407.
- B. Examine lighting control devices before installation. Reject lighting control devices that are wet, moisture damaged, or mold damaged.
- C. Examine walls and ceilings for suitable conditions where lighting control devices and panels will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 Installation Requirements

- A. Installation Procedures and Verification
 - 1. Review all required installation and pre-startup procedures with the manufacturer's representative through pre-construction meetings.

3.3 SENSOR INSTALLATION

- A. Comply with NECA 1.

- B. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression systems, and partition assemblies.
- C. Contractor shall arrange a pre-installation meeting with manufacturer's factory authorized representative, at Owner's facility, to verify placement of sensors and installation criteria. Vacancy/occupancy sensors shall be located per the approved vendor submittals.
- D. Proper judgment must be exercised in executing the installation to ensure the best possible installation in the available space and to overcome local difficulties due to space limitations or interference of structural components. It is the contractor's responsibility to locate and aim sensors for complete and proper volumetric coverage of the controlled area(s) per the manufacturer's recommendations. Rooms shall have ninety (90) to one hundred (100) percent coverage throughout the controlled area to accommodate all occupancy habits of single or multiple occupants at any location within the room(s). The location and quantity of sensors shown on the drawings are diagrammatic and indicate only the rooms which are occupancy controlled. The contractor shall provide additional sensors, at no additional cost, as required to properly and completely cover the space.
- E. 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.
- F. Set, program and adjust all devices as directed by the Owner.
- G. Vacancy sensors shall be programmed/installed as manual on/auto off. This is to include a low voltage switch when used in conjunction with a ceiling mounted sensor.
- H. Wall box or aimable sensors shall be installed so that most or all of the sensor coverage is confined to the room and will provide 100% coverage of the room with minimal coverage of any adjacent corridor. Install manufacturer provided shielding to wallbox sensor switches as required to prevent false operation in locations such as office doors that remain open.

3.4 WIRING INSTALLATION

- A. Comply with NECA 1.
- B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
 - 1. Above accessible suspended ceilings: Install on J-hooks, cable tray, or other dedicated support structure. Cables shall not be directly fastened to the outside of raceways or other building structures.
 - 2. Above concealed, non-accessible ceilings: Cables shall be installed in raceway.
 - 3. Within open ceiling structures: Cables shall be installed in raceway or dedicated cable tray systems where deployed. Open support structures shall be avoided.
 - 4. Inside wall cavities: Cables shall be installed in raceways from device box to above ceiling as indicated for ceiling type (i.e. accessible or non-accessible).
 - 5. Exposed: Cables shall be installed in raceway.
 - 6. Provide plenum-rated cable in environmental airspaces, including plenum ceilings.

7. Comply with requirements for raceways and boxes specified in Section 26 05 33 "Raceways and Boxes for Electrical Systems."

- C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.
- D. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.
- E. Size conductors according to lighting control device manufacturer's written instructions, unless otherwise indicated.
- F. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

3.5 DIMMER INSTALLATION

- A. Dimmers:
 - 1. Install dimmers within terms of their listing.
 - 2. Verify that dimmers used for fan-speed control are listed for that application.
 - 3. Install unshared neutral conductors on the line and load side of dimmers according to manufacturers' device listing conditions in the written instructions.
 - 4. Provide dimmers rated for the appropriate load type and wattage. Follow manufacturer's instructions for grouping devices in multi-gang boxes. Derate dimmers as necessary.
- B. 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.

3.6 IDENTIFICATION

- A. Identify components and power and control wiring according to Division 26 Section "Identification for Electrical Systems."
 - 1. Identify circuits or luminaries controlled by photoelectric and occupancy sensors at each sensor.
- B. Create a directory to indicate loads served by each relay/power pack/room controller; incorporate Owner's final room designations. Obtain approval before installing. Use a PC or typewriter to create directory; handwritten directories are unacceptable.
- C. Permanently label each relay/power pack/room controller with the following:
 - 1. Panel name and circuit number(s).
 - 2. Load description(s) from the Lighting Control Schedule (or similar), i.e. "CANS: DAYLIT ZONE". Include room name if the controller is located outside of that space.

3.7 FIELD QUALITY CONTROL

- A. The Contractor will set, test and verify the functionality of all lighting control components.
- B. Perform the following field tests and inspections and prepare test reports:
 - 1. After installing time switches and sensors, and after electrical circuitry has been energized, adjust and test for compliance with requirements.
 - 2. Operational Test: Verify operation of each lighting control device and adjust time delays.
 - 3. Confirm sequence of operations as noted on the drawings. Submit written report of the test.
- C. Lighting control devices that fail tests and inspections are defective work.

3.8 COMMISSIONING

- A. Prior to the installation of the digital control system, a factory authorized service technician will meet on site with the electrical foreman for the project. At this meeting the foreman will be provided a full set of approved lighting control drawings. The lighting control technician will review photocell placement, occupancy sensor requirements, switch locations, wiring requirements and any other information critical to the installation of the system.
- B. Upon completion of the installation, the system shall be completely commissioned by the manufacturer's factory authorized technician who will verify all adjustments and sensor placement to ensure a trouble-free lighting control system that meets the design intent of the construction documents.
- C. The electrical contractor shall coordinate start-up and commissioning with the manufacturer and then provide the Owner and electrical engineer with ten (10) working days written notice of the that date.
- D. Upon completion of the system fine tuning the factory authorized technician shall provide two (2) sets of proper training as follows:
 - 1. For the owner's maintenance personnel in the adjustment and maintenance of the sensors and programming of the system.
 - 2. For the owner's staff in the use of the system. This should also include verification of preset scenes. Adjust each scene to the satisfaction of the owner prior to leaving the site.
- E. The manufacturer shall provide a factory authorized technician to confirm proper installation and operation of all lighting control system components. The startup requirement is intended to verify that:
 - 1. All occupancy sensors are located, installed, and adjusted as intended by the factory and the contract documents.
 - 2. The occupancy sensors are operating within the manufacturers specifications.
 - 3. The sensors and relay panels/power packs/room controllers interact as a complete and operational system to meet the design intent.
 - 4. The manufacturer shall provide a written statement verifying that the system meets the above requirements.

- F. The manufacturer shall provide a factory authorized technician to train owner personnel in the operation, programming, and maintenance of the lighting control system, including all occupancy sensors. The contractor shall also provide, at the owner's facility, the training necessary to familiarize the owner's personnel with the adjustment, and problem-solving diagnosis of the occupancy sensing devices and systems.

3.9 PHASED INSTALLATION

- A. If renovation and/or construction is Phased, the contractor shall make the Digital Lighting Control system functional prior to occupancy of each separate Phase. No extra costs will be allowed for programming trips necessary to comply with phased construction.

3.10 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting sensors to suit occupied conditions. Provide up to three (3) visits to the Project during other-than-normal occupancy hours for this purpose.
- B. It shall be the contractor's responsibility to make all proper adjustments to assure owner's satisfaction with the occupancy system.

3.11 DEMONSTRATION

- A. Coordinate demonstration of products specified in this Section with demonstration requirements for low-voltage, programmable lighting control system.
- B. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain lighting control devices. Refer to Division 01 Section "Demonstration and Training." Training shall be videoed, and DVD shall be submitted to the Owner with the O&M Manuals.

END OF SECTION 260923

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. ATS: Acceptance testing specification.
- B. GFCI: Ground-fault circuit interrupter.
- C. GFEP: Ground-fault equipment protection.
- D. MCCB: Molded-case circuit breaker.
- E. SPD: Surge protective device.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of panelboard.
 - 1. Include materials, switching and overcurrent protective devices, SPDs, accessories, and components indicated.
 - 2. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
- B. Shop Drawings: For each panelboard and related equipment.
 - 1. Include dimensioned plans, elevations, sections, and details.
 - 2. Show tabulations of installed devices with nameplates, conductor termination sizes, equipment features, and ratings.
 - 3. Detail enclosure types including mounting and anchorage, environmental protection, knockouts, corner treatments, covers and doors, gaskets, hinges, and locks.
 - 4. Detail bus configuration, current, and voltage ratings.
 - 5. Short-circuit current rating of panelboards and overcurrent protective devices.

6. Include evidence of NRTL listing for SPD as installed in panelboard.
7. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

1.5 INFORMATIONAL SUBMITTALS

- A. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing. Coordinate room names and/or numbers to be used in panel schedules with final naming and numbering conventions.

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 Division 01 Section "Operation and Maintenance Data," include the following:
 1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Keys: Two spares for each type of panelboard cabinet lock.

1.8 QUALITY ASSURANCE

- A. Manufacturer Qualifications: ISO 9001 or 9002 certified.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating (250 W per panelboard) to prevent condensation.
- B. Handle and prepare panelboards for installation according to NEMA PB 1.

1.10 FIELD CONDITIONS

- A. Environmental Limitations:
 1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
 - a. Ambient Temperature: Not exceeding 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.
- C. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
 1. Notify Owner no fewer than 14 days in advance of proposed interruption of electric service.
 2. Do not proceed with interruption of electric service without Owner's written permission.
 3. Comply with NFPA 70E.

1.11 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to repair or replace panelboards that fail in materials or workmanship within specified warranty period.
 1. Panelboard Warranty Period: 18 months from date of Substantial Completion.
- B. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace SPD that fails in materials or workmanship within specified warranty period.
 1. SPD Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PANELBOARD COMMON REQUIREMENTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. ABB.
 2. Eaton.
 3. Siemens Power Transmission & Distribution, Inc.
 4. Square D; by Schneider Electric.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Comply with NEMA PB 1.

- D. Comply with NFPA 70.
- E. Enclosures: Flush and surface-mounted, dead-front cabinets.
 - 1. Rated for environmental conditions at installed location.
 - a. Kitchen and Food Service areas: NEMA 250, Type 4X.
 - 2. Height: 84 inches maximum. Comply with ADA requirements for apartment unit load centers.
 - 3. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover. Trims shall cover all live parts and shall have no exposed hardware.
- F. Phase, Neutral, and Ground Buses:
 - 1. Material: Tin-plated aluminum.
 - a. Plating shall run entire length of bus.
 - b. Bus shall be fully rated the entire length.
 - 2. Interiors shall be factory assembled into a unit. Replacing switching and protective devices shall not disturb adjacent units or require removing the main bus connectors.
 - 3. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
 - 4. Full-Sized Neutral: Equipped with full-capacity bonding strap for service entrance applications. Mount electrically isolated from enclosure. Do not mount neutral bus in gutter.
- G. Conductor Connectors: Suitable for use with conductor material and sizes.
 - 1. Material: Tin-plated aluminum.
 - 2. Terminations shall allow use of 75 deg C rated conductors without derating.
 - 3. Size: Lugs suitable for indicated conductor sizes, with additional gutter space, if required, for larger conductors.
 - 4. Main and Neutral Lugs: Mechanical type, with a lug on the neutral bar for each pole in the panelboard.
 - 5. Ground Lugs and Bus-Configured Terminators: Mechanical type, with a lug on the bar for each pole in the panelboard.
 - 6. Feed-Through Lugs: Mechanical type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
- H. Future Devices: Panelboards or load centers shall have mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.
- I. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals. Assembly listed by an NRTL for 100 percent interrupting capacity.
 - 1. Panelboards and overcurrent protective devices rated 240 V or less shall have short-circuit ratings as shown on Drawings, but not less than 10,000 A rms symmetrical.

2. Panelboards and overcurrent protective devices rated above 240 V and less than 600 V shall have short-circuit ratings as shown on Drawings, but not less than 14,000 A rms symmetrical.

Note: Series rated panelboards shall not be accepted.

J. SPD: Provide where indicated in schedules for panelboards.

1. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 100 kA. The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.
2. Protection modes and UL 1449 VPR for grounded wye circuits with 208Y/120 V, three-phase, four-wire circuits shall not exceed the following, respectively:
 - a. Line to Neutral: 700 V for 208Y/120 V.
 - b. Line to Ground: 700 V for 208Y/120 V.
 - c. Neutral to Ground: 700 V for 208Y/120 V.
 - d. Line to Line: 1200 V for 208Y/120 V.
3. SCCR: Equal to the SCCR of the panelboard in which installed or exceed 100 kA.
4. Inominal Rating: 20 kA.

2.2 PERFORMANCE REQUIREMENTS

- A. Surge Suppression: Factory installed as an integral part of indicated panelboards, complying with UL 1449 SPD Type 2. Provide where indicated on drawings or as required by other sections of specifications.

2.3 POWER PANELBOARDS

- A. Panelboards: NEMA PB 1, distribution type.
- B. Doors: Secured with vault-type latch with tumbler lock; keyed alike.
1. For doors more than 36 inches high, provide two latches, keyed alike.
- C. Branch Overcurrent Protective Devices: Bolt-on circuit breakers.

2.4 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

- A. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.
- B. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

- C. Doors: Door-in-door construction with concealed hinges; secured with multipoint latch with tumbler lock; keyed alike. Outer door shall permit full access to the panel interior. Inner door shall permit access to breaker operating handles and labeling, but current carrying terminals and bus shall remain concealed.

2.5 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

- A. MCCB: Comply with UL 489, with interrupting capacity to meet available fault currents.

- 1. Thermal-Magnetic Circuit Breakers:
 - a. Inverse time-current element for low-level overloads.
 - b. Instantaneous magnetic trip element for short circuits.
 - c. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
- 2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
- 3. GFCI Circuit Breakers: Single- and double-pole configurations with Class A ground-fault protection (6-mA trip).
- 4. GFEP Circuit Breakers: Class B ground-fault protection (30-mA trip).
- 5. Arc-Fault Circuit Interrupter Circuit Breakers: Comply with UL 1699; 120/240-V, single-pole configuration.
- 6. Subfeed Circuit Breakers: Vertically mounted.
- 7. MCCB Features and Accessories:
 - a. Standard frame sizes, trip ratings, and number of poles.
 - b. Breaker handle indicates tripped status.
 - c. UL listed for reverse connection without restrictive line or load ratings.
 - d. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.
 - e. Application Listing: Appropriate for application.
 - f. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
 - g. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage.
 - h. Rating Plugs: Three-pole breakers with ampere ratings greater than 150 amperes shall have interchangeable rating plugs or electronic adjustable trip units.
 - i. Multipole units enclosed in a single housing with a single handle.
 - j. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in on or off position.

- k. Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position.

2.6 IDENTIFICATION

- A. Panelboard Label: Manufacturer's name and trademark, voltage, amperage, number of phases, and number of poles shall be located on the interior of the panelboard door.
- B. Breaker Labels: Faceplate shall list current rating, UL and IEC certification standards, and AIC rating.
- C. Circuit Directory: Computer-generated circuit directory mounted inside panelboard door with transparent plastic protective cover.
 - 1. Circuit directory shall identify specific purpose with detail sufficient to distinguish it from all other circuits.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify actual conditions with field measurements prior to ordering panelboards to verify that equipment fits in allocated space in, and comply with, minimum required clearances specified in NFPA 70.
- B. Receive, inspect, handle, and store panelboards according to NEMA PB 1.1.
- C. Examine panelboards before installation. Reject panelboards that are damaged, rusted, or have been subjected to water saturation.
- D. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Comply with NECA 1.
- C. Install panelboards and accessories according to NEMA PB 1.1.

- D. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.
- E. Mount top of trim 84 above finished floor unless otherwise indicated.
- F. Mount panelboard cabinet plumb and rigid without distortion of box.
- G. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.
- H. Install overcurrent protective devices and controllers not already factory installed.
 - 1. Set field-adjustable, circuit-breaker trip ranges.
 - 2. Tighten bolted connections and circuit breaker connections using calibrated torque wrench or torque screwdriver per manufacturer's written instructions.
- I. Make grounding connections and bond neutral for services and separately derived systems to ground. Make connections to grounding electrodes, separate grounds for isolated ground bars, and connections to separate ground bars.
- J. Install filler plates in unused spaces.
- K. 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.
- L. Arrange conductors in gutters into groups and bundle and wrap with wire ties after completing load balancing.

3.3 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; install warning signs complying with requirements in Section 26 05 53 "Identification for Electrical Systems."
- B. Create a directory to indicate installed circuit loads after balancing panelboard loads; incorporate Owner's final room designations. Obtain approval before installing. Handwritten directories are not acceptable. Install directory inside panelboard door.
- C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."
- D. Device Nameplates: Label each branch circuit device in power panelboards with a nameplate complying with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."
- E. Install warning signs complying with requirements in Section 26 05 53 "Identification for Electrical Systems" identifying source of remote circuit.

3.4 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Acceptance Testing Preparation:
 - 1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
- C. Tests and Inspections:
 - 1. Perform each visual and mechanical inspection and electrical test for low-voltage air circuit breakers stated in NETA ATS, Paragraph 7.6 Circuit Breakers. Certify compliance with test parameters.
 - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
 - 3. Perform the following infrared scan tests and inspections and prepare reports:
- D. Panelboards will be considered defective if they do not pass tests and inspections.

3.5 ADJUSTING

- A. Adjust moving parts and operable components to function smoothly and lubricate as recommended by manufacturer.
- B. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes. Prior to making circuit changes to achieve load balancing, inform Architect of effect on phase color coding.
 - 1. Measure loads during period of normal facility operations.
 - 2. Perform circuit changes to achieve load balancing outside normal facility operation schedule or at times directed by the Architect. Avoid disrupting services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
 - 3. After changing circuits to achieve load balancing, recheck loads during normal facility operations. Record load readings before and after changing circuits to achieve load balancing.
 - 4. Tolerance: Maximum difference between phase loads, within a panelboard, shall not exceed 20 percent.

3.6 PROTECTION

- A. Temporary Heating: Prior to energizing panelboards, apply temporary heat to maintain temperature according to manufacturer's written instructions.

END OF SECTION 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. Straight-blade convenience, and tamper-resistant receptacles.
 - 2. GFCI receptacles.
 - 3. Twist-locking receptacles.
 - 4. Cord and plug sets.
 - 5. Wall plates.

1.3 DEFINITIONS

- A. Abbreviations of Manufacturers' Names:
 - 1. Cooper: Cooper Wiring Devices; Division of Cooper Industries, Inc.
 - 2. Hubbell: Hubbell Incorporated: Wiring Devices-Kellems.
 - 3. Leviton: Leviton Mfg. Company, Inc.
 - 4. Pass & Seymour: Pass& Seymour/Legrand.
 - 5. GE: General Electric
- B. GFCI: Ground-fault circuit interrupter.
- C. Pigtail: Short lead used to connect a device to a branch-circuit conductor.

1.4 ACTION SUBMITTALS

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

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing-label warnings and instruction manuals that include labeling conditions.

PART 2 - PRODUCTS

2.1 GENERAL WIRING-DEVICE REQUIREMENTS

- A. Wiring Devices, Components, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with NFPA 70.
- C. Devices for Owner-Furnished Equipment:
 - 1. Receptacles: Match plug configurations.
 - 2. Cord and Plug Sets: Match equipment requirements.
- D. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

2.2 MANUFACTURERS

- A. Manufacturers' Names: Shortened versions (shown in parentheses) of the following manufacturers' names are used in other Part 2 articles:
 - 1. Cooper Wiring Devices; a division of Cooper Industries, Inc. (Cooper).
 - 2. Hubbell Incorporated; Wiring Device-Kellems (Hubbell).
 - 3. Leviton Mfg. Company Inc. (Leviton).
 - 4. Pass & Seymour/Legrand; Wiring Devices & Accessories (Pass & Seymour).

2.3 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.
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; 5362 (duplex).
 - b. Hubbell; CR20 (duplex).
 - c. Leviton; BR20 (duplex).
 - d. Pass & Seymour; 5352 (duplex).
- B. Tamper-Resistant Convenience Receptacles: 125 V, 20 A; comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, and FS W-C-596.
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; TR5362 (duplex).
 - b. Hubbell; CR20TR (duplex).
 - c. Leviton; TBR20 (duplex).
 - d. Pass & Seymour; TR5352 (duplex).

2.4 GFCI RECEPTACLES

A. General Description:

1. Indoors: 125 V, 20 A, straight blade, tamper-resistant, non-feed-through type.
2. Outdoors: 125 V, 20 A, straight blade, tamper-resistant, weather-resistant, non-feed-through type.
3. Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, UL 943 Class A, and FS W-C-596.

B. Duplex GFCI Convenience Receptacles:

1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper: VGF20 (indoor), WRVGF20 (outdoor).
 - b. Hubbell: GFST20 (indoor), GFWRST20 (outdoor).
 - c. Leviton: GF2 (indoor), GFW2 (outdoor).
 - d. Pass & Seymour: PT2095 (indoor), 2095WR (outdoor).

C. Tamper-Resistant, Duplex GFCI Convenience Receptacles:

1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper: TRVGF20 (indoor), TWRVGF20 (outdoor).
 - b. Hubbell: GFTRST20 (indoor), GFTWRST20 (outdoor).
 - c. Leviton: GFTR2 (indoor), GFWT2 (outdoor).
 - d. Pass & Seymour: PT2095TR (indoor), 2095TRWR (outdoor).

2.5 USB CHARGER DEVICES

A. Tamper-Resistant, USB Charger Receptacles: 125 V, 20 A; comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, UL 1310, and FS W-C-596.

1. Manufactures: Subject to compliance with requirements, provide products by one of the following:
 - a. Eaton (Arrow Hart).
 - b. Hubbell Incorporated; Wiring Device-Kellems.
 - c. Leviton Manufacturing Co., Inc.
 - d. Pass & Seymour/Legrand (Pass & Seymour).
2. Description: Single-piece, rivetless, nickel-plated, all-brass grounding system. Nickel-plated, brass mounting strap.
3. USB Receptacles: Dual, Type A and C.
4. Line Voltage Receptacles: Dual, two pole, three wire, and self-grounding.

2.6 TWIST-LOCKING RECEPTACLES

A. Twist-Lock, Single Convenience Receptacles: 125 V, 20 A; comply with NEMA WD 1, NEMA WD 6 Configuration L5-20R, and UL 498.

1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper: AHL520R.
 - b. Hubbell: HBL7210B.
 - c. Leviton: 2310.
 - d. Pass & Seymour: L520R.

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.

C. Toggle Switches: Square Face, paddle style, 120/277 V, 20 A; comply with NEMA WD 1, UL 20, and FS W-S-896.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Eaton (Arrow Hart).
 - b. Hubbell Incorporated; Wiring Device-Kellems.
 - c. Leviton Manufacturing Co., Inc.
 - d. Pass & Seymour/Legrand (Pass & Seymour).

D. Pilot-Light Switches: 120/277 V, 20 A.

1. Description: Single pole, with LED-lighted handle, illuminated when switch is off.

2.9 WALL PLATES

A. Single and combination types shall match corresponding wiring devices.

1. Plate-Securing Screws: Metal with head color to match plate finish.
2. Material for Finished Spaces: Satin-finished stainless steel.
3. Material for Unfinished Spaces: Smooth, high-impact thermoplastic.
4. Material for Damp Locations: Thermoplastic with spring-loaded lift cover and listed and labeled for use in wet and damp locations.

5. Material for all food service areas: Stainless steel.
- B. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with Type 3R, weather-resistant, die-cast aluminum with lockable cover.

2.10 FINISHES

- A. Device Color:
 1. All device colors and wall plate colors shall be confirmed with the Architect prior to ordering.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with NECA 1, including mounting heights listed in that standard, unless otherwise indicated.
- B. Coordination with Other Trades:
 1. Protect installed devices and their boxes. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of boxes.
 2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
 3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
 4. Install wiring devices after all wall preparation, including painting, is complete.
- C. Conductors:
 1. Do not strip insulation from conductors until right before they are spliced or terminated on devices.
 2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
 3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
- D. Device Installation:
 1. Replace devices that have been in temporary use during construction and that were installed before building finishing operations were complete.
 2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
 3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
 4. Connect devices to branch circuits using pigtails that are not less than 6 inches in length.

5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, two-thirds to three-fourths of the way around terminal screw.
6. Use a torque screwdriver when a torque is recommended or required by manufacturer.
7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
8. Tighten unused terminal screws on the device.
9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device-mounting screws in yokes, allowing metal-to-metal contact.

E. Receptacle Orientation:

1. Match existing.

F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

G. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on bottom. Group adjacent switches under single, multigang wall plates.

H. Adjust locations of ceiling devices to suit arrangement of equipment served.

3.2 GFCI RECEPTACLES

- A. Install non-feed-through-type GFCI receptacles, unless specifically noted otherwise on drawings.
- B. Where GFCI receptacles are not readily accessible behind large appliances (including, but not limited to refrigerators, freezers, vending machines, etc.) or fixed-in place appliances (including, but not limited to microwaves, under-counter refrigerators, etc.) provide a remote test/reset GFCI device with integral indicating light located in a readily accessible location.

3.3 IDENTIFICATION

- A. Comply with Section 26 05 53 "Identification for Electrical Systems."
- B. Identify each receptacle with panelboard identification and circuit number. Use permanent marker on back of faceplates 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.
- C. Wiring device will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

END OF SECTION 26 27 26

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. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.

1.4 CLOSEOUT SUBMITTALS

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

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

1.6 FIELD CONDITIONS

- A. Where ambient temperature to which fuses are directly exposed is less than 40 deg F 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, provide products by one of the following:
 - 1. Bussmann, an Eaton business.
 - 2. Edison; a brand of Bussmann by Eaton.
 - 3. Littelfuse, Inc.
 - 4. Mersen USA.
- 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.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Comply with NEMA FU 1 for cartridge fuses.
- D. Comply with NFPA 70.
- E. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.
- B. Examine holders to receive fuses for compliance with installation tolerances and other conditions affecting performance, such as rejection features.
- C. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.
- D. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.

- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 FUSE APPLICATIONS

A. Cartridge Fuses:

1. Motor Branch Circuits: Class RK1, time delay, unless otherwise recommend by equipment manufacturer.
2. Other Branch Circuits: Class RK5, time delay.
3. Control Circuits: Class CC, fast acting.

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 26 05 53 "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. Nonfusible switches.
 - 3. Molded-case circuit breakers (MCCBs).
 - 4. Enclosures.

1.3 DEFINITIONS

- A. NC: Normally closed.
- B. NO: Normally open.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include nameplate ratings, dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.
 - 1. Enclosure types and details for types other than NEMA 250, Type 1.
 - 2. Current and voltage ratings.
 - 3. Short-circuit current ratings (interrupting and withstand, as appropriate).
 - 4. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals.
 - 1. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

- a. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.
- b. Time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device.

1.6 FIELD CONDITIONS

- A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:
 - 1. Ambient Temperature: Not less than minus 22 deg F and not exceeding 104 deg F.
 - 2. Altitude: Not exceeding 6600 feet.

1.7 WARRANTY

- A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace components that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: One year from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

- A. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single manufacturer.
- B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- D. Comply with NFPA 70.

2.2 FUSIBLE SWITCHES

- A. Manufacturer: Match panelboard manufacturer.
- B. Type HD, Heavy Duty:
 - 1. Single throw.
 - 2. Three pole.
 - 3. 600-V ac.
 - 4. 1200 A and smaller.

5. UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate fuses.
6. Lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Hookstick Handle: Allows use of a hookstick to operate the handle.
4. Lugs: Mechanical type, suitable for number, size, and conductor material.

2.3 NONFUSIBLE SWITCHES

A. Manufacturer: Match panelboard manufacturer.

B. Type HD, Heavy Duty, Three Pole, Single Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

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. Hookstick Handle: Allows use of a hookstick to operate the handle.
4. Lugs: Mechanical type, suitable for number, size, and conductor material.

2.4 MOLDED-CASE CIRCUIT BREAKERS

A. Manufacturer: Match panelboard manufacturer.

B. Circuit breakers shall be constructed using glass-reinforced insulating material. Current carrying components shall be completely isolated from the handle and the accessory mounting area.

C. Circuit breakers shall have a toggle operating mechanism with common tripping of all poles, which provides quick-make, quick-break contact action. The circuit-breaker handle shall be over center, be trip free, and reside in a tripped position between on and off to provide local trip indication. Circuit-breaker escutcheon shall be clearly marked on and off in addition to providing international I/O markings. Equip circuit breaker with a push-to-trip button, located on the face of the circuit breaker to mechanically operate the circuit-breaker tripping mechanism for maintenance and testing purposes.

D. The maximum ampere rating and UL, IEC, or other certification standards with applicable voltage systems and corresponding interrupting ratings shall be clearly marked on face of circuit breaker. Circuit breakers shall be 100 percent rated. Circuit breaker/circuit breaker MCCBs shall be equipped with a device for locking in the isolated position.

- E. Standards: Comply with UL 489 and NEMA AB 3, with interrupting capacity to comply with available fault currents.
- F. Thermal-Magnetic Circuit Breakers: Inverse time-current thermal element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
- G. Ground-Fault Circuit-Interrupter (GFCI) Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).
- H. Ground-Fault Equipment-Protection (GFEP) Circuit Breakers: With Class B ground-fault protection (30-mA trip).
- I. 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. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
 - 4. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.

2.5 ENCLOSURES

- A. Enclosed Switches and Circuit Breakers: UL 489, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.
- B. Enclosure Finish: The enclosure shall be finished with gray baked enamel paint, electrodeposited on cleaned, phosphatized steel (NEMA 250 Type 1) or gray baked enamel paint, electrodeposited on cleaned, phosphatized galvanized steel (NEMA 250 Types 3R).
- C. Operating Mechanism: The circuit-breaker operating handle shall be directly operable through the front cover of the enclosure (NEMA 250 Type 1) or directly operable through the dead front trim of the enclosure (NEMA 250 Type 3R). The cover interlock mechanism shall have an externally operated override. The override shall not permanently disable the interlock mechanism, which shall return to the locked position once the override is released. The tool used to override the cover interlock mechanism shall not be required to enter the enclosure in order to override the interlock.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.
 - 1. Commencement of work shall indicate Installer's acceptance of the areas and conditions as satisfactory.

3.2 ENCLOSURE ENVIRONMENTAL RATING APPLICATIONS

- A. Enclosed Switches and Circuit Breakers: Provide enclosures at installed locations with the following environmental ratings.
 - 1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
 - 2. Indoor food service areas: Stainless steel, NEMA 250, Type 4X or non-metallic, food-service-grade.
 - 3. Outdoor Locations: NEMA 250, Type 3R.

3.3 INSTALLATION

- A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.
- C. Temporary Lifting Provisions: Remove temporary lifting of eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
- D. Install fuses in fusible devices.
- E. Comply with NFPA 70 and NECA 1.

3.4 IDENTIFICATION

- A. Comply with requirements in Section 26 05 53 "Identification for Electrical Systems."
 - 1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
 - 2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.5 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections for Switches:
 - 1. Visual and Mechanical Inspection:
 - a. Inspect physical and mechanical condition.
 - b. Inspect anchorage, alignment, grounding, and clearances.
 - c. Verify that the unit is clean.
 - d. Verify blade alignment, blade penetration, travel stops, and mechanical operation.
 - e. Verify that fuse sizes and types match the Specifications and Drawings.
 - f. Verify that each fuse has adequate mechanical support and contact integrity.

- g. Verify lubrication of moving current-carrying parts and moving and sliding surfaces.

C. Tests and Inspections for Molded Case Circuit Breakers:

1. Visual and Mechanical Inspection:

- a. Verify that equipment nameplate data are as described in the Specifications and shown on the Drawings.
- b. Inspect physical and mechanical condition.
- c. Inspect anchorage, alignment, grounding, and clearances.
- d. Verify that the unit is clean.
- e. Operate the circuit breaker to ensure smooth operation.
- f. Inspect operating mechanism, contacts, and chutes in unsealed units.
- g. Perform adjustments for final protective device settings in accordance with the coordination study.

2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

- D. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.

3.6 ADJUSTING

- A. Adjust moving parts and operable components to function smoothly and lubricate as recommended by manufacturer.

END OF SECTION 262816

SECTION 265100 - 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.
- B. Related requirements:
 - 1. Section 26 09 23 "Lighting Controls and Devices" for manual and automatic control of lighting, including time switches, analog wall box dimmers for LED lamps and luminaires, analog occupancy sensors and power packs, as well as digital control system and components.

1.2 SUMMARY

- A. This Section includes interior lighting fixtures, lighting fixtures mounted on exterior building surfaces, lamps, ballasts, emergency lighting units, and accessories.

1.3 DEFINITIONS

- A. CCT: Correlated Color Temperature.
- B. CRI: Color Rendering Index.
- C. Emergency Lighting Unit: A lighting unit with internal or external emergency battery powered supply and the means for controlling and charging the battery and unit operation.
- D. Fixture: See "Luminaire."
- E. LED: Light-emitting diode.
- F. Lumen: Measured output of lamp and luminaire, or both.
- G. Luminaire: Complete lighting unit, including lamp, reflector and housing.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of lighting fixture indicated, arranged in order of fixture designation. Include data on features, accessories, and the following:
 - 1. Physical description and dimensions of luminaires.
 - 2. Include life, output (lumens, CCT and CRI), and energy efficiency data.

3. Include photometric data and adjustment factors based on laboratory tests, complying with IES LM45, IES LM-79, and IES LM-80.

- a. Manufacturers' Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program (NVLAP) for Energy Efficient Lighting Products.

- B. Product Schedule: For luminaires and lamps. Use same designations indicated on Drawings.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For luminaires and lighting systems to include in maintenance manuals.

1. Provide a list of all lamp types used on Project; use ANSI and manufacturers' codes.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Lamps: Five for every 100 of each type and rating installed. Furnish at least one of each type.
2. LED Drivers: One for every 50 of each LED fixture type installed. Furnish at least one of each type.

1.7 QUALITY ASSURANCE

- A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturer's laboratory is accredited under the NVLAP for Energy Efficient Lighting Products.

1.8 DELIVERY, STORAGE AND HANDLING

- A. Protect finished of exposed surfaces by applying a strippable, temporary protective covering before shipping.

1.9 WARRANTY

- A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years minimum for all LED Luminaires and two-year(s) minimum for all other luminaires from date of Substantial Completion

1.10 COORDINATION

- A. Fixtures, Mounting Hardware, and Trim: Coordinate layout and installation of lighting fixtures with ceiling system and other construction.

1.11 WARRANTY

- A. General Warranty: Special warranty specified in this Article shall not deprive Owner of other rights Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by Contractor under requirements of the Contract Documents.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. In Lighting Fixture Schedule where titles below are column or row headings that introduce lists, the following requirements apply to product selection:
 - 1. Basis-of-Design Product: The design for each lighting fixture is based on the product named. Subject to compliance with requirements, provide either the named product or a comparable product by one of the other manufacturers specified in the Light Fixture Schedule on the Drawings.

2.2 LUMINAIRE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Lamp base complying with ANSI C81.61 or IEC 60061-1.
- C. Nominal Operating Voltage: As indicated on the Light Fixture Schedule.
- D. Recessed Luminaires: Comply with NEMA LE 4.
- E. Comply with NFPA 70 and NFPA 101 for emergency lighting.
- F. Bulb Shape: Complying with ANSI C79.1 for incandescent, LED, and emergency lighting.

2.3 LED LUMINAIRES

- A. CRI of minimum 90. CCT of as indicated on Light Fixture Schedule.
- B. Rated lamp life of minimum 35,000 hours.
- C. Lamps dimmable from 100 percent to 0 percent of maximum light output.

- D. Minimum required luminaire efficacy of:
 - 1. Lamps (socket base): 90 lumens per watt.
 - 2. Downlights: 80 lumens per watt.
 - 3. Troffers/Linears: 100 lumens per watt.
 - 4. Alternate manufacturer efficacy shall be equal to, or greater than, the efficacy of the first-line manufacturer in the Light Fixture Schedule.
- E. Internal driver (unless indicated otherwise on the Light Fixture Schedule).
- F. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.
- G. Housings:
 - 1. Extruded-aluminum housing and heat sink.
- H. Minimum allowable luminaire efficacy of 80. Lumens per watt.
- I. Each LED luminaire shall be binned within a three-step macadam ellipse minimum to ensure color consistency among luminaires.

2.4 EXIT SIGNS

- A. General Requirements for Exit Signs: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.
- B. Internally Lighted Signs:
 - 1. Operating at nominal voltage of as indicated on Light Fixture Schedule.
 - 2. Lamps for AC Operation: LEDs; 50,000 hours minimum rated lamp life.

2.5 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. Glass: Annealed crystal glass unless otherwise indicated.
 - 2. 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.
 - 3. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.

- D. Housings:
 - 1. Extruded-aluminum housing and heat sink.
- 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.

2.6 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.

2.7 LIGHTING FIXTURE SUPPORT COMPONENTS

- A. Comply with requirements in Section 26 05 29 "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 shall match luminaire.
- C. Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated steel, 12 gage.
- D. Rod Hangers: 3/16-inch minimum diameter, cadmium-plated, threaded steel rod
- E. Aircraft Cable Support: Use cable, anchorages, and intermediate supports recommended by fixture manufacturer.

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.
- C. 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. Coordinate layout and installation of luminaires and suspension system with other construction that penetrates ceilings or is supported by them.
- E. 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.
- F. Ceiling-Grid-Mounted Luminaire Supports: Use grid as a support element.
 - 1. Install ceiling support system rods or wires independent of the ceiling suspension devices, for each luminaire. Locate not more than 6 inches from luminaire corners.
 - 2. Support Clips: Fasten to luminaires and to ceiling grid members at or near each luminaire corner with clips that are UL listed for the application.
 - 3. Luminaires of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support luminaires independently with at least two 3/4-inch metal channels spanning and secured to ceiling tees.
 - 4. Install at least one independent support rod or wire from structure to a tab on luminaire. Wire or rod shall have breaking strength of the luminaire weight at a safety factor of 3.
- G. 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.
- H. Wall-Mounted Luminaire Support:
 - 1. Attached to structural members in walls or Attached to a minimum 20 gauge backing plate attached to wall structural members.
 - 2. Do not attach luminaires directly to gypsum board.
- I. 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.
- J. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" and Section 260533 "Raceways and Boxes for Electrical Systems" for wiring connections and wiring methods.

3.4 CONNECTIONS

- A. Ground equipment.
1. 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.

3.5 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

3.6 FIELD QUALITY CONTROL

- A. The Contractor shall inspect each installed fixture for damage. Replace damaged fixtures and components.
- B. The Contractor shall provide instruments to make and record test results.
- C. Tests: As follows:
1. Verify normal operation of each fixture after installation.
 2. Emergency Lighting: Interrupt electrical supply to demonstrate proper operation.
- D. Malfunctioning Fixtures and Components: The Contractor shall replace or repair, then retest. Repeat procedure until units operate properly.
- E. Corrosive Fixtures: Replace during warranty period.
- F. Luminaires shall be installed such that light sources are aligned in the same relative orientation from one fixture to the next.

3.7 START-UP SERVICE

- A. Burn-in all lamps that require specific aging period to operate properly, prior to occupancy by Owner.
- B. Perform startup service:
 - 1. Charge emergency power units and batteries minimum of one hour and depress switch to conduct short-duration test.

3.8 CLEANING AND ADJUSTING

- A. Clean fixtures internally and externally after installation. Use methods and materials recommended by manufacturer. All luminaires shall be thoroughly cleaned and clear from dust, paint, construction debris and fingerprints after all other trades are complete, but prior to the date of substantial completion.

END OF SECTION 265100

SECTION 271500 - COMMUNICATIONS HORIZONTAL CABLING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. UTP cabling.
 - 2. Cable connecting hardware, patch panels, and cross-connects.
 - 3. Telecommunications outlet/connectors.
 - 4. Cabling system identification products.
 - 5. Cable management system.

1.3 DEFINITIONS

- A. BICSI: Building Industry Consulting Service International.
- B. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.
- C. EMI: Electromagnetic interference.
- D. IDC: Insulation displacement connector.
- E. LAN: Local area network.
- F. Outlet/Connectors: A connecting device in the work area on which horizontal cable or outlet cable terminates.
- G. RCDD: Registered Communications Distribution Designer.
- H. UTP: Unshielded twisted pair.

1.4 HORIZONTAL CABLING DESCRIPTION

- A. Horizontal cable and its connecting hardware provide the means of transporting signals between the telecommunications outlet/connector and the horizontal cross-connect located in the communications equipment room. This cabling and its connecting hardware are called a "permanent link," a term that is used in testing protocols.

1. TIA-568-C.1 requires that a minimum of two telecommunications outlet/connectors be installed for each work area.
 2. Horizontal cabling shall contain no more than one transition point or consolidation point between the horizontal cross-connect and the telecommunications outlet/connector.
 3. Bridged taps and splices shall not be installed in the horizontal cabling.
 4. Splitters shall not be installed as part of the optical fiber cabling.
- B. A work area is approximately 100 sq. ft. and includes the components that extend from the telecommunications outlet/connectors to the station equipment.
- C. The maximum allowable horizontal cable length is 295 feet. This maximum allowable length does not include an allowance for the length of 16 feet to the workstation equipment and in the horizontal cross-connect.

1.5 PERFORMANCE REQUIREMENTS

- A. General Performance: Horizontal cabling system shall comply with transmission standards in TIA-568-C.1 when tested according to test procedures of this standard.

1.6 SUBMITTALS

- A. Product Data: For each type of product.
1. For coaxial cable, include the following installation data for each type used:
 - a. Nominal OD.
 - b. Minimum bending radius.
 - c. Maximum pulling tension.
- B. Shop Drawings:
1. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by Owner.
 2. System Labeling Schedules: Electronic copy of labeling schedules that are part of the cabling and asset identification system of the software.
 3. Cabling administration drawings and printouts.
- C. Qualification Data: For Installer, qualified layout technician, installation supervisor, and field inspector.
- D. Field quality-control reports.
- E. Maintenance Data: For splices and connectors to include in maintenance manuals.

1.7 QUALITY ASSURANCE

- A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.

1. Layout Responsibility: Preparation of Shop Drawings, Cabling Administration Drawings, and field testing program development by an RCDD.
2. Installation Supervision: Installation shall be under the direct supervision of Registered Technician Level 2 Installer, who shall be present at all times when Work of this Section is performed at Project site.
3. Testing Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Test cables upon receipt at Project site.
 1. Test each pair of UTP cable for open and short circuits.

1.9 PROJECT CONDITIONS

- A. Environmental Limitations: Do not deliver or install cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

1.10 COORDINATION

- A. Coordinate layout and installation of telecommunications pathways and cabling with the Owner's telecommunications and LAN equipment and service suppliers. Arrange for a pre-installation meeting with the Owner prior to beginning any rough-in, or installing any cables.
- B. Coordinate telecommunications outlet/connector locations with location of power receptacles at each work area.

PART 2 - PRODUCTS

2.1 PATHWAYS

- A. General Requirements: Comply with TIA-569-B.
- B. Cable Support: NRTL labeled for support of Category 5e cabling, designed to prevent degradation of cable performance and pinch points that could damage cable.
 1. Support brackets with slots for reusable straps. Use reusable straps, not cable ties.
 2. Lacing bars, spools, J-hooks, and D-rings.
 3. Straps and other devices.

2.2 UTP CABLE

- A. Surface-Burning Characteristics: Comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 - 1. Flame-Spread Index: 25 or less.
 - 2. Smoke-Developed Index: 50 or less.
- 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. Grounding: Comply with NEC and the AHJ requirements.
- D. Manufacturers: All cable, hardware, and patch cords shall be by the same Manufacturer. Subject to compliance with requirements, provide products by one of the following O.A.E.:
 - 1. Hubbell NextSpeed.
 - 2. Systemax GigaSpeed Products.
 - 3. The Siemon Company.
- E. Description: 100-ohm, four-pair UTP covered with a thermoplastic jacket. Coordinate cable colors with Owner.
 - 1. Comply with ICEA S-90-661 for mechanical properties.
 - 2. Comply with TIA-568-C.1 for performance specifications.
 - 3. Comply with TIA-568-C.2, Category 5e.
 - 4. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444 and NFPA 70 for the following types:
 - a. Communications, Plenum Rated: Type CMP, complying with NFPA 262.
 - b. Communications, Riser Rated: Type CMR, complying with UL 1666.
- F. Color coding of cables: Match existing.

2.3 UTP CABLE HARDWARE

- A. Manufacturers: All cable, hardware, and patch cords shall be by the same Manufacturer. Subject to compliance with requirements, provide products by one of the following O.A.E.:
 - 1. Hubbell NextSpeed.
 - 2. Systemax GigaSpeed Products.
 - 3. The Siemon Company.
- B. General Requirements for Cable Connecting Hardware: Comply with TIA-568-C.2, IDC type, with modules designed for punch-down caps or tools. Cables shall be terminated with connecting hardware of same category or higher.

- C. Connecting Blocks: 110-style IDC for Category 5e. Provide blocks for the number of cables terminated on the block, plus 25 percent spare. Integral with connector bodies, including plugs and jacks where indicated.
- D. Patch Panel: Modular panels housing multiple-numbered jack units with IDC-type connectors at each jack for permanent termination of pair groups of installed cables.
 - 1. Number of Jacks per Field: One for each four-pair UTP cable indicated plus spares and blank positions adequate to suit specified expansion criteria.
- E. Jacks and Jack Assemblies: Modular, color-coded, eight-position modular receptacle units with integral IDC-type terminals.
- F. Patch Cords: Factory-made, 4-pair cables in lengths, by the same manufacturer as the horizontal cable, suitable for proper patching with 12" of slack in each cord plus or minus 3 inches; terminated with 8-position modular plug at each end.
 - 1. Patch cords shall have bend-relief-compliant boots and color-coded icons to ensure Category 5e performance. Patch cords shall have latch guards to protect against snagging.
 - 2. Patch cords shall have color-coded boots for circuit identification.

PART 3 - EXECUTION

3.1 WIRING METHODS

- A. Install cables in pathways except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Conceal pathways and cables except in unfinished spaces.
 - 1. Install plenum cable in environmental air spaces, including plenum ceilings.
 - 2. Comply with requirements for raceways and boxes specified in Division 26 Section "Raceway and Boxes for Electrical Systems."
- B. Wiring within Enclosures:
 - 1. Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii.
 - 2. Install lacing bars and distribution spools.
 - 3. Install conductors parallel with or at right angles to sides and back of enclosure.

3.2 INSTALLATION OF PATHWAYS

- A. Comply with requirements for demarcation point, pathways, cabinets, and racks specified in Division 26.
- B. Comply with TIA-569-A for pull-box sizing and length of conduit and number of bends between pull points.

- C. Comply with requirements in Division 26 Section "Raceway and Boxes for Electrical Systems" for installation of conduits and wireways.
- D. Install manufactured conduit sweeps and long-radius elbows whenever possible.
- E. Pathway Installation in Communications Equipment Rooms:
 - 1. Position conduit ends adjacent to a corner on backboard where a single piece of plywood is installed, or in the corner of room where multiple sheets of plywood are installed around perimeter walls of room.
 - 2. Secure conduits to backboard when entering room overhead.
 - 3. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.

3.3 INSTALLATION OF CABLES

- A. Comply with NECA 1.
- B. General Requirements for Cabling:
 - 1. Comply with TIA-568-C.1.
 - 2. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."
 - 3. Install 110-style IDC termination hardware unless otherwise indicated.
 - a. Do not use consolidation point as a cross-connect point, as a patch connection, or for direct connection to workstation equipment.
 - b. Locate consolidation points for UTP at least 49 feet from communications equipment room.
 - 4. Terminate conductors; Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
 - 5. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
 - 6. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
 - 7. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIM, "Cabling Termination Practices" Chapter. Install lacing bars and distribution spools.
 - 8. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
 - 9. Cold-Weather Installation: Bring cable to room temperature before de-reeling. Heat lamps shall not be used for heating.
 - 10. In the communications equipment room, install a 10-foot- long service loop on each end of cable.
 - 11. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.
- C. UTP Cable Installation:

1. Comply with TIA-568-C.2.
2. Do not untwist UTP cables more than 1/2 inch from the point of termination to maintain cable geometry.

D. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Suspend UTP cable not in a wireway or pathway a minimum of 8 inches above ceilings by cable supports not more than 60 inches apart.
3. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.

E. Group connecting hardware for cables into separate logical fields.

F. Separation from EMI Sources:

1. Comply with BICSI TDMM and TIA-569-B for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches.
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches.
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches.
3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches.
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches.
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches.
4. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: No requirement.
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches.
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches.
5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches.
6. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches.

3.4 FIRESTOPPING

- A. Comply with requirements in Section 07 "Penetration Firestopping."
- B. Comply with TIA-569-B, Annex A, "Firestopping."
- C. Comply with BICSI TDMM, "Firestopping Systems" Article.

3.5 GROUNDING

- A. Install grounding according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.
- B. Comply with TIA-607-B, the NEC, and the AHJ requirements.

3.6 IDENTIFICATION

- A. Identify system components, wiring, and cabling complying with TIA-606-A. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."
 - 1. Administration Class: 2.
 - 2. Color-code cross-connect fields. Apply colors to voice and data service backboards, connections, covers, and labels.
- B. Paint and label colors for equipment identification shall comply with TIA-606-A for Class 2 level of administration, including optional identification requirements of this standard.
- C. Cable Schedule: Post in prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.
- D. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets, backbone pathways and cables, entrance pathways and cables, terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors. Follow convention of TIA-606-A. Furnish electronic record of all drawings, in software and format selected by Owner.
- E. Cable and Wire Identification:
 - 1. Label each cable within 4 inches of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
 - 2. Each wire connected to building-mounted devices is not required to be numbered at device if color of wire is consistent with associated wire connected and numbered within panel or cabinet.
 - 3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet.
 - 4. Label each terminal strip and screw terminal in each cabinet, rack, or panel.

- a. Individually number wiring conductors connected to terminal strips and identify each cable or wiring group being extended from a panel or cabinet to a building-mounted device shall be identified with name and number of particular device as shown.
 - b. Label each unit and field within distribution racks and frames.
- 5. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.
- F. Labels shall be preprinted or computer-printed type with printing area and font color that contrasts with cable jacket color but still complies with requirements in TIA-606-A.
 - 1. Cables use flexible vinyl or polyester that flex as cables are bent.

3.7 FIELD QUALITY CONTROL

- A. Contractor shall submit test results to Owner at project completion in paper and electronic format.
- B. Perform the following tests and inspections.
 - 1. Visually inspect UTP cable jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with TIA-568-C.1.
 - 2. Visually confirm Category 5e, marking of outlets, cover plates, outlet/connectors, and patch panels.
 - 3. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
 - 4. UTP Performance Tests:
 - a. Test for each outlet and MUTOA. Perform the following tests according to TIA-568-C.1 and TIA-568-C.2:
 - 1) Wire map.
 - 2) Length (physical vs. electrical, and length requirements).
 - 3) Insertion loss.
 - 4) Near-end crosstalk (NEXT) loss.
 - 5) Power sum near-end crosstalk (PSNEXT) loss.
 - 6) Equal-level far-end crosstalk (ELFEXT).
 - 7) Power sum equal-level far-end crosstalk (PSELFEXT).
 - 8) Return loss.
 - 9) Propagation delay.
 - 10) Delay skew.
 - 5. Final Verification Tests: Perform verification tests for UTP systems after the complete communications cabling and workstation outlet/connectors are installed.

- a. Voice Tests: These tests assume that dial tone service has been installed. Connect to the network interface device at the demarcation point. Go off-hook and listen and receive a dial tone. If a test number is available, make and receive a local, long distance, and digital subscription line telephone call.
 - b. Data Tests: These tests assume the Information Technology Staff has a network installed and is available to assist with testing. Connect to the network interface device at the demarcation point. Log onto the network to ensure proper connection to the network.
- C. Document data for each measurement. Data for submittals shall be printed in a summary report that is formatted similar to Table 10.1 in BICSI TDMM, or transferred from the instrument to the computer, saved as text files, and printed and submitted.
- D. End-to-end cabling will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

3.8 DEMONSTRATION

- A. Train Owner's maintenance personnel in cable-plant management operations, including changing signal pathways for different workstations, rerouting signals in failed cables, and keeping records of cabling assignments and revisions when extending wiring to establish new workstation outlets.

END OF SECTION 271500

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. Addressable fire alarm system.
 - 2. Manual fire-alarm boxes.
 - 3. System smoke detectors.
 - 4. Heat detectors.
 - 5. Notification appliances.
 - 6. Addressable interface device.

1.3 DEFINITIONS

- A. FACP: Fire Alarm Control Panel.
- B. NICET: National Institute for Certification in Engineering Technologies.

1.4 SYSTEM DESCRIPTION

- A. Noncoded, UL-certified addressable system, with multiplexed signal transmission, dedicated to fire-alarm service only.

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 voltage drop calculations for notification-appliance circuits.
 - 4. Include battery-size calculations.

5. Include input/output matrix.
6. 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.
7. Include performance parameters and installation details for each detector.
8. Verify that each duct detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
9. 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. The Contractor shall be responsible for preparing and submitting fire alarm submittals to the authorities having jurisdiction.
2. Submittals shall be approved by authorities having jurisdiction prior to submitting them to Architect.
3. 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 IV minimum.
 - c. Licensed or certified by authorities having jurisdiction.

D. Delegated-Design Submittal: For notification appliances and smoke and heat detectors, in addition to submittals listed above, indicate compliance with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation. Device locations and quantities shown on the drawings shall be the minimum required, even though they may exceed code requirements.

1. Drawings showing the location of each notification appliance and smoke and heat detector, ratings of each, and installation details as needed to comply with listing conditions of the device.
2. Design Calculations: Calculate requirements for selecting the spacing and sensitivity of detection, complying with NFPA 72. Calculate spacing and intensities for strobe signals and sound-pressure levels for audible appliances.
3. Indicate audible appliances required to produce square wave signal per NFPA 72.

1.6 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer.
- B. Field quality-control reports.

1.7 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 Division 01 Section "Operation and Maintenance Data," include the following and deliver copies to authorities having jurisdiction:

- a. Comply with the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
- b. Provide "Fire Alarm and Emergency Communications System Record of Completion Documents" according to the "Completion Documents" Article in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
- c. Complete wiring diagrams showing connections between all devices and equipment. Each conductor shall be numbered at every junction point with indication of origination and termination points.
- d. Riser diagram.
- e. Device addresses.
- f. Record copy of site-specific software.
- g. Provide "Inspection and Testing Form" according to the "Inspection, Testing and Maintenance" chapter in NFPA 72, and include the following:
 - 1) Equipment tested.
 - 2) Frequency of testing of installed components.
 - 3) Frequency of inspection of installed components.
 - 4) Requirements and recommendations related to results of maintenance.
 - 5) Manufacturer's user training manuals.
- h. Manufacturer's required maintenance related to system warranty requirements.
- i. Abbreviated operating instructions for mounting at fire-alarm control unit and each annunciator unit.

B. Software and Firmware Operational Documentation:

- 1. Software operating and upgrade manuals.
- 2. Program Software Backup.
- 3. Device address list.
- 4. Printout of software application and graphic screens.

1.8 QUALITY ASSURANCE

- A. Installer Qualifications: Personnel shall be trained and certified by manufacturer for installation of units required for this Project.
- B. Installer Qualifications: Installation shall be by personnel certified by NICET as fire-alarm Level III technician.
- C. Source Limitations for Fire-Alarm System and Components: Obtain fire-alarm system from single source from single manufacturer.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- E. NFPA Certification: Obtain certification according to NFPA 72 by a UL-listed alarm company.

1.9 PROJECT CONDITIONS

- A. Perform a full test of the existing system in the areas of work prior to starting work. Document any equipment or components not functioning as designed.
- B. Interruption of Existing Fire-Alarm Service: Do not interrupt fire-alarm service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary guard service according to requirements indicated:
 - 1. Notify Owner no fewer than 14 days in advance of proposed interruption of fire-alarm service.
 - 2. Do not proceed with interruption of fire-alarm service without Owner's written permission.
- C. Use of Devices during Construction: Protect devices during construction unless devices are placed in service to protect the facility during construction.

1.10 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace fire-alarm system equipment and components that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Extent: All equipment and components not covered in the Maintenance Service Agreement.
 - 2. Warranty Period: Five years from date of Substantial Completion.

1.11 SEQUENCING AND SCHEDULING

- A. Existing Fire-Alarm Equipment: Maintain existing equipment fully operational until new equipment has been tested and accepted. As new equipment is installed, label it "NOT IN SERVICE" until it is accepted. Remove labels from new equipment when put into service.
- B. Equipment Removal: After acceptance of new fire-alarm system, remove existing disconnected fire-alarm equipment and wiring.

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 existing 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. In addition to existing devices, fire-alarm signal initiation shall be by one or more of the following new devices and systems:
 - 1. Manual stations.
 - 2. Heat detectors.
 - 3. Smoke detectors.
 - 4. Duct smoke detectors.
 - 5. 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 and remote annunciators.
 - 3. Transmit an alarm signal to the remote alarm receiving station.
 - 4. Unlock electric door locks in designated egress paths.
 - 5. Release fire and smoke doors held open by magnetic door holders.
 - 6. Switch heating, ventilating, and air-conditioning equipment controls to fire-alarm mode. Shut-down fans and air handling equipment serving the zone where the alarm was initiated, unless otherwise indicated.
 - 7. Close smoke dampers in air ducts of designated air-conditioning duct systems.
 - 8. Recall elevators to primary or alternate recall floors.
 - 9. Activate elevator power shunt trip.
 - 10. Activate emergency shutoffs for gas and fuel supplies.
 - 11. Record events in the system memory.
- C. Supervisory signal and system trouble initiation shall remain as is.
- D. System Supervisory Signal Actions:
 - 1. Initiate notification appliances.
 - 2. Identify specific device initiating the event at fire-alarm control unit and remote annunciators.
 - 3. Record the event on system.
 - 4. After a time delay of 200 seconds, transmit a trouble or supervisory signal to the remote alarm receiving station.

2.3 FIRE-ALARM CONTROL UNIT

- A. Existing to remain. Simplex 4100ES (Johnson Controls).

2.4 MANUAL FIRE-ALARM BOXES

- A. General Requirements for Manual Fire-Alarm Boxes: Comply with UL 38. Boxes shall be finished in red with molded, raised-letter operating instructions in contrasting color; shall show visible indication of operation; and shall be mounted on recessed outlet box. If indicated as surface mounted, provide manufacturer's surface back box.
1. 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.

2.5 SYSTEM SMOKE DETECTORS

- A. General Requirements for System Smoke Detectors:
1. Comply with UL 268; operating at 24-V dc, nominal.
 2. Detectors shall be two-wire type.
 3. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
 4. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.
 5. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
 6. Integral Visual-Indicating Light: LED type, indicating detector has operated and power-on status.
 7. Remote Control: Unless otherwise indicated, detectors shall be digital-addressable type, individually monitored at fire-alarm control unit for calibration, sensitivity, and alarm condition and individually adjustable for sensitivity by fire-alarm control unit.
 - a. Rate-of-rise temperature characteristic of combination smoke- and heat-detection units shall be selectable at fire-alarm control unit for 15 or 20 deg F per minute.
 - b. Fixed-temperature sensing characteristic of combination smoke- and heat-detection units shall be independent of rate-of-rise sensing and shall be settable at fire-alarm control unit to operate at 135 or 155 deg F.
 - c. Multiple levels of detection sensitivity for each sensor.
 - d. Sensitivity levels based on time of day.
- B. Photoelectric Smoke Detectors:
1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
 2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
 - a. Primary status.
 - b. Device type.
 - c. Present average value.
 - d. Present sensitivity selected.

- e. Sensor range (normal, dirty, etc.).

C. Ionization Smoke Detector:

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
 - a. Primary status.
 - b. Device type.
 - c. Present average value.
 - d. Present sensitivity selected.
 - e. Sensor range (normal, dirty, etc.).

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.

2.6 HEAT DETECTORS

A. General Requirements for Heat Detectors: Comply with UL 521.

B. Heat Detector, Combination Type: Actuated by either a fixed temperature of 135 deg F or a rate of rise that exceeds 15 deg F per minute unless otherwise indicated.

1. Mounting: Twist-lock base interchangeable with smoke-detector bases.
2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

C. Heat Detector, Fixed-Temperature Type: Actuated by temperature that exceeds a fixed temperature of 190 deg F.

1. Mounting: Twist-lock base interchangeable with smoke-detector bases.
2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

2.7 HEAT DETECTORS

- A. General Requirements for Heat Detectors: Comply with UL 521.
 1. Temperature sensors shall test for and communicate the sensitivity range of the device.
- B. Heat Detector, Combination Type: Actuated by either a fixed temperature of 135 or a rate of rise that exceeds 15 deg F per minute unless otherwise indicated.
 1. Mounting: Twist-lock base interchangeable with smoke-detector bases.
 2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
- C. Heat Detector, Fixed-Temperature Type: Actuated by temperature that exceeds a fixed temperature of 190 deg F.
 1. Mounting: Twist-lock base interchangeable with smoke-detector bases.
 2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

2.8 NOTIFICATION APPLIANCES

- A. General Requirements for Notification Appliances: Individually addressed, connected to a signaling-line circuit, equipped for mounting as indicated, and with screw terminals for system connections.
 1. Combination Devices: Factory-integrated audible and visible devices in a single-mounting assembly, equipped for mounting as indicated, and with screw terminals for system connections.
 2. Devices shall be white in color, if allowed by the Authority Having Jurisdiction.
- B. Audible Devices: Match existing. All audible alarm devices with temporal sound patterns shall be synchronized.
- C. Visible Notification Appliances: Xenon strobe lights complying with UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The word "FIRE" is engraved in minimum 1-inch-high letters on the lens.
 1. Rated Light Output: As necessary to comply with ADA requirements.
 - a. 15/30/75/110 cd, selectable in the field.
 2. Mounting: Wall mounted unless otherwise indicated.
 3. Flashing shall be in a temporal pattern, synchronized with other units.
 4. Strobe Leads: Factory connected to screw terminals.
 5. Mounting Faceplate: Factory finished, white, if permitted by the AHJ.

2.9 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 or 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.
3. Operate gas solenoid valve(s).

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for ventilation, temperature, humidity, and other conditions affecting performance of the Work.

1. Verify that manufacturer's written instructions for environmental conditions have been permanently established in spaces where equipment and wiring are installed, before installation begins.

B. Examine roughing-in for electrical connections to verify actual locations of connections before installation.

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

3.2 EQUIPMENT INSTALLATION

A. Comply with NFPA 72, NFPA 101, and requirements of authorities having jurisdiction for installation and testing of fire-alarm equipment. Install all electrical wiring to comply with requirements in NFPA 70 including, but not limited to, Article 760, "Fire Alarm Systems."

1. Devices placed in service before all other trades have completed cleanup shall be replaced.

2. Devices installed but not yet placed in service shall be protected from construction dust, debris, dirt, moisture, and damage according to manufacturer's written storage instructions.
- B. Connecting to Existing Equipment: Verify that existing fire-alarm system is operational before making changes or connections.
1. Connect new equipment to existing control panel in existing part of building.
 2. Expand, modify, and supplement existing control and/or monitoring equipment as necessary to extend existing control and monitoring functions to new points. New components must be capable of merging with existing configuration without degrading 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- or Heat-Detector Spacing:
1. Comply with the "Smoke-Sensing Fire Detectors" section in the "Initiating Devices" chapter in NFPA 72, for smoke-detector spacing.
 2. Comply with the "Heat-Sensing Fire Detectors" section in the "Initiating Devices" chapter in NFPA 72, for heat-detector spacing.
 3. Smooth ceiling spacing shall not exceed 30.
 4. 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.
 5. HVAC: Locate detectors not closer than 60 inches from air-supply diffuser or return-air opening.
 6. Lighting Fixtures: Locate detectors not closer than 12 inches from any part of a lighting fixture and not directly above pendant mounted or indirect lighting.
- F. Install a cover on each smoke detector that is not placed in service during construction. Cover shall remain in place except during system testing. Remove cover prior to system turnover.
- G. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of duct. Tubes more than 36 inches long shall be supported at both ends.
1. Do not install smoke detector in duct smoke-detector housing during construction. Install detector only during system testing and prior to system turnover.
- H. Remote Status and Alarm Indicators: Install in a visible location near each smoke detector, sprinkler water-flow switch, and valve-tamper switch that is not readily visible from normal viewing position.

- I. Audible Alarm-Indicating Devices: Install not less than 6 inches below the ceiling. Install 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 at least 6 inches below the ceiling. Install all devices at the same height unless otherwise indicated.
- K. Device Location-Indicating Lights and Remote Test Switches: Locate in public space near the device they monitor. Confirm final locations with the AHJ.
- L. Installation of Detectors: Detectors shall not be installed until all work of all other trades is complete, per NFPA 72.
- M. Remote Power Supplies and/or Booster Panels: Panels shall not be located in finished spaces. Provide a smoke detector at each panel location, if not already indicated on the drawings. Provide 120V circuit from nearest available spare emergency circuit, if not already indicated on drawings.
- N. System Programming: Provide all required programming at the system fire alarm control unit as necessary to accommodate the work in this project.

3.3 PATHWAYS

- A. Match existing.
- B. EMT shall be painted red enamel.

3.4 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. Alarm-initiating connection to activate emergency shutoffs for gas and fuel supplies.

3.5 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

3.6 GROUNDING

- A. Ground shielded cables at the control panel location only. Insulate shield at device location.

3.7 FIELD QUALITY CONTROL

- A. Field tests shall be witnessed by authorities having jurisdiction.
- B. 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 visible appliances for the public operating mode according to manufacturer's written instructions.
 - 5. 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.
- C. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.
- D. Fire-alarm system will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.
- F. Maintenance Test and Inspection: Perform tests and inspections listed for weekly, monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.
- G. Annual Test and Inspection: One year after date of Substantial Completion, test fire-alarm system complying with visual and testing inspection requirements in NFPA 72. Use forms developed for initial tests and inspections.
- H. Coordinate programming of system and labeling/naming of devices and locations for LCD annunciator displays with the Owner.

END OF SECTION 283111

SECTION 31 10 00 - SITE CLEARING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplemental Conditions and all Divisions of these Specifications apply to this section.

1.02 DESCRIPTION OF WORK

- A. Provide all materials, labor and equipment required for the execution of all clearing, grubbing and site preparation and related work in accordance with the Drawings, schedules, and this Specification, including, but not necessarily limited to the following:
 - 1. Soil erosion and sediment control.
 - 2. Stripping and stockpiling all available top-soil for re-use as part of Site Improvements and Planting.
 - 3. Removal of trees and/or vegetation, and protection of trees and shrubs which are shown to be retained.
 - 4. Layout for all temporary access areas and storage areas.
 - 5. General preparation of the site for excavating, filling, and backfilling.
 - 6. Removal of all excess rubbish, debris, unsuitable material, etc.
 - 7. Disposal off-site, legally.
 - 8. Stake out of all new work.
 - 9. Contractor to verify location of all utilities.

1.03 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 312000 – Earth Moving.
- B. Section 321313 – Concrete Paving.

1.04 JOB CONDITIONS

- A. Protection of Existing Improvements
 - 1. Provide protection necessary to prevent damage to existing improvements indicated to remain in place.
 - 2. Protect improvements on adjoining properties and on the Owner's property.
 - 3. Restore damaged improvements to their original condition, as acceptable to parties having jurisdiction.
- B. Protection of Existing Trees and Vegetation:
 - 1. Protect existing trees and other vegetation indicated to remain in place, against unnecessary cutting, breaking, or skinning of roots, skinning and bruising of bark, smothering of trees by stockpiling construction materials or excavated materials within 4-feet of drip line, excess foot or vehicular traffic, or parking of vehicle within 4-feet of drip line. Provide temporary snow fencing or armoring to protect

trees and vegetation to be left standing during construction operations. Such protection shall be placed before any excavation or grading is begun and shall be maintained and remain until the landscape planting work is started and then removed.

- a. Existing trees and groups of shrubs in the construction area shall be fenced around their outer perimeter (drip line of the trees) in the following manner: Fences shall be standard 48-inches high snow fence mounted on standard steel posts not greater than 6-feet apart.
 - b. Existing individual trees near heavy construction traffic shall be armored in the following manner: Trunks shall be wrapped with burlap and 2-inches by 4-inches planks wired vertically as armor around trunks and spaced no greater than 2-inches apart to 5-feet above ground.
 - c. All other trees in groups, near construction traffic, on the property to be preserved shall be protected by fencing in the following manner: Fences shall have posts equivalent to 4-inches by 4-inches set 3-feet in the ground and 5-feet above the ground, not over 8-feet on center. Provide two walers equivalent to 2-inches by 6-inches and vertical 1-inch by 6-inches boards not over 1.5-feet apart or plywood fencing.
2. Water trees and other vegetation to remain within the limits of the contract work as required to maintain their health during the course of construction operations.
 3. Provide protection for roots over 1.5-inches diameter cut during construction operations. Coat the cut faces with emulsified asphalt, or other coating, formulated for use on damaged plant tissues. Temporarily cover exposed roots with wet burlap to prevent roots from drying out, cover with earth as soon as possible.
 4. Repair or replace trees and vegetation damaged by construction operations. Repairing of damage to tree crowns or root systems shall be performed by a qualified Landscape Architect.
 5. Replace trees which cannot be repaired and restored to full growth status.
- C. Soil erosion and sediment control shall include the furnishing of all materials, labor, and equipment necessary for implementing proper measures to reasonably control soil erosion from construction operations and prevent excessive flow of sediment from the construction site. Such work may include the installation of water diversion structures, diversion ditches and sediment basins, silt fence, inlet filters, seeding and mulching and sodding critical areas to provide temporary protection. All work shall be performed in accordance with the approved soil erosion plan and details.
- D. Protection of water migration into construction pad and excavations.

1.05 QUALITY ASSURANCE

- A. Materials shall conform to the requirements of appropriate articles of "Standard for Soil Erosion and Sediment Control" as revised and adopted 2017, and the Standard Specification for Road and Bridge Construction of the Pennsylvania Department of Transportation, 2019, as added to and amended. Such standard specifications are made part of the specifications by this reference and will not be repeated herein. In case of conflict between the above-mentioned requirements, the standard requiring the higher in terms of quality of materials and workmanship shall prevail.

PART 2 - EXECUTION

2.01 SOIL EROSION AND SEDIMENT CONTROL

- A. All soil erosion and sediment control practices on this project shall be constructed in accordance with the "Standards for Soil Erosion and Sediment Control", or as approved for this project. The smallest practicable area of land shall be exposed at any one time during the project and wherever feasible, natural vegetation shall be retained and protected. Stripping of vegetation, grading or other soil disturbance shall be done in a manner which will minimize soil erosion.
- B. A schedule of construction operations shall be submitted to the Engineer for his approval. A 72-hour notice shall be given to the Engineer prior to the start of construction or grading. This notice can be verbal but must be followed by a written statement not less than 48-hours prior to start-up.
- C. All soil erosion and sediment control devices shall be in place prior to any major soil disturbance or installed and removed in their proper sequence to allow for further operations on the site. All sediment control structures shall be checked and maintained on a regular basis and all basins shall be cleaned periodically when storage capacity is affected by siltation. During construction, any additional control measures as deemed necessary to prevent erosion or control sediment beyond those measures shown on the approved plans shall be installed or employed at the direction of the Engineer. After completion of construction, soil and sediment controls shall be left in place until all disturbed areas are stabilized.
- D. Disturbed areas including roadway embankments shall be maintained in a rough graded condition and temporarily seeded and/or mulched until proper weather conditions exist for the establishment of permanent vegetative cover. All areas disturbed by grading on which permanent or semi-permanent seeding or temporary seeding have not been made, and all slopes with a grade steeper than 2:1, shall be treated by mulching. The mulch shall be applied at a rate of 2-tons per acre or equivalent measure, according to State standards. All areas disturbed by grading including soil stockpiles, which will not be used or constructed upon a period greater than 30-days shall be temporarily seeded and protected as required. All areas disturbed by grading which will not be constructed upon with 6-months are to be stabilized with a permanent type seeding and fertilizing. All disturbed areas shall be topsoiled, limed, and fertilized prior to both temporary and permanent seeding in conformance with charts and tables as set forth in the "Standards for Soil Erosion and Sediment Control".
- E. Access and haul roads shall be protected with stone access strips and coarse stone filters in appropriate locations.
- F. Fording of streams shall be kept to a minimum and where frequent crossings are contemplated; temporary bridges or culverts shall be constructed.
- G. Storm drainage inlets are to be either capped or protected by temporary filter devices to prevent the entry of sediment carried by runoff water until vegetation and/or paving is established as planned.
- H. Wherever well points, pumps or other dewatering methods are used, care shall be taken to provide for the elimination of said dewatering.

- I. All drainage swales shall be parabolic in shape unless otherwise noted and shall conform to SCS design and standards. Drainage swales and other structures shall be located in the field so as to retain as much of the original vegetation as possible, especially large trees.
- J. Roadways shall be swept at the end of each working day by the Contractor. When deemed necessary by the Engineer, the Contractor shall have the roadways swept by a mechanical sweeper. Same shall be provided at no additional cost to the owner.
- K. Washdown shall be provided.

CLEARING AND GRUBBING

- A. Cut down and cut up all trees, shrubs, brush, rubbish, and debris projecting above ground in the site limit area except those indicated to remain. Grub or root out all stumps, roots, matted roots, and underground grass or weeds, and similar refuse underground not suitable for compaction to a depth of 18-inches below subgrade.
- B. Use only hand methods for grubbing inside the drip line of trees indicated to be left standing.
- C. Fill and compact depressions caused by clearing and grubbing operations with satisfactory soil material unless further excavation or earthwork is indicated.
- D. Place fill material in horizontal layers not exceeding 8-inches loose depth, and thoroughly compact to a density equal to adjacent original ground, or as otherwise required.

3.02 STRIPPING TOPSOIL

- A. Prior to stripping of onsite topsoil for stockpiling, the topsoil shall be tested, and an estimate of the onsite volume determined. The quantity of additional topsoil as required for the project shall be determined by the Landscape Contractor and submitted to the Landscape Architect for approval.
- B. Remove topsoil to its full depth. Screen material removed to be free of clay, debris, or other foreign matter. Stockpile as noted on site plans ready for re-use as required for seeding and planting. Determine amount of topsoil so required and remove all excess topsoil from the site; and dispose of in a legal manner or as requested by Owner. Construct stockpiles to freely drain surface water. Cover stockpiles, if required, to prevent windblown dust. Protect topsoil from erosion. Submit estimated amount of topsoil to be stockpiled to the Landscape Architect.

3.03 DISPOSAL OF EXCESS MATERIAL

- A. Remove all excess cleared material from the building site. Break-up concrete and pavement debris and otherwise process material to sizes suitable for landfill as directed. Under local regulations absolutely no burning of material will be allowed on the site. Obtain all required permits and authorizations for transportation/disposal of excess material.
- B. Excess material shall be disposed of in accordance with Subsections 201.03 and 202.03 of the PennDOT 2019 Standard Specifications for Road and Bridge Construction.

END OF SECTION 31 10 00

SECTION 31 13 00 - TREE PROTECTION

PART 1 GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMAR

- A. This Section includes the protection and trimming of existing trees that interfere with, or are affected by, execution of the Work, whether temporary or permanent construction.
- B. Related Sections include the following:
 - 1. Division 1 Section "Summary" for limits placed on Contractor's use of the site.
 - 2. Division 1 Section "Temporary Facilities and Controls" for temporary tree protection.
 - 3. Division 31 Section "Site Clearing" for removal limits of trees, shrubs, and other plantings affected by new construction.
 - 4. Division 31 Section "Earthwork" for building and utility trench excavation, backfilling, compacting, and grading requirements, and soil materials.

1.03 DEFINITIONS

- A. Tree Protection Zone: Area surrounding individual trees or groups of trees to remain during construction and defined by the drip line of individual trees or the perimeter drip line of groups of trees, unless otherwise indicated.

1.04 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Tree Pruning Schedule: Written schedule from arborist detailing scope and extent of pruning of trees to remain that interfere with or are affected by construction.
- C. Qualification Data: For tree service firm and arborist.
- D. Certification: From arborist, certifying that trees indicated to remain have been protected during construction according to recognized standards and that trees were promptly and properly treated and repaired when damaged.
- E. Maintenance Recommendations: From arborist, for care and protection of trees affected by construction during and after completing the Work.

1.05 QUALITY ASSURANCE

- A. Tree Service Firm Qualifications: An experienced tree service firm that has successfully completed tree protection and trimming work similar to that required for this Project and that will assign an experienced, qualified arborist to Project site during execution of tree protection and trimming.
- B. Arborist Qualifications: An arborist certified by ISA or licensed in the jurisdiction where Project is located.
- C. Tree Pruning Standard: Comply with ANSI A300 (Part 1), "Tree, Shrub, and Other Woody Plant Maintenance-Standard Practices (Pruning)."
- D. Preinstallation Conference: Conduct conference at Project site to comply with requirements in Division 1 Section "Project Management and Coordination."
 - 1. Before tree protection and trimming operations begin, meet with representatives of authorities having jurisdiction, Owner, Architect, consultants, and other concerned entities to review tree protection and trimming procedures and responsibilities.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Drainage Fill: Selected crushed stone, or crushed or uncrushed gravel, washed, ASTM D 448, Size 24, with 90% to 100% passing a 2.5-inch sieve and not more than 10% passing a 3/4-inch sieve.
- B. Topsoil: Natural or cultivated surface-soil layer containing organic matter and sand, silt, and clay particles; friable, pervious, and black or a darker shade of brown, gray, or red than underlying subsoil; reasonably free of subsoil, clay lumps, gravel, and other objects more than 1-inch (25mm) in diameter; and free of weeds, roots, and toxic and other non-soil materials.
 - 1. Obtain topsoil only from well-drained sites where topsoil is 4-inches (100mm) deep or more; do not obtain from bogs or marshes.
- C. Filter Fabric: Manufacturer's standard, nonwoven, pervious, geotextile fabric of polypropylene, nylon, or polyester fibers.
- D. Chain-Link Fence: Metallic-coated steel chain-link fence fabric of 0.120-inch (3mm) diameter wire; a minimum of 48-inches (1200mm) high; with 1.9-inch (48mm) diameter line posts; 2-3/8-inch (60mm) diameter terminal and corner posts; 1-5/8-inch (41mm) diameter top rail; and 0.177-inch (4.5mm) diameter bottom tension wire; with tie wires, hog ring ties, and other accessories for a complete fence system.
- E. Organic Mulch: Shredded hardwood, free of deleterious materials.

PART 3 EXECUTION

3.01 PREPARATION

- A. Temporary Fencing: Install temporary fencing around tree protection zones to protect remaining trees and vegetation from construction damage. Maintain temporary fence and remove when construction is complete.

1. Install chain-link fence according to ASTM F 567 and manufacturer's written instructions.
- B. Protect tree root systems from damage caused by runoff or spillage of noxious materials while mixing, placing, or storing construction materials. Protect root systems from ponding, eroding, or excessive wetting caused by dewatering operations.
- C. Mulch areas inside tree protection zones and other areas indicated.
 1. Apply 3-inch (75mm) average thickness of organic mulch. Do not place mulch within 6-inches (150mm) of tree trunks.
- D. Do not store construction materials, debris, or excavated material inside tree protection zones. Do not permit vehicles or foot traffic within tree protection zones; prevent soil compaction over root systems.
- E. Maintain tree protection zones free of weeds and trash.
- F. Do not allow fires within tree protection zones.

3.02 EXCAVATION

- A. Install shoring or other protective support systems to minimize sloping or benching of excavations.
- B. Do not excavate within tree protection zones, unless otherwise indicated.
- C. Where excavation for new construction is required within tree protection zones, hand clear and excavate to minimize damage to root systems. Use narrow-tine spading forks and comb soil to expose roots.
 1. Redirect roots in backfill areas where possible. If encountering large, main lateral roots, expose roots beyond excavation limits as required to bend and redirect them without breaking. If encountered immediately adjacent to location of new construction and redirection is not practical, cut roots approximately 3-inches (75mm) back from new construction.
 2. Do not allow exposed roots to dry out before placing permanent backfill. Provide temporary earth cover or pack with peat moss and wrap with burlap. Water and maintain in a moist condition. Temporarily support and protect roots from damage until they are permanently relocated and covered with soil.
- D. Where utility trenches are required within tree protection zones, tunnel under or around roots by drilling, auger boring, pipe jacking, or digging by hand.
 1. Root Pruning: Do not cut main lateral roots or taproots; cut only smaller roots that interfere with installation of utilities. Cut roots with sharp pruning instruments; do not break or chop.

3.03 REGRADING

- A. Grade Lowering: Where new finish grade is indicated below existing grade around trees, slope grade beyond tree protection zones. Maintain existing grades within tree protection zones.
- B. Grade Lowering: Where new finish grade is indicated below existing grade around trees, slope grade away from trees as recommended by arborist, unless otherwise indicated.
 1. Root Pruning: Prune tree roots exposed during grade lowering. Do not cut main lateral roots or taproots; cut only smaller roots. Cut roots with sharp pruning

instruments; do not break or chop.

- C. Minor Fill: Where existing grade is 6-inches (150mm) or less below elevation of finish grade, fill with topsoil. Place topsoil in a single uncompacted layer and hand grade to required finish elevations.
- D. Moderate Fill: Where existing grade is more than 6-inches (150mm) but less than 12-inches (300mm) below elevation of finish grade, place drainage fill, filter fabric, and topsoil on existing grade as follows:
 - 1. Carefully place drainage fill against tree trunk approximately 2-inches (50mm) above elevation of finish grade and extend not less than 18-inches (450mm) from tree trunk on all sides. For balance of area within drip-line perimeter, place drainage fill up to 6-inches (150mm) below elevation of grade.
 - 2. Place filter fabric with edges overlapping 6-inches (150mm) minimum.
 - 3. Place fill layer of topsoil to finish grade. Do not compact drainage fill or topsoil. Hand grade to required finish elevations.

3.04 TREE PRUNING

- A. Prune trees to remain that are affected by temporary and permanent construction.
- B. Prune trees to remain to compensate for root loss caused by damaging or cutting root system. Provide subsequent maintenance during Contract period as recommended by arborist.
- C. Pruning Standards: Prune trees according to ANSI A300 (Part 1) as follows:
 - 1. Type of Pruning: Cleaning.
 - 2. Specialty Pruning: Restoration.
- D. Cut branches with sharp pruning instruments; do not break or chop.
- E. Chip removed tree branches and dispose of off-site.

3.05 TREE REPAIR AND REPLACEMENT

- A. Promptly repair trees damaged by construction operations within 24-hours. Treat damaged trunks, limbs, and roots according to arborist's written instructions.
- B. Remove and replace trees indicated to remain that die or are damaged during construction operations that Architect determines are incapable of restoring to normal growth pattern.
 - 1. Provide new trees of same size and species as those being replaced; plant and maintain as specified in Division 2 Section "Exterior Plants."
 - 2. Provide new trees of 6-inch (150mm) caliper size and of a species selected by Architect when damaged trees more than 6-inches (150mm) in caliper size, measured 12-inches (300mm) above grade, are required to be replaced. Plant and maintain new trees as specified in Division 2 Section "Exterior Plants."
- C. Aerate surface soil, compacted during construction, 10-feet (3m) beyond drip line and no closer than 36-inches (900mm) to tree trunk. Drill 2-inch (50mm) diameter holes a minimum of 12-inches (300mm) deep at 24-inches (600mm) on center. Backfill holes with an equal mix of augered soil and sand.

3.06 DISPOSAL OF WASTE MATERIALS

- A. Burning is not permitted.
- B. Disposal: Remove excess excavated material and displaced trees from Owner's property.

END OF SECTION 31 13 00

SECTION 31 20 00 - EARTH MOVING

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. Excavating and filling for rough grading the Site.
 - 2. Preparing subgrades for slabs-on-grade, walks, pavements, turf and grasses, and plants.
 - 3. Excavating and backfilling for buildings and structures.
 - 4. Drainage course for concrete slabs-on-grade.
 - 5. Subbase course for concrete walks.
 - 6. Subbase course and base course for asphalt paving.
 - 7. Subsurface drainage backfill for walls and trenches.
 - 8. Excavating and backfilling trenches for utilities and pits for buried utility structures.
- B. Related Requirements:
 - 1. Section 013200 "Construction Progress Documentation" and Section 013233 "Photographic Documentation" for recording pre-excavation and earth-moving progress
 - 2. Section 033000 "Cast-in-Place Concrete" for granular course if placed over vapor retarder and beneath the slab-on-grade
 - 3. Section 311000 "Site Clearing" for site stripping, grubbing, stripping and stockpiling topsoil, and removal of above- and below-grade improvements and utilities.
 - 4. Section 329200 "Turf and Grasses" for finish grading in turf and grass areas, including preparing and placing planting soil for turf areas.

1.03 DEFINITIONS

- A. Backfill: Soil material or controlled low-strength material used to fill an excavation.
 - 1. Initial Backfill: Backfill placed beside and over pipe in a trench, including haunches to support sides of pipe.
 - 2. Final Backfill: Backfill placed over initial backfill to fill a trench.
- B. Base Course: Aggregate layer placed between the subbase course and hot-mix asphalt paving.
- C. Bedding Course: Aggregate layer placed over the excavated subgrade in a trench before laying pipe.
- D. Borrow Soil: Suitable soil imported from off-site for use as fill or backfill.

- E. Drainage Course: Aggregate layer supporting the slab-on-grade that also minimizes upward capillary flow of pore water.
- F. Excavation: Removal of material encountered above subgrade elevations and to lines and dimensions indicated.
 - 1. Authorized Additional Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions as directed by Engineer.
 - 2. Bulk Excavation: Excavation more than 10-feet in width and more than 30-feet in length.
 - 3. Unauthorized Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions without direction by Engineer. Unauthorized excavation, as well as remedial work directed by Engineer, shall be without additional compensation.
 - 4. Unclassified Excavation: Excavation and management of material of whatever nature encountered, except hazardous material.
- G. Fill: Soil materials used to raise existing grades.
- H. 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.
- I. 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
- J. Subgrade: Uppermost surface of an excavation or the top surface of a fill or backfill immediately below subbase, drainage fill, drainage course, or topsoil materials
- K. Utilities: On-site underground pipes, conduits, ducts, and cables as well as underground services within buildings

1.04 PREINSTALLATION MEETINGS

- A. Pre-installation Conference: Conduct pre-excavation conference at Project site.
 - 1. Review methods and procedures related to earthmoving, including, but not limited to, the following:
 - a. Personnel and equipment needed to make progress and avoid delays.
 - b. Coordination of Work with utility locator service.
 - c. Coordination of Work and equipment movement with the locations of tree- and plant-protection zones.
 - d. Extent of trenching by hand or with air spade.
 - e. Field quality control.
 - 1) ACTION SUBMITTALS
- B. Product Data: For each type of the following manufactured products required
 - 1. Geotextiles
 - 2. Controlled low-strength material, including design mixture
 - 3. Geofoam
 - 4. Warning tapes
- C. Samples for Verification: For the following products, in sizes indicated below:
 - 1. Geotextile: 12-inches by 12-inches
 - 2. Warning Tape: 12-inches long; of each color

1.05 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified testing agency
- B. Material Test Reports: For each borrow soil material proposed for fill and backfill as follows:
 - 1. Classification according to ASTM D 2487
 - 2. Laboratory compaction curve according to ASTM D 698 or ASTM D 1557
- C. Pre-excavation Photographs or Videotape: Show existing conditions of adjoining construction and site improvements, including finish surfaces that might be misconstrued as damage caused by earth-moving operations. Submit before earth moving begins.

1.06 QUALITY ASSURANCE

- A. Blasting: Not permitted
- B. Geotechnical Testing Agency Qualifications: Qualified according to ASTM E 329 and ASTM D 3740 for testing indicated.

1.07 FIELD CONDITIONS

- A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during earth-moving operations.
 - 1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction.
 - 2. Provide alternate routes around closed or obstructed traffic ways if required by Owner or authorities having jurisdiction.
- B. Improvements on Adjoining Property: Authority for performing earth moving indicated on property adjoining Owner's property will be obtained by Owner before award of Contract.
 - 1. Do not proceed with work on adjoining property until directed by Engineer.
- C. Utility Locator Service: Notify "One Call" for area where Project is located before beginning earth-moving operations.
- D. Do not commence earth-moving operations until temporary site fencing and erosion- and sedimentation-control measures specified in Section 311000 "Site Clearing" are in place.
- E. The following practices are prohibited within protection zones:
 - 1. Storage of construction materials, debris, or excavated material.
 - 2. Parking vehicles or equipment.
 - 3. Foot traffic
 - 4. Erection of sheds or structures
 - 5. Impoundment of water
 - 6. Excavation or other digging unless otherwise indicated
 - 7. Attachment of signs to or wrapping materials around trees or plants unless otherwise indicated.
- F. Do not direct vehicle or equipment exhaust towards protection zones.

- G. Prohibit heat sources, flames, ignition sources, and smoking within or near protection zones.

PART 2 PRODUCTS

2.01 SOIL MATERIALS

- A. General: Provide borrow soil materials when sufficient suitable soil materials are not available from excavations.
- B. Suitable Soils: Soil Classification Groups GW, GP, GM, SW, SP, and SM according to ASTM D 2487, or a combination of these groups; free of rock or gravel larger than 3-inches in any dimension, debris, waste, frozen materials, vegetation, and other deleterious matter, or as determined by the Engineer.
- C. Unsuitable Soils: Soil Classification Groups GC, SC, CL, ML, OL, CH, MH, OH, and PT according to ASTM D 2487, a combination of these groups, or as determined by the Engineer.
 - 1. Unsuitable soils also include suitable soils not maintained within 2% of optimum moisture content at time of compaction.
- D. Subbase Material: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940/D 2940M; with at least 90% passing a 1.5-inch sieve and not more than 12% passing a No. 200 sieve.
- E. Base Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 294/D 2940M 0; with at least 95% passing a 1.5-inch sieve and not more than 8% passing a No. 200 sieve.
- F. Engineered Fill: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940/D 2940M; with at least 90% passing a 1.5-inch sieve and not more than 12% passing a No. 200 sieve, or as provided for in associated Geotechnical Reports
- G. Bedding Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940/D 2940M; except with 100% passing a 1-inch sieve and not more than 8% passing a No. 200 sieve.
- H. Drainage Course: Narrowly graded mixture of washed crushed stone, or crushed or uncrushed gravel; ASTM D 448; coarse-aggregate grading Size 57; with 100% passing a 1.5-inch sieve and 0% to 5% passing a No. 8 sieve. Drainage course shall be utilized for suitable structural backfill where directed by the Geotechnical Report or ordered by the Engineer, or for the suitable backfill of areas of unclassified or unsuitable material which has been excavated, if and where ordered by the Engineer.
- I. Filter Material: Narrowly graded mixture of natural or crushed gravel, or crushed stone and natural sand; ASTM D 448; coarse-aggregate grading Size 67; with 100% passing a 1-inch sieve and 0% to 5% passing a No. 4 sieve.
- J. Sand: ASTM C 33/C 33M; fine aggregate.
- K. Impervious Fill: Clayey gravel and sand mixture capable of compacting to a dense state.

2.02 GEOTEXTILES

- A. Subsurface Drainage Geotextile: Nonwoven needle-punched geotextile, manufactured for subsurface drainage applications, made from polyolefins or polyesters; with elongation greater than 50%; complying with AASHTO M 288 and the following, measured per test methods referenced:
 - 1. Survivability: Class 2; AASHTO M 288
 - 2. Survivability: As follows:
 - a. Grab Tensile Strength: 157-lb/f; ASTM D 4632
 - b. Sewn Seam Strength: 142-lb/f; ASTM D 4632
 - c. Tear Strength: 56-lb/f; ASTM D 4533
 - d. Puncture Strength: 56-lb/f; ASTM D 4833
 - 3. Apparent Opening Size: No. 40, No. 60, or No. 70 sieve, maximum to be determined by the Engineer; ASTM D 4751.
 - 4. Permittivity: 0.5, 0.2, or 0.1 per second, minimum to be determined by the Engineer; ASTM D 4491.
 - 5. UV Stability: 50% after 500-hours exposure; ASTM D 4355.
- B. Separation Geotextile: Woven geotextile fabric, manufactured for separation applications, made from polyolefins or polyesters; with elongation less than 50%; complying with AASHTO M 288 and the following, measured per test methods referenced:
 - 1. Survivability: Class 2; AASHTO M 288
 - 2. Survivability as follows:
 - a. Grab Tensile Strength: 247 lbf; ASTM D 4632
 - b. Sewn Seam Strength: 222 lbf; ASTM D 4632
 - c. Tear Strength: 90-lb/f ; ASTM D 4533
 - d. Puncture Strength: 90-lb/f; ASTM D 4833
 - 3. Apparent Opening Size: No. 60 sieve, maximum; ASTM D 4751
 - 4. Permittivity: 0.02 per second, minimum; ASTM D 4491
 - 5. UV Stability: 50% after 500-hours exposure; ASTM D 4355

2.03 CONTROLLED LOW-STRENGTH MATERIAL

- A. Controlled Low-Strength Material: Self-compacting, low-density, flowable concrete material produced from the following:
 - 1. Portland Cement: ASTM C 150/C 150M, Type I, Type II, or Type III as determined by the Engineer
 - 2. Fly Ash: ASTM C 618, Class C or F
 - 3. Normal-Weight Aggregate: ASTM C 33/C 33M, nominal maximum aggregate size to be determined by the Engineer
 - 4. Foaming Agent: ASTM C 869/C 869M
 - 5. Water: ASTM C 94/C 94M
 - 6. Air-Entraining Admixture: ASTM C 260/C 260M
- B. Produce low-density, controlled low-strength material with the following physical properties:
 - 1. As-Cast Unit Weight: 36- to 42-lb/cu.ft at point of placement, when tested according to ASTM C 138/C 138M
 - 2. Compressive Strength: 140-psi (965kPa) when tested according to ASTM C 495/C 495M

- C. Produce conventional-weight, controlled low-strength material with compressive strength to be determined by the Engineer when tested according to ASTM C 495/C 495M

2.04 ACCESSORIES

- A. Warning Tape: Acid- and alkali-resistant, polyethylene film warning tape manufactured for marking and identifying underground utilities, 6-inches wide and 4-mils thick, continuously inscribed with a description of the utility; colored as follows:
 - 1. Red: Electric
 - 2. Yellow: Gas, oil, steam, and dangerous materials
 - 3. Orange: Telephone and other communications
 - 4. Blue: Water systems
 - 5. Green: Sewer systems
- B. Detectable Warning Tape: Acid- and alkali-resistant, polyethylene 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 the 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 as follows:
 - 1. Red: Electric
 - 2. Yellow: Gas, oil, steam, and dangerous materials
 - 3. Orange: Telephone and other communications
 - 4. Blue: Water systems
 - 5. Green: Sewer systems

PART 3 EXECUTION

3.01 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earth-moving operations.
- B. Protect and maintain erosion and sedimentation controls during earth-moving operations.
- C. Protect subgrades and foundation soils from freezing temperatures and frost. Remove temporary protection before placing subsequent materials.

3.02 DEWATERING

- A. Provide dewatering system of sufficient scope, size, and capacity to control hydrostatic pressures and to lower, control, remove, and dispose of ground water and permit excavation and construction to proceed on dry, stable subgrades.
- B. Prevent surface water and ground water from entering excavations, from ponding on prepared subgrades, and from flooding Project site and surrounding area.
- C. Protect subgrades from softening, undermining, washout, and damage by rain or water accumulation.

1. Reroute surface water runoff away from excavated areas. Do not allow water to accumulate in excavations. Do not use excavated trenches as temporary drainage ditches.
- D. Dispose of water removed by dewatering in a manner that avoids endangering public health, property, and portions of work under construction or completed. Dispose of water and sediment in a manner that avoids inconvenience to others.

3.03 EXPLOSIVES

- A. Explosives: Do not use explosives.

3.04 EXCAVATION, GENERAL

- A. Unclassified Excavation: Excavate to subgrade elevations regardless of the character of surface and subsurface conditions encountered. Unclassified excavated materials may include, but is not limited to, rock, soil materials, debris, and obstructions. The Contractor shall immediately notify the Engineer if and where unclassified material is encountered. Additional measurement and payment shall not be made for the excavation, unclassified, of asphalt or concrete surfaces present on site.
 1. If excavated materials intended for fill and backfill include unsuitable soil materials and rock, replace with suitable soil materials.
 2. Remove rock to lines and grades indicated to permit installation of permanent construction without exceeding the following dimensions unless otherwise specific in project reports or in details:
 - a. 24-inches outside of concrete forms other than at footings.
 - b. 12-inches outside of concrete forms at footings.
 - c. 6-inches outside of minimum required dimensions of concrete cast against grade.
 - d. Outside dimensions of concrete walls indicated to be cast against rock without forms or exterior waterproofing treatments
 - e. 6 inches beneath bottom of concrete slabs-on-grade.
 - f. 6 inches beneath pipe in trenches and the greater of 24-inches wider than pipe or 42-inches wide.

3.05 EXCAVATION FOR STRUCTURES

- A. Excavate to indicated elevations and dimensions within a tolerance of plus or minus 1-inch. If applicable, extend excavations a sufficient distance from structures for placing and removing concrete formwork, for installing services and other construction, and for inspections.
 1. Excavations for Footings and Foundations: Do not disturb bottom of excavation. Excavate by hand to final grade just before placing concrete reinforcement. Trim bottoms to required lines and grades to leave solid base to receive other work.
 2. Pile Foundations: Stop excavations 6- to 12-inches above bottom of pile cap before piles are placed. After piles have been driven, remove loose and displaced material. Excavate to final grade, leaving solid base to receive concrete pile caps.
 3. Excavation for Underground Tanks, Basins, and Mechanical or Electrical Utility Structures: Excavate to elevations and dimensions indicated within a tolerance of plus or minus 1-inch. Do not disturb bottom of excavations intended as bearing

surfaces.

3.06 EXCAVATION FOR WALKS AND PAVEMENTS

- A. Excavate surfaces under walks and pavements to indicated lines, cross sections, elevations, and subgrades.

3.07 EXCAVATION FOR UTILITY TRENCHES

- A. Excavate trenches to indicated gradients, lines, depths, and elevations.
 - 1. Beyond building perimeter, excavate trenches to allow installation of top of pipe below frost line.
- B. Excavate trenches to uniform widths to provide the following clearance on each side of pipe or conduit. Excavate trench walls vertically from trench bottom to 12-inches higher than top of pipe or conduit unless otherwise indicated.
 - 1. Clearance: 12inches each side of pipe or conduit or as indicated on Contract Drawings.
- C. Trench Bottoms: Excavate and shape trench bottoms to provide uniform bearing and support of pipes and conduit. Shape subgrade to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits. Remove projecting stones and sharp objects along trench subgrade.
 - 1. For pipes and conduit less than 6-inches in nominal diameter, hand-excavate trench bottoms and support pipe and conduit on an undisturbed subgrade.
 - 2. For pipes and conduit 6-inches or larger in nominal diameter, shape bottom of trench to support bottom 90° of pipe or conduit circumference. Fill depressions with tamped sand backfill.
 - 3. For flat-bottomed, multiple-duct conduit units, hand-excavate trench bottoms and support conduit on an undisturbed subgrade.
 - 4. Excavate trenches 6-inches deeper than elevation required in rock or other unyielding bearing material to allow for bedding course.
- D. Trench Bottoms: Excavate trenches 6-inches deeper than bottom of pipe and conduit elevations to allow for bedding course. Hand-excavate deeper for bells of pipe.
 - 1. Excavate trenches 6-inches deeper than elevation required in rock or other unyielding bearing material to allow for bedding course.

3.08 SUBGRADE INSPECTION

- A. Notify Engineer when excavations have reached required subgrade.
- B. If Engineer determines that unsuitable soil is present, continue excavation and replace with compacted backfill or fill material as directed.
- C. Proof-roll subgrade below the building slabs and pavements with a pneumatic-tired and loaded 10-wheel, tandem-axle dump truck weighing not less than 15-tons to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.
 - 1. Completely proof-roll subgrade in one direction, repeating proof-rolling in direction perpendicular to first direction. Limit vehicle speed to 3-mph.
 - 2. Excavate soft spots, unsuitable soils, and areas of excessive pumping or rutting, as determined by Engineer, and replace with compacted backfill or fill as directed.

- D. Authorized additional excavation and replacement material will be paid for according to Contract provisions for unit prices changes in the Work, if included.
- E. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities, as directed by Engineer, without additional compensation.

3.09 UNAUTHORIZED EXCAVATION

- A. Fill unauthorized excavation under foundations or wall footings by extending bottom elevation of concrete foundation or footing to excavation bottom, without altering top elevation. Lean concrete fill, with 28-day compressive strength of 2500-psi, may be used when approved by Engineer.
 - 1. Fill unauthorized excavations under other construction, pipe, or conduit as directed by Engineer.

3.10 STORAGE OF SOIL MATERIALS

- A. Stockpile borrow soil materials and excavated suitable soil materials without intermixing. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust.
 - 1. Stockpile soil materials away from edge of excavations. Do not store within drip line of remaining trees.
- B. Stockpile and secure petroleum impacted soil, if encountered, during excavation and earthwork on site in a location directed by the Owner. Place material on and cover with 10-mill polyethylene sheeting. Secure covers at all times. Overlap joints a minimum of 12-inches. Maintain the cover, and replace damaged polyethylene sheeting as needed. Do not reuse petroleum impacted material. Sampling and analysis shall be performed by the Owner.

3.11 BACKFILL

- A. Place and compact backfill in excavations promptly, but not before completing the following:
 - 1. Construction below finish grade including, where applicable, subdrainage, damp proofing, waterproofing, and perimeter insulation.
 - 2. Surveying locations of underground utilities for Record Documents.
 - 3. Testing and inspecting underground utilities.
 - 4. Removing concrete formwork.
 - 5. Removing trash and debris.
 - 6. Removing temporary shoring, bracing, and sheeting.
 - 7. Installing permanent or temporary horizontal bracing on horizontally supported walls.
- B. Place backfill on subgrades free of mud, frost, snow, or ice.

3.12 UTILITY TRENCH BACKFILL

- A. Place backfill on subgrades free of mud, frost, snow, or ice.

- B. Place and compact bedding course on trench bottoms and where indicated. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits.
- C. Trenches under Footings: Backfill trenches excavated under footings and within 18-inches or as provided for in Geotechnical Report, of bottom of footings with suitable soil; fill with concrete to elevation of bottom of footings. Concrete is specified in Section 033000 "Cast-in-Place Concrete.
- D. Trenches under Roadways: Per Contract Drawings.
- E. Backfill voids with suitable soil while removing shoring and bracing.
- F. Initial Backfill
 - 1. Soil Backfill: Place and compact initial backfill of suitable soil, free of particles larger than 1-inch in any dimension, to a height of 12-inches over the pipe or conduit.
 - a. Carefully compact initial backfill under pipe haunches and compact evenly up on both sides and along the full length of piping or conduit to avoid damage or displacement of piping or conduit. Coordinate backfilling with utilities testing.
 - 2. Controlled Low-Strength Material: Place initial backfill of controlled low-strength material to a height of 12-inches) over the pipe or conduit. Coordinate backfilling with utilities testing.
- G. Final Backfill:
 - 1. Soil Backfill: Place and compact final backfill of suitable soil to final subgrade elevation.
 - 2. Controlled Low-Strength Material: Place final backfill of controlled low-strength material to final subgrade elevation.
- H. Warning Tape: Install warning tape directly above utilities, 12-inches below finished grade, except 6-inches below subgrade under pavements and slabs.

3.13 SOIL FILL

- A. Contractor shall deliver clean suitable fill material to the project site, if required to meet lines and grades on the Contract Drawings.
- B. Plow, scarify, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so fill material will bond with existing material.
- C. Place and compact fill material in layers to required elevations as follows:
 - 1. Under grass and planted areas, use suitable soil material.
 - 2. Under walks and pavements, use suitable soil material.
 - 3. Under steps and ramps, use engineered fill.
 - 4. Under building slabs, use engineered fill.
 - 5. Under footings and foundations, use engineered fill.
- D. Place soil fill on subgrades free of mud, frost, snow, or ice.
- E. Contractor shall provide certification that all fill material is clean and free of environmental contaminants.

3.14 SOIL MOISTURE CONTROL

- A. Uniformly moisten or aerate subgrade and each subsequent fill or backfill soil layer before compaction to within 2% of optimum moisture content.
 - 1. Do not place backfill or fill soil material on surfaces that are muddy, frozen, or contain frost or ice.
 - 2. Remove and replace, or scarify and air dry, otherwise suitable soil material that exceeds optimum moisture content by 2% and is too wet to compact to specified dry unit weight.

3.15 COMPACTION OF SOIL BACKFILLS AND FILLS

- A. Place backfill and fill soil materials in layers not more than 8-inches in loose depth for material compacted by heavy compaction equipment and not more than 4-inches in loose depth for material compacted by hand-operated tampers.
- B. Place backfill and fill soil materials evenly on all sides of structures to required elevations and uniformly along the full length of each structure.
- C. Compact soil materials to not less than the following percentages of maximum dry unit weight according to ASTM D 698:
 - 1. Under structures, building slabs, steps, and pavements, scarify and recompact top 12-inches of existing subgrade and each layer of backfill or fill soil material at 95%.
 - 2. Under walkways, scarify and recompact top 6-inches below subgrade and compact each layer of backfill or fill soil material at 95% MPD.
 - 3. Under turf or unpaved areas, scarify and recompact top 6-inches below subgrade and compact each layer of backfill or fill soil material at 85% MPD.
 - 4. For utility trenches, compact each layer of initial and final backfill soil material at 85% MPD.

3.16 GRADING

- A. General: Uniformly grade areas to a smooth surface, free of irregular surface changes. Comply with compaction requirements and grade to cross sections, lines, and elevations indicated.
 - 1. Provide a smooth transition between adjacent existing grades and new grades.
 - 2. Cut out soft spots, fill low spots, and trim high spots to comply with required surface tolerances.
- B. Site Rough Grading: Slope grades to direct water away from buildings and to prevent ponding. Finish subgrades to elevations required to achieve indicated finish elevations, within the following subgrade tolerances.
 - 1. Turf or Unpaved Areas: Plus or minus 1-inch
 - 2. Walks: Plus or minus 1-inch
 - 3. Pavements: Plus or minus 1/2-inch
- C. Grading inside Building Lines: Finish subgrade to a tolerance of 1/2-inch when tested with a 10-foot straightedge.

3.17 SUBSURFACE DRAINAGE

- A. Subsurface Drain: Place subsurface drainage geotextile around perimeter of subdrainage trench. Place a 6-inch course of filter material on subsurface drainage

geotextile to support subdrainage pipe. Encase subdrainage pipe in a minimum of 12-inches of filter material, placed in compacted layers 6-inches thick, and wrap in subsurface drainage geotextile, overlapping sides and ends at least 6-inches

1. Compact each filter material layer with a minimum of two passes of a plate-type vibratory compactor.
- B. Drainage Backfill: Place and compact filter material over subsurface drain, in width indicated, to within 12-inches of final subgrade, in compacted layers 6-inches thick. Overlay drainage backfill with one layer of subsurface drainage geotextile, overlapping sides and ends at least 6-inches.
1. Compact each filter material layer with a minimum of two passes of a plate-type vibratory compactor.
 2. Place and compact impervious fill over drainage backfill in 6-inch thick compacted layers to final subgrade.

3.18 SUBBASE AND BASE COURSES UNDER PAVEMENTS AND WALKS

- A. Place subbase course and base course on subgrades free of mud, frost, snow, or ice.
- B. On prepared subgrade, place subbase course and base course under pavements and walks as follows:
1. If specified, install separation geotextile on prepared subgrade according to manufacturer's written instructions, overlapping sides and ends.
 2. Place base course material over subbase course under hot-mix asphalt pavement.
 3. Shape subbase course and base course to required crown elevations and cross-slope grades.
 4. Place subbase course and base course inches or less in compacted thickness in a single layer.
 5. Place subbase course and base course that exceeds 6-inches in compacted thickness in layers of equal thickness, with no compacted layer more than 6-inches thick or less than 3-inches thick.
 6. Compact subbase course and base course at optimum moisture content to required grades, lines, cross sections, and thickness to not less than 95% of maximum dry unit weight according to ASTM D 698.

3.19 DRAINAGE COURSE UNDER CONCRETE SLABS-ON-GRADE

- A. Place drainage course on subgrades free of mud, frost, snow, or ice.
- B. On prepared subgrade, place and compact drainage course under cast-in-place concrete slabs-on-grade as follows:
1. Install subdrainage geotextile on prepared subgrade according to manufacturer's written instructions, overlapping sides and ends.
 2. Place drainage course 6-inches or less in compacted thickness in a single layer.
 3. Place drainage course that exceeds 6-inches in compacted thickness in layers of equal thickness, with no compacted layer more than 6-inches thick or less than 3-inches thick.
 4. Compact each layer of drainage course to required cross sections and thicknesses to not less than 95% of maximum dry unit weight according to ASTM D 698.

3.20 FIELD QUALITY CONTROL

- A. Special Inspections: Engage a qualified special inspector to perform the following special inspections:
 - 1. Determine prior to placement of fill that site has been prepared in compliance with requirements.
 - 2. Determine that fill material classification and maximum lift thickness comply with requirements.
 - 3. Determine, during placement and compaction, that in-place density of compacted fill complies with requirements.
- B. Testing Agency: Engage a qualified geotechnical engineering testing agency to perform tests and inspections. Contractor is responsible for all testing.
- C. Allow testing agency to inspect and test subgrades and each fill or backfill layer. Proceed with subsequent earth moving only after test results for previously completed work comply with requirements.
- D. Footing Subgrade: At footing subgrades, at least one test of each soil stratum will be performed to verify design bearing capacities. Subsequent verification and approval of other footing subgrades may be based on a visual comparison of subgrade with tested subgrade when approved by Engineer.
- E. Testing agency will test compaction of soils in place according to ASTM D 1556, ASTM D 2167, ASTM D 2937, and ASTM D 6938, as applicable. Tests will be performed at the following locations and frequencies:
 - 1. Paved and Building Slab Areas: At subgrade and at each compacted fill and backfill layer, at least one test for every 2000-sq./ft. or less of paved area or building slab but in no case fewer than three tests.
 - 2. Foundation Wall Backfill: At each compacted backfill layer, at least one test for every 100-feet or less of wall length but no fewer than two tests.
 - 3. Trench Backfill: At each compacted initial and final backfill layer, at least one test for every 150-feet or less of trench length but no fewer than two tests.
- F. When testing agency reports that subgrades, fills, or backfills have not achieved degree of compaction specified, scarify and moisten or aerate, or remove and replace soil materials to depth required; recompact and retest until specified compaction is obtained.

3.21 PROTECTION

- A. Protecting Graded Areas: Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash and debris.
- B. Repair and reestablish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or where they lose compaction due to subsequent construction operations or weather conditions.
 - 1. Scarify or remove and replace soil material to depth as directed by Engineer; reshape and recompact.
- C. Where settling occurs before Project correction period elapses, remove finished surfacing, backfill with additional soil material, compact, and reconstruct surfacing.

1. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

3.22 DISPOSAL OF SURPLUS AND WASTE MATERAILS

- A. Remove surplus satisfactory soil and waste materials, including unsatisfactory soil, unclassified material, trash, and debris, and legally dispose of them off Owner's property unless otherwise noted in the Contract Documents.

END OF SECTION 31 20 00

SECTION 31 22 13 - ROUGH GRADING

PART 1 – GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Excavating topsoil.
 - 2. Excavating subsoil.
 - 3. Cutting, grading, filling, rough contouring, compacting site for site structures and building pads.
- B. Related Sections:
 - 1. Section 311000 - Site Clearing.
 - 2. Section 312316 - Excavation.
 - 3. Section 312317 - Trenching.
 - 4. Section 329119 - Landscape Grading.

1.02 REFERENCES

- A. American Association of State Highway and Transportation Officials:
 - 1. AASHTO T180 – Standard Specification for Moisture-Density Relations of Soils Using a 4.54-kg (10lb) Rammer and a 457-mm (18in) drop.
- B. ASTM International:
 - 1. ASTM C136 – Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
 - 2. ASTM D698 – Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400-ft-lbf/ft³ (600kN-m/m³)).
 - 3. ASTM D1556 – Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method.
 - 4. ASTM D1557 – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000-ft-lbf/ft³ (2,700kN-m/m³)).
 - 5. ASTM D2167 – Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method.
 - 6. ASTM D2419 – Standard Test Method for Sand Equivalent Value of Soils and Fine Aggregate.
 - 7. ASTM D2434 – Standard Test Method for Permeability of Granular Soils (Constant Head).
 - 8. ASTM D2922 – Standard Test Method for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).
 - 9. ASTM D3017 – Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth).
- C. PennDOT Standard Specifications for Road and Bridge Construction, 2019, as amended.

1.03 CLOSEOUT SUBMITTALS

- A. Project Record Documents: Accurately record actual locations of utilities remaining by horizontal dimensions, elevations or inverts, and slope gradients.

1.04 QUALITY ASSURANCE

- A. Perform Work in accordance with PennDOT Standard Specifications for Road and Bridge Construction, 2019, as amended.
- B. Perform Work in accordance with Section 312316.
- C. Perform Work in accordance with the Standards for Soil Erosion and Sediment Control.

PART 2 – PRODUCTS

2.01 MATERIALS- AS SPECIFIED IN SECTION 310513.

2.02 EXAMINATION

- A. Verify site conditions.
- B. Verify survey benchmark and intended elevations for the Work are as indicated on Drawings.

2.03 PREPARATION

- A. Call One Call not less than three working days before performing Work.
 - 1. Request underground utilities to be located and marked within and surrounding construction areas.
- B. Identify required lines, levels, contours, and datum.
- C. Notify utility company to remove and relocate utilities.
- D. Protect utilities indicated to remain from damage.
- E. Protect plant life, lawns, rock outcropping and other features remaining as portion of final landscaping.
- F. Protect benchmarks, survey control point, existing structures to remain including but not limited to fences, sidewalks, paving, and curbs from excavating equipment and vehicular traffic.

2.04 SUBSOIL EXCAVATION

- A. Excavate subsoil from areas to be further excavated, re-landscaped, or re-graded.
- B. Excavate and process wet material to obtain optimum moisture content.
- C. When excavating through roots, perform Work by hand and cut roots with sharp axe.
- D. Remove excess subsoil not intended for reuse, from site.

- E. Benching Slopes: Horizontally bench existing slopes greater than 1:4 to key placed fill material to slope to provide firm bearing.
- F. Stability: Replace damaged or displaced subsoil as specified for fill.

2.05 FILLING

- A. Fill areas to contours and elevations with approved materials free of excessive moisture and frozen material.
- B. Place fill material in continuous layers and compact in accordance with PennDOT Standard Specifications for Road and Bridge Construction, 2019, as amended, Section 203 for Landscaped Areas and Section 301 for all other areas.
- C. Maintain optimum moisture content of fill materials within plus or minus 2% to attain required compaction density.
- D. Slope grade away from building as shown on the drawings.
- E. Make grade changes gradual. Blend slope into level areas.
- F. Repair or replace items indicated to remain damaged by excavation or filling.

2.06 TOLERANCES

- A. Top Surface of Subgrade: Plus or minus 1/10-foot from required elevation.

END OF SECTION 31 22 13

SECTION 31 23 16 - EXCAVATION

PART 1 – GENERAL

1.01 STIPULATIONS

- A. Excavation for this Project shall be considered unclassified and shall include all types of earth and soil, any pebbles, boulders, and bedrock, municipal trash, rubbish and garbage and all types of debris of the construction industry such as wood, stone, concrete, plaster, brick, mortar, steel and iron shapes, pipe, wire, asphaltic materials, paper, and glass. Unclassified excavation does not include unforeseen concrete foundations, walls, or slabs. All such materials encountered which are identified by this paragraph as unclassified shall be removed to the required widths and depths to create a finished product as shown and/or noted on the drawings and as written in the specifications. No additional compensation shall be made to the contractor for this unclassified excavation. The materials defined by this paragraph as unclassified will not be considered to be concealed conditions or unknown physical conditions below the surface of the ground for purposes of interpreting the language in the General Conditions of the Construction Contract.

1.02 SUMMARY

- A. Section Includes:
 - 1. Excavating for paving, sidewalks, and paver areas.
 - 2. Excavating for foundations and slabs-on-grade.
- B. Related Sections:
 - 1. Section 312213 – Rough Grading.
 - 2. Section 312317 – Trenching.

1.03 REFERENCES

- A. Local utility standards when working within 24-inches of utility lines.
- B. PennDOT Standard Specifications for Road and Bridge Construction, 2019, as amended.

1.04 QUALITY ASSURANCE

- A. Perform Work in accordance with PennDOT Standard Specifications for Road and Bridge Construction, 2019, as amended.

PART 2 – EXECUTION

2.01 PREPARATION

- A. Call One Call not less than three working days before performing Work.
 - 1. Request underground utilities to be located and marked within and surrounding construction areas.
- B. Identify required lines, levels, contours, and datum.
- C. Perform Test Pits as necessary to determine the location and depth of the sanitary septic system and piping within the limits of the project.

2.02 EXCAVATION

- A. Excavate subsoil to accommodate building foundations, slabs-on-grade, paving and site structures and construction operations to the required depth as shown on the plans.
- B. Compact disturbed load bearing soil in direct contact with foundations to original bearing capacity.
- C. Slope banks with machine to angle of repose or less until shored.
- D. Do not interfere with 45-degree bearing splay of foundations.
- E. Grade top perimeter of excavation to prevent surface water from draining into excavation.
- F. Trim excavation. Remove loose matter.
- G. Remove lumped subsoil, boulders, and rock up to 1/3-cu/yd measured by volume.
- H. Notify Architect/Engineer of unexpected subsurface conditions.
- I. Correct areas over excavated with structural fill as directed by Geotechnical Engineer.
- J. Remove excess and unsuitable material from site.
- K. Stockpile excavated material in area designated on site.
- L. Repair or replace items indicated to remain damaged by excavation.

2.03 FIELD QUALITY CONTROL

- A. Approval of Bearing Strata
 - 1. The Contractor shall furnish adequate advance notification to the Architect/Engineer of times when footing excavations are to be completed, so that the bearing quality of bottoms may be inspected and/or tested and approved. Formwork, reinforcing steel and concreting shall follow only after this approval.
 - 2. Should the bearing at the levels indicated be found by the Architect/Engineer/ Code Official to be inadequate, they may order the excavation carried down to sound bearing. Should suitable bearing be found at a lesser depth than indicated, the Architect/Engineer and the Department may order the reduction of excavation specified or shown on the drawings, and the Contractor shall allow a credit for excavation thus omitted on the same basis.
 - 3. Request inspection of excavation and controlled fill operations in accordance with applicable code.
- B. Quality Control Testing
 - 1. The Contractor shall perform all necessary Quality Control tests and procedures for the performance of the work in accordance with Section 014000 and this section, to produce end results specified. The Contractor shall maintain clear and

orderly records of such tests and procedures and make them available for field review and approval of the Professional. The Contractor's bid shall include the cost of all Quality Control Tests.

2. The Contractor shall submit its plan for Quality Control testing to the Professional for review and comments.
3. Quality Control tests shall include tests on fill material, optimum moisture content and maximum density and field density tests of fill layers. The QC Testing agent shall comment on the suitability of all subgrades, and the subgrades shall be acceptable to the QA Agency.
4. Handwritten copies of field test reports shall be provided to the Contractor. They shall be given to the Contractor and inspector within 2-hours of completion, but in no event shall the technician leave the site without providing the Contractor and inspector with a copy of the test results. This shall include density, percent moisture, plan location, elevation, comments, and any other relevant data. Comments shall include any condition that might have an adverse effect on the operations, including weather, drainage, etc.
5. The Contractor shall request consultation with the Consulting Geotechnical Engineer on any problems that arise during construction. Copies of the daily in-place soil density tests shall be faxed to the consultant by the Contractor through the testing agency within 24-hours of the time the tests are made.
6. The Contractor shall approve each subgrade and each fill layer before proceeding to the next layer. Any area which does not meet density, percent moisture or other requirements at any time, shall be suitably reworked and retested by the Contractor at his own expense.

2.04 THE PROFESSIONAL AND/OR THE OWNER MAY PERFORM QUALITY ASSURANCE TESTS AS DEEMED NECESSARY FOR THE ASSURANCE OF THE PROFESSIONAL AND/OR THE OWNER. THIS DOES NOT RELIEVE THE CONTRACTOR OF HIS RESPONSIBILITIES.

2.05 PROTECTION

- A. Prevent displacement or loose soil from falling into excavation; maintain soil stability.
- B. Protect bottom of excavations and soil adjacent to and beneath foundation from freezing.
- C. Prevent excavations from accumulating water and protect excavations from weather.
- D. Protect structures, utilities and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earth operations.

END OF SECTION 31 23 16

SECTION 31 23 17 - TRENCHING

PART 1 – GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Backfilling and compaction.
- B. Related Sections:
 - 1. Section 312213 - Rough Grading.
 - 2. Section 312316 – Excavation.

1.02 REFERENCES

- A. American Association of State Highway and Transportation Officials:
 - 1. AASHTO T180 – Standard Specification for Moisture-Density Relations of Soils Using a 10-lb (4.54kg) Rammer and an 18-inch (457mm) drop.
- B. ASTM International:
 - 1. ASTM D698 – Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400ft-lbf/ft³ (600kN-m/m³)).
 - 2. ASTM D1556 – Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method.
 - 3. ASTM D1557 – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000ft-lbf/ft³ (2,700kN-m/m³)).
 - 4. ASTM D2167 – Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method.
 - 5. ASTM D2922 – Standard Test Method for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).
 - 6. ASTM D3017 – Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth).

1.03 PENNDOT STANDARD SPECIFICATIONS FOR ROAD AND BRIDGE CONSTRUCTION, 2019, AS AMENDED.

1.04 DEFINITIONS

- A. Utility: Any buried pipe, duct, conduit, or cable.

1.05 FIELD MEASUREMENTS

- A. Verify field measurements prior to fabrication of any sheeting or shoring system.

1.06 COORDINATION

- A. Verify Work associated with lower elevation utilities is complete before placing higher elevation utilities.

PART 2 – PRODUCTS

2.01 FILL MATERIALS

- A. General Fill: As specified in Section 310513.
- B. Structural Fill: As specified in Section 310513.

PART 3 – EXECUTION

3.01 LINES AND GRADES

- A. Use laser-beam instrument with qualified operator to establish lines and grades.

3.02 PREPARATION

- A. Call One Call not less than three working days before performing Work.
 - 1. Request underground utilities to be located and marked within and surrounding construction areas.
- B. Identify required lines, levels, contours, and datum locations.
- C. Protect plant life, lawns, rock outcropping and other features remaining as portion of final landscaping.
- D. Protect benchmarks, existing structures, fences, sidewalks, paving, and curbs from excavating equipment and vehicular traffic.
- E. Maintain and protect above and below grade utilities indicated to remain.

3.03 TRENCHING

- A. All work shall be performed in accordance with OSHA regulations. OSHA regulations shall govern, should there be a question or discrepancy between their regulations and these specifications.
- B. Remove water or materials that interfere with Work.
- C. Provide uniform and continuous bearing and support for bedding material.
- D. Do not interfere with 45-degree bearing splay of foundations.
- E. When subsurface materials at bottom of trench are loose or soft, excavate to greater depth as directed by Landscape Architect until suitable material is encountered.
- F. Cut out soft areas of subgrade not capable of compaction in place. Backfill with Structural Fill and compact to density equal to or greater than requirements for subsequent backfill material.
- G. Correct areas over excavated areas with compacted backfill as specified for authorized excavation or replace with fill concrete as directed by Landscape Architect.

- H. Remove excess subsoil not intended for reuse, from site.

3.04 SHEETING AND SHORING

- A. Sheet, shore, and brace excavations to prevent danger to persons, structures, and adjacent properties and to prevent caving, erosion, and loss of surrounding subsoil.
- B. Support trenches more than 5-feet deep excavated through unstable, loose, or soft material. Provide sheeting, shoring, bracing, or other protection to maintain stability of excavation.
- C. Design sheeting and shoring to be removed at completion of excavation work.
- D. Repair damage caused by failure of the sheeting, shoring, or bracing and for settlement of filled excavations or adjacent soil.
- E. Repair damage to new and existing Work from settlement, water or earth pressure or other causes resulting from inadequate sheeting, shoring, or bracing.

3.05 BACKFILLING

- A. Backfill trenches to contours and elevations with approved fill materials free of excessive moisture and frozen material.
- B. Systematically backfill to allow maximum time for natural settlement. Do not backfill over porous, wet, frozen, or spongy subgrade surfaces.
- C. Place material in continuous layers as follows:
 - 1. General Fill: Maximum 8-inches compacted depth.
 - 2. Structural Fill: Maximum 8-inches compacted depth.
- D. Employ placement method that does not disturb or damage foundation perimeter drainage, utilities in trench.
- E. Maintain optimum moisture content of fill materials within plus or minus 2% to attain required compaction density.
- F. Do not leave trench open at end of working day.
- G. Protect open trench to prevent danger to the public.

3.06 TOLERANCES

- A. Top Surface of Backfilling under Paved Areas: Plus or minus 1/2-inch from required elevations.
- B. Top Surface of General Backfilling: Plus or minus 1-inch from required elevations.

3.07 FIELD QUALITY CONTROL

- A. Perform all work in accordance with Section 312316.

3.08 PROTECTION OF FINISHED WORK

- A. Reshape and re-compact fills subjected to vehicular traffic during construction.

END OF SECTION 31 23 17

SECTION 31 23 19 - DEWATERING

PART 1 GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

- A. This Section includes construction dewatering.
- B. Related Sections include the following:
 - 1. Division 3 Section "Cast-in-Place Concrete" for concrete slabs, pads, and foundations
 - 2. Division 31 Section "Earth Moving" for excavating, backfilling, site grading and for site utilities.
 - 3. Division 31 Section "Excavation Support and Protection".
 - 4. Division 33 Section "Storm Utility Drainage Piping" for storm drains and structures.

1.03 PERFORMANCE REQUIREMENTS

- A. Dewatering Performance: Design, furnish, install, test, operate, monitor, and maintain dewatering system of sufficient scope, size, and capacity to control ground-water flow into excavations and permit construction to proceed on dry, stable subgrades.
 - 1. Maintain dewatering operations to ensure erosion control, stability of excavations and constructed slopes, that excavation does not flood, and that damage to subgrades and permanent structures is prevented.
 - 2. Prevent surface water from entering excavations by grading, dikes, or other means.
 - 3. Accomplish dewatering without damaging existing improvements adjacent to excavation.
 - 4. Remove dewatering system if no longer needed.
- B. SUBMITTALS
 - 1. Field Test Reports: Before starting excavation, submit test results and computations demonstrating that dewatering system is capable of meeting performance requirements. Contractor shall submit a dewatering plan which shall include the disposal of water, for review and approval by the Architect.

1.04 QUALITY ASSURANCE

- A. Regulatory Requirements: Comply with water disposal requirements of the Department of Environmental Protection and the Freehold Soil Conservation District.

1.05 PROJECT CONDITIONS

- A. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted in writing and then only after arranging to provide temporary utility services according to requirements indicated.
- B. Project-Site Information:
 - 1. The Contractor shall make test borings and conduct other exploratory operations necessary for dewatering.
- C. Survey adjacent structures and improvements, employing a qualified professional engineer or land surveyor, establishing exact elevations at fixed points to act as benchmarks. Clearly identify benchmarks and record existing elevations.
 - 1. During dewatering, regularly resurvey benchmarks, maintaining an accurate log of surveyed elevations for comparison with original elevations. Promptly notify Architect if changes in elevations occur or if cracks, sags, or other damage is evident in adjacent construction.

PART 2 EXECUTION

2.01 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by dewatering operations.
 - 1. Prevent surface water and subsurface or ground water from entering excavations, from ponding on prepared subgrades, and from flooding site and surrounding area.
 - 2. Protect subgrades and foundation soils from softening and damage by rain or water accumulation.
- B. Install dewatering system to ensure minimum interference with roads, streets, walks, and other adjacent occupied and used facilities.
 - 1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.

2.02 INSTALLATION

- A. Install dewatering system utilizing wells, well points, or similar methods complete with pump equipment, standby power and pumps, filter material gradation, valves, appurtenances, water disposal, and surface-water controls.
- B. Before excavating below ground-water level, place system into operation to lower water to specified levels. Operate system continuously until drains, sewers, and structures have been constructed and fill materials have been placed, or until dewatering is no longer required.
- C. Provide an adequate system to lower and control ground water to permit excavation, construction of structures, and placement of fill materials on dry subgrades. Install

sufficient dewatering equipment to drain water-bearing strata above and below bottom of foundations, drains, sewers, and other excavations.

1. Do not permit open sump pumping that leads to loss of fines, soil piping, subgrade softening, and slope instability.
- D. Reduce hydrostatic head in water-bearing strata below subgrade elevations of foundations, drains, sewers, and other excavations.
1. Maintain piezometric water level a minimum of 24-inches below surface of excavation.
- E. Dispose of water removed by dewatering in a manner that avoids endangering public health, property, and portions of work under construction or completed. Dispose of water in a manner that avoids inconvenience to others. Provide sumps, sedimentation tanks, and other flow-control devices as required by authorities having jurisdiction.
- F. Provide standby equipment on-site, installed, and available for immediate operation, to maintain dewatering on continuous basis if any part of system becomes inadequate or fails. If dewatering requirements are not satisfied due to inadequacy or failure of dewatering system, restore damaged structures and foundation soils at no additional expense to Owner.
1. Remove dewatering system from Project site on completion of dewatering. Plug or fill well holes with sand or cut off and cap wells a minimum of 36-inches below overlying construction.
- G. Damages: Promptly repair damages to adjacent facilities caused by dewatering operations.

END OF SECTION 31 23 19

SECTION 31 23 23 - FILL

PART 1 – GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Backfilling site structures to subgrade elevations.
 - 2. Fill under slabs-on-grade.
 - 3. Fill under paving.
 - 4. Fill for over-excavation.
- B. Related Sections:
 - 1. Section 310513 – Soils for Earthwork.
 - 2. Section 310516 – Aggregates for Earthwork.
 - 3. Section 312213 – Rough Grading.
 - 4. Section 312316 – Excavation.
 - 5. Section 312317 – Trenching.

1.02 REFERENCES

- A. American Association of State Highway and Transportation Officials:
 - 1. AASHTO T180 – Standard Specification for Moisture-Density Relations of Soils Using a 10-lb (4.54kg) Rammer and an 18-inch (457mm) drop.
- B. ASTM International:
 - 1. ASTM D698 – Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400ft-lbf/ft³ (600kN-m/m³)).
 - 2. ASTM D1556 – Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method.
 - 3. ASTM D1557 – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000ft-lbf/ft³ (2,700kN-m/m³)).
 - 4. ASTM D2167 – Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method.
 - 5. ASTM D2922 – Standard Test Method for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).
 - 6. ASTM D3017 – Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth).
- C. PennDOT Standard Specifications for Road and Bridge Construction, 2019, as amended.

1.03 SUBMITTALS

- A. Materials Source: Submit name of imported fill materials suppliers.
- B. Provide certification that the fill material to be used for Rain Garden meets the specifications detailed on the plans.

- C. Provide certification that the clay core for the pond liner meets or exceeds the specifications detailed on the plans.
- D. Manufacturer's Certificate: Certify Products meets or exceed PADEP requirements for "clean fill".

1.04 QUALITY ASSURANCE

- A. Perform Work in accordance with PennDOT Standard Specifications for Road and Bridge Construction, 2019, as amended.

PART 2 – PRODUCTS

2.01 FILL MATERIALS

- A. General Fill: As specified in Section 310513.
- B. Structural Fill: As specified in Section 310513. Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand free of all organic material and contaminants, with a maximum particle size of 3-inches, between 10% and 70% by weight passing the U.S. Standard No. 40 sieve and containing no more than 12% by weight passing the U.S. Standard No. 200 sieve. Recycled concrete is considered suitable for use as engineered fill when approved by Geotechnical Engineer. Imported fill material shall be approved by Geotechnical Engineer well in advance of fill construction.

PART 3 – EXECUTION

3.01 EXAMINATION

- A. Verify subdrainage, dampproofing, or waterproofing installation has been inspected.
- B. Verify structural ability of unsupported walls to support loads imposed by fill.

3.02 PREPARATION

- A. Compact subgrade to density requirements for subsequent backfill materials.
- B. Cut out soft areas of subgrade not capable of compaction in place. Backfill with structural fill and compact to density equal to or greater than requirements for subsequent fill material.
- C. Scarify subgrade surface to depth of 6-inches.
- D. Proof roll to identify soft spots; fill and compact to density equal to or greater than requirements for subsequent fill material.
- E. For Rain Garden, there shall be no compaction of the subgrade. Subgrade shall be scarified to a depth of 6-inches below planting bed mix.

3.03 BACKFILLING

- A. Backfill areas to contours and elevations with approved materials free of excessive moisture and frozen material.
- B. Systematically backfill to allow maximum time for natural settlement. Do not backfill over porous, wet, frozen, or spongy subgrade surfaces.
- C. Place material in continuous layers as follows:
 - 1. General Fill: Maximum 8-inches compacted depth.
 - 2. Structural Fill: Maximum 8-inches compacted depth.
 - 3. Planting Bed Mix: Material shall be placed in 12- to 18-inch lifts.
- D. Employ placement method that does not disturb or damage other work.
- E. Maintain optimum moisture content of backfill materials within plus or minus 2% to attain required compaction density.
- F. Backfill against supported foundation walls. Do not backfill against unsupported foundation walls.
- G. Backfill simultaneously on each side of unsupported foundation walls until supports are in place.
- H. Slope grade away from building minimum 2% slope for minimum distance of 10-feet, unless noted otherwise.
- I. Make gradual grade changes. Blend slope into level areas.
- J. Remove surplus backfill materials from site.
- K. Leave fill material stockpile areas free of excess fill materials.
- L. Structural fill shall be compacted to at least 95% of the laboratory determined dry density per ASTM D1557 for footings, slab on grade and pavement.
- M. Fill of Rain Garden shall be performed with all construction vehicles outside the limits of the Rain Garden.

3.04 TOLERANCES

- A. Top Surface of Backfilling under Paved Areas. Plus or minus 1/2-inch from required elevations.
- B. Top Surface of General Backfilling: Plus or minus 1-inch from required elevations.

3.05 FIELD QUALITY CONTROL

- A. Perform all work in accordance with Section 312316.

END OF SECTION 31 23 23

SECTION 31 23 33 - TRENCHING AND BACKFILLING

PART 1 - GENERAL

1.01 DESCRIPTION

- A. The Contractor shall provide all labor, materials, equipment, and services necessary for, and incidental to, the excavation of trenching, backfilling, compacting, dewatering, protection, and disposal, as shown on the Contract Drawings, and as herein specified.
- B. The Contractor shall accept the site in the condition in which it exists at the time of award of the Contract.
- C. The Engineer will determine the suitability of materials that are to be used in the work and should any materials encountered be unsatisfactory for the purpose intended, they shall be removed from the site at the Contractor's expense.
- D. This section supplements Section 203 of the PennDOT Standard Specifications.

1.02 QUALITY ASSURANCE

- A. Reference Standards:
 - 1. The latest edition of the following standards, as referenced herein, shall be applicable.
 - a. Department of Transportation Specifications, latest edition.
 - b. "Standard Specifications for Highway Materials and Methods of Sampling and Testing, American Association of State Highway and Transportation Officials (AASHTO)."
 - c. American Society for Testing and Materials (ASTM).
- B. The Contractor shall comply with the requirements for soil erosion and sedimentation control and other requirements of governmental authorities having jurisdiction, including the State of Pennsylvania.
- C. The Contractor shall provide and pay for all costs in connection with an approved independent testing facility to determine conformance of soils and aggregate with the specifications, in accordance with Section "Quality Requirements."

1.03 SUBMITTALS

- A. Samples:
 - 1. The Contractor shall furnish representative earth materials to the testing laboratory for analysis and report, as directed by the Engineer, or as outlined in the specifications.
- B. Test Results:
 - 1. The testing laboratory shall submit written reports of all tests, investigations, findings and recommendations to the Contractor and the Engineer.

1.04 PROJECT REQUIREMENTS

- A. Notify the Engineer of any unexpected subsurface condition.
- B. Protect excavations by shoring, bracing, sheet piling, or by other methods, as required to ensure the stability of the excavation. Comply with OSHA requirements.
- C. Underpin or otherwise support structures adjacent to the excavation which may be damaged by the excavation. This includes service lines.
- D. Protection of Existing Utilities:
 - 1. Locate existing underground utilities in areas of work. If utilities are to remain in place, provide adequate means of support and protection during earthwork operations. Comply with OSHA requirements.
 - 2. Coordinate interruption and/or termination of utilities with the utility companies and the Owner.
 - 3. Provide a minimum of 48-hours' notice to the Owner and receive written notice to proceed before interrupting any utility.
 - 4. Demolish and completely remove from the site any existing underground utilities designated to be removed, as shown on the Drawings, or as specified in Section "Clearing and Grubbing."
 - 5. Repair any damaged utilities as acceptable to the Owner, Engineer, and utility company at no additional cost to the Owner.
- E. Protection of Persons and Property:
 - 1. Barricade open excavations occurring as part of this work and post with warning lights, if required.
 - 2. Operate warning lights as recommended by authorities having jurisdiction.
 - 3. Protect structures, utilities, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earthwork operations.
 - 4. Perform excavation within dripline of large trees to remain by hand and protect the root system from damage or dry-out to the greatest extent possible. Maintain moist conditions for root system and cover exposed roots with burlap. Paint root cuts of one 1-inch diameter and larger with emulsified asphalt tree paint.

PART 2 - PRODUCTS

2.01 MATERIALS

- A. Pipe Zone Bedding: Select mixture of graded crushed stone, free from organic, frozen, or other deleterious and shall be supplied in graded three-fourths 3/4-inch size.
- B. Pipe Zone Backfill: Sound, durable sand, gravel, stone, or blends of these materials, free from organic, frozen, or other deleterious materials, conforming to the requirements of PennDOT and meeting the following gradation requirements:

Sieve	Percent Passing
2"	100
3/4"	70 – 100

No. 4	30 – 80
No. 50	10 – 35
No. 200	5 – 12

- C. Sand Backfill (Water Service Installation): Provide material conforming to the requirements per PennDOT.
- D. “Flowable Fill” Backfill: Flowable Concrete shall be ASTM C150 Type III cement with sand, water, DaraFill, a controlled low strength material performance additive as manufactured by Grace Construction Products, or approved equal, and an air entraining agent, Air Mix, all as manufactured by the Euclid Chemical Co., or approved equal. Use approximately 90-lbs. of cement per cubic yard, 2,555-lbs. of sand per cubic yard, 3-lbs. of DaraFill per cubic yard, and 267-lbs. of water per cubic yard. Actual dosages of all ingredients shall be as per manufacture’s instructions for obtaining a compressive strength of 50-200-psi within 8-hours of placement. All materials shall conform to the requirements of PennDOT.

PART 3 - EXECUTION

3.01 PRECONSTRUCTION MATERIAL QUALIFICATION TESTING

- A. General:
 - 1. Sufficient size samples shall be obtained from the potential borrow source to allow completion of tests listed in paragraph B below. Samples may be obtained from test borings, test pits, or from borrow pit faces provided that surficial dry or wet soil is removed to expose undisturbed earth. Tests listed below shall be performed on each sample obtained. A minimum of 3-representative samples from each potential borrow source shall be furnished to the testing laboratory for prequalification testing. Test data shall be provided to the Engineer a minimum of 2-weeks prior to construction for approval of borrow source. 3-test reports completed within 3-months prior to construction may be submitted for commercial earth borrow sources or suppliers of stone products (crushed stone or PennDOT graded stone products) in lieu of prequalification tests as approved by the Engineer.
- B. Material Tests:
 - 1. Particle Size Analysis:
 - a. Method: ASTM D422
 - b. Number of Tests: One (1) per sample; three (3) per potential source.
 - c. Acceptance Criteria: Gradation within specified limits.
 - 2. Maximum Density Determination:
 - a. Method: ASTM D1557 – Modified Proctor
 - b. Number of Tests: One (1) per sample; three (3) per potential source.
 - 3. Re-establish gradation and maximum density of fill material if source is changed during construction.

3.02 PREPARATION

- A. Establish required lines, levels, contours, and datum.
- B. Maintain benchmarks and other elevation control points; re-establish if disturbed or destroyed, at no additional cost to the Owner.
- C. Establish location and extent of existing utilities prior to commencement of excavation.

3.03 EXCAVATION

- A. All excavation shall be made to such depth as required and of the width shown on the Contract Drawings to provide suitable room for building the structures and laying the pipe(s) they are to contain and for sheeting, shoring, pumping, and draining as necessary, and for removing peat, silt, or any other materials which the Engineer may deem unsuitable.
- B. Trench excavation for pipes shall be made by open cut to accommodate the pipe or structure at the depths indicated on the Contract Drawings. Excavation shall be made to such a depth and to the width indicated on the Contract Drawings so as to allow a minimum of 6-inches of pipe zone bedding to be placed beneath the bottom of all structures and barrels, bells or couplings of all pipes installed unless otherwise specified on the drawings.
- C. The bottom of the trench shall be accurately graded to provide a uniform layer of bedding material, as required, for each section of pipe. Trim and shape trench bottoms and leave free of irregularities, lumps, and projections.
- D. Stockpile excavated subsoil for reuse, where directed or approved. Remove excess or unsuitable excavated material from site.
- E. Excavation Below Grade: If, in the opinion of the Engineer, existing material below the trench grade is unsuitable for properly placing bedding material and laying pipe, the Contractor shall excavate and remove the unsuitable material and replace the same with an approved fill material properly compacted.
- F. Stability of Excavation: Slope sides of excavations shall comply with local codes and ordinances having jurisdiction. Shore and brace where sloping is not possible because of space restrictions or stability of material excavated. Maintain sides and slopes of excavation in safe condition until completion of backfilling.
- G. Removal of materials beyond the indicated subgrade elevations, without authorization by the Engineer, shall be classified as unauthorized excavation and shall be performed at no additional cost to the Owner.

3.04 DEWATERING

- A. The Contractor shall remove all water from the excavation promptly and continuously throughout the progress of the work and shall keep the excavation dry at all times until the structures to be built therein are completed and are backfilled or have sufficient weight to resist uplift pressures. Groundwater levels shall be depressed to a minimum of 2-feet below excavation subgrade. No pipe or masonry is to be laid in water and water shall not be allowed to rise on or flow over any pipe or masonry until such time as approved by the Engineer.
- B. All necessary precautions shall be taken to prevent disturbances of and to properly drain the subgrades upon which concrete is to be placed and upon which pipe is to be laid. If necessary, in the opinion of the Engineer, well points, deep wells, or other

means shall be used to lower the ground-water level, and observation wells shall be installed to confirm that groundwater levels are lowered as specified. Well points, if used, shall be shifted frequently to avoid drainage from too long a distance. Provide a suitable point of discharge in a manner satisfactory to the Engineer.

- C. Precautions shall be taken to protect uncompleted work from flooding during storms or from other causes. All pipelines or structures not stable against uplift during construction or prior to completion shall be thoroughly braced or otherwise protected.

3.05 BEDDING AND BACKFILLING

- A. All pipe trenches backfill (pipe zone bedding, pipe zone backfill, and trench backfill) shall be compacted by tamping or rolling to achieve a minimum dry density of 90% of the Modified Proctor maximum dry density of the material used (ASTM D1557). Backfill in pipe trenches to be covered with pavement shall be compacted to a minimum of 95% of Modified Proctor maximum dry density. Backfill materials shall be placed with water content within plus or minus 4% of optimum moisture content per the Modified Proctor method (ASTM D1557). Any water used for compaction shall be provided by the Contractor at his own expense. The approval of the Engineer of the proposed method of compaction of backfill shall in no way be construed as relieving the Contractor of responsibility of settlement of trenches, etc. and any settlement shall be repaired by him at his own expense.
- B. Bedding and backfilling shall be accomplished in 2-stages unless otherwise specified on the Contract Drawings. The first stage shall involve placement of "pipe zone bedding" as a layer(s) of selected material required to support, or to stabilize unsound or unsatisfactory foundation conditions. The second stage shall involve placement of "pipe zone backfill" from the top of the bedding material up to the surface of the ground or the bottom of any special surface treatment subgrade elevation.
- C. The bedding material shall be placed in the trench after the trench has been excavated a minimum of 6-inches below the bell of the pipe to permit the placing of not less than 6-inches of bedding material unless otherwise specified on the Contract Drawings. Where, in the opinion of the Engineer, more than 6-inches of bedding material shall be required, the excavation shall be performed, and bedding placed to the depth ordered by the Engineer.
- D. The bedding material shall be placed to the full width of trench. The bedding material shall be placed in loose lifts not exceeding 6-inches to the elevation shown on the Contract Drawings or directed by the Engineer. The bedding material shall be tamped and compacted to form a firm and even bearing surface.
- E. Pipe zone backfill shall be placed to the elevation shown on the Contract Drawings in loose lifts not-to-exceed 6-inches in thickness, before compaction. The backfill shall be placed on both sides of the pipe at the same time and to approximately the same elevation. Any pipe that is damaged or moved out of alignment, regardless of cause, shall be replaced or realigned at the Contractor's expense. Each layer shall be thoroughly compacted by hand-tamping or mechanical means being careful not to damage the pipe. When the pipe zone backfill reaches 1-foot over the top of the pipe, the entire surface shall be compacted by mechanical means.

3.06 BACKFILLING AROUND STRUCTURES

- A. The Contractor shall not place backfill against any structure without obtaining the approval of the Engineer. No dumping shall be allowed where materials would flow against or around such structures. Backfill material shall be deposited in horizontal layers not exceeding 8-inches in loose thickness or as shown on the Contract Drawings and thoroughly compacted by hand or pneumatic tampers to the satisfaction of the Engineer.

3.07 SUSPENSION OF WORK

- A. Whenever the work is suspended, excavations shall be protected and the roadways, if any, left unobstructed. Within or adjacent to private property, material shall be stored at such locations as will not unduly interfere with traffic of any nature and in no case shall materials be stored in locations which will cause damage to existing improvements.

3.08 DISPOSAL OF MATERIAL

- A. Excess and unsuitable materials shall be landfilled by the Contractor on the site in an area approved by the Engineer or disposed of off-site at the Contractor's expense. Any loam, material of a high clay content, or material containing a high percentage of organic material which the Engineer declares to be unsuitable for backfill shall be replaced at the Contractor's expense.

3.09 FIELD QUALITY CONTROL

- A. Notify the Engineer at least 1-working day in advance of all phases of filling and backfilling operations.
- B. In-place density testing shall be performed to ascertain the compacted density of the fill and backfill materials in accordance with the following methods:
 - 1. In-place relative density:
 - a. Method: AASHTO T191, Sand Cone Method
AASHTO T238, Nuclear Method
- C. In-place density tests on trench backfills shall be provided for every 500-cu/yd of fill and in vertical lifts not exceeding 2-feet, and at least once daily.
- D. One particle size analysis (ASTM D422) and one Modified Proctor compaction test (ASTM D1557) shall be completed for every 5,000-cu/yd of material placed.
- E. The Engineer may direct additional tests to establish gradation, maximum density, and in-place density as required by working conditions, at the Contractor's expense.
- F. Acceptance Criteria: The criteria for acceptability of in-place fill shall be in-situ dry density and moisture content. If a test fails to qualify, the fill shall be further compacted and re-tested. Subsequent test failures shall be followed by removal and replacement of the material.

END OF SECTION 31 23 33

SECTION 31 30 00 - EARTHWORK

PART 1 GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. Earthwork shall be performed in accordance with the Department of Transportation Specifications, latest edition.

1.02 SUMMARY

- A. This Section includes the following:
 - 1. Preparing subgrades for slabs-on-grade, walks, pavements and lawns and grasses.
 - 2. Excavating and backfilling for structures.
 - 3. Drainage course for slabs-on-grade.
 - 4. Subbase course for walks and pavements.
 - 5. Subbase and base course for asphalt paving.
 - 6. Excavating and backfilling for utility trenches.
 - 7. Excavating and backfilling for buried mechanical and electrical utilities and pits for buried utility structures.
 - 8. Excavation for foundations.
 - 9. Excavation for proposed pavement and slabs.
- B. Related Sections include the following:
 - 1. Division 31 Section "Site Clearing" for temporary erosion and sedimentation control measures, site stripping, grubbing, stripping, and stockpiling topsoil, and removal of above- and below-grade improvements and utilities.
 - 2. Division 31 Section "Dewatering" for lowering and disposing of ground water during construction.
 - 3. Division 31 Section "Excavation Support and Protection" for shoring, bracing, and sheet piling of excavations.
 - 4. Division 32 Section "Lawns and Grasses" for finish grading, including preparing and placing topsoil and planting soil for lawns.
 - 5. Division 33 Section "Water Distribution" for water main and structures.
 - 6. Division 3 Section "Cast-in-Place Concrete" for concrete slabs, pads, and foundations.

1.03 DEFINITIONS

- A. Backfill: Soil material used to fill an excavation.
 - 1. Initial Backfill: Backfill placed beside and over pipe in a trench, including haunches to support sides of pipe.
 - 2. Final Backfill: Backfill placed over initial backfill to fill a trench.

- B. Base Course: Course placed between the subbase course and hot-mix asphalt paving.
- C. Bedding Course: Course placed over the excavated subgrade in a trench before laying pipe.
- D. Borrow Soil: Satisfactory soil imported from off-site for use as fill or backfill.
- E. Drainage Course: Course supporting the slab-on-grade that also minimizes upward capillary flow of pore water.
- F. Excavation: Removal of material encountered above subgrade elevations and to lines and dimensions indicated.
 - 1. Bulk Excavation: Excavation more than 10-feet in width and more than 30-feet in length.
 - 2. Unauthorized Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions without direction by Engineer. Unauthorized excavation, as well as remedial work directed by Engineer, shall be without additional compensation.
- G. Fill: Soil materials used to raise existing grades.
- H. 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.
- I. Subbase Course: Course placed between the subgrade and base course for hot-mix asphalt pavement, or course placed between the subgrade and a cement concrete pavement or a cement concrete or hot-mix asphalt walk.
- J. Subgrade: Surface or elevation remaining after completing excavation, or top surface of a fill or backfill immediately below subbase, drainage fill, or topsoil materials.
- K. Utilities: On-site underground pipes, conduits, ducts, and cables, as well as underground services within buildings.
- L. Unsuitable Material: All material containing organic matter as directed by the Engineer.

1.04 SUBMITTALS

- A. Product Data: For the following:
 - 1. Structural Fill
- B. Material Test Reports: From a qualified testing agency indicating and interpreting test results for compliance of the following with requirements indicated:
 - 1. Classification according to ASTM D 2487 of each on-site and borrow soil material proposed for fill and backfill.
 - 2. Laboratory compaction curve according to ASTM D 1557 for each on-site and borrow soil material proposed for fill and backfill.
- C. Pre-excavation Photographs or Videotape: Show existing conditions of adjoining construction and site improvements, including finish surfaces that might be misconstrued as damage caused by earthwork operations. Submit before earthwork begins.

1.05 QUALITY ASSURANCE

- A. Geotechnical Testing Agency Qualifications: An independent testing agency qualified according to ASTM E 329 to conduct soil materials and rock-definition testing, as documented according to ASTM D 3740 and ASTM E 548.

1.06 PROJECT CONDITIONS

- A. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted in writing by Engineer and then only after arranging to provide temporary utility services according to requirements indicated.
 - 1. Notify Engineer not less than 2-days in advance of proposed utility interruptions.
 - 2. Do not proceed with utility interruptions without Engineer's written permission.
 - 3. Contact utility-locator service for area where Project is located before excavating.
- B. Demolish and completely remove from site existing underground utilities indicated to be removed. Coordinate with utility companies to shut off services if lines are active.

PART 2 PRODUCTS

2.01 SOIL MATERIALS

- A. General: Provide borrow soil materials when sufficient satisfactory soil materials are not available from excavations.
- B. Satisfactory Soils: ASTM D 2487 Soil Classification Groups GW, GP, GM, SW, SP, and SM, or a combination of these groups; free of rock or gravel larger than 3-inches in any dimension, debris, waste, frozen materials, vegetation, and other deleterious matter.
- C. Unsatisfactory Soils: Soil Classification Groups GC, SC, CL, ML, OL, CH, MH, OH, and PT according to ASTM D 2487, or a combination of these groups.
 - 1. Unsatisfactory soils also include satisfactory soils not maintained within 2% of optimum moisture content at time of compaction.
- D. Subbase Material: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; with at least 90% passing a 1.5-inch sieve and not more than 12% passing a No. 200 sieve.
- E. Base Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; with at least 95% passing a 1.5-inch sieve and not more than 8% passing a No. 200 sieve.
- F. Engineered Fill: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; with at least 90% passing a 1.5-inch sieve and not more than 12% passing a No. 200 sieve.
- G. Bedding Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; except with 100% passing a 1-inch sieve and not more than 8% passing a No. 200 sieve.
- H. Drainage Course: Narrowly graded mixture of crushed stone or crushed or uncrushed gravel; ASTM D 448; coarse-aggregate grading Size 57; with 100% passing a 1.5-inch sieve and 0-5% passing a No. 8 sieve.
- I. Filter Material: Narrowly graded mixture of natural or crushed gravel, or crushed stone and natural sand; ASTM D 448; coarse-aggregate grading Size 67; with 100% passing

a 1-inch sieve and 0-5% passing a No. 4 sieve.

- J. Sand: ASTM C 33; fine aggregate, natural, or manufactured sand.

PART 3 EXECUTION

3.01 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earthwork operations.
- B. Preparation of subgrade for earthwork operations including removal of vegetation, topsoil, debris, obstructions, and deleterious materials from ground surface is specified in Division 2 Section "Site Clearing."
- C. Protect and maintain erosion and sedimentation controls, which are specified in Division 2 Section "Site Clearing," during earthwork operations.

3.02 DEWATERING

- A. Prevent surface water and ground water from entering excavations, from ponding on prepared subgrades, and from flooding Project site and surrounding area.
- B. Protect subgrades from softening, undermining, washout, and damage by rain or water accumulation.
 - 1. Reroute surface water runoff away from excavated areas. Do not allow water to accumulate in excavations. Do not use excavated trenches as temporary drainage ditches.
 - 2. Install a dewatering system, specified in Division 2 Section "Dewatering," to keep subgrades dry and convey ground water away from excavations. Maintain until dewatering is no longer required.

3.03 EXPLOSIVES

- A. Explosives: Do not use explosives.

3.04 EXCAVATION, GENERAL

- A. Unclassified Excavation: Excavate to subgrade elevations regardless of the character of surface and subsurface conditions encountered. Unclassified excavated materials may include rock, soil materials, and obstructions. No changes in the Contract Sum or the Contract Time will be authorized for rock excavation or removal of obstructions.
 - 1. If excavated materials intended for fill and backfill include unsatisfactory soil materials and rock, replace with satisfactory soil materials.

3.05 EXCAVATION FOR STRUCTURES

- A. Excavate to indicated elevations and dimensions within a tolerance of plus or minus 1-inch. If applicable, extend excavations a sufficient distance from structures for placing and removing concrete formwork, for installing services and other construction, and for

inspections.

1. Excavations for Footings and Foundations: Do not disturb bottom of excavation. Excavate by hand to final grade just before placing concrete reinforcement. Trim bottoms to required lines and grades to leave solid base to receive other work.
2. Excavate for all footings down to virgin fill.
3. Excavation for Underground Tanks, Basins, and Mechanical or Electrical Utility Structures: Excavate to elevations and dimensions indicated within a tolerance of plus or minus 1-inch. Do not disturb bottom of excavations intended as bearing surfaces.

3.06 EXCAVATION FOR WALKS AND PAVEMENTS

- A. Excavate surfaces under walks and pavements to indicated lines, cross sections, elevations, and subgrades.

3.07 EXCAVATION FOR UTILITY TRENCHES

- A. Excavate trenches to indicated gradients, lines, depths, and elevations.
 1. Beyond building perimeter, excavate trenches to allow installation of top of pipe below frost line.
- B. Excavate trenches to uniform widths to provide the following clearance on each side of pipe or conduit. Excavate trench walls vertically from trench bottom to 12-inches higher than top of pipe or conduit, unless otherwise indicated.
 1. Clearance: As indicated.
- C. Trench Bottoms: Excavate trenches 4-inches deeper than bottom of pipe elevation to allow for bedding course. Hand-excavate for bell of pipe.

3.08 SUBGRADE INSPECTION

- A. Notify Engineer when excavations have reached required subgrade.
- B. If Engineer determines that unsatisfactory soil is present, continue excavation and replace with compacted backfill or fill material as directed.
- C. Proof-roll subgrade below the building slabs and pavements with heavy pneumatic-tired equipment to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.
 1. Completely proof-roll subgrade in one direction, repeating proof-rolling in direction perpendicular to first direction. Limit vehicle speed to 3-mph.
 2. Proof-roll with a loaded 10-wheel, tandem-axle dump truck weighing not less than 15-tons.
 3. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Engineer, and replace with compacted backfill or fill as directed.
- D. Authorized additional excavation and replacement material will be paid for according to Contract provisions for unit prices.
- E. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities, as directed by Engineer, without additional compensation.

3.09 UNAUTHORIZED EXCAVATION

- A. Fill unauthorized excavation under foundations or wall footings by extending bottom elevation of concrete foundation or footing to excavation bottom, without altering top elevation. Lean concrete fill, with 28-day compressive strength of 2500-psi, may be used when approved by Engineer.
 - 1. Fill unauthorized excavations under other construction or utility pipe as directed by Engineer.

3.10 STORAGE OF SOIL MATERIALS

- A. Stockpiles borrow soil materials and excavated satisfactory soil materials without intermixing. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust.
 - 1. Stockpile soil materials away from edge of excavations. Do not store within drip line of remaining trees.

3.11 BACKFILL

- A. Place and compact backfill in excavations promptly, but not before completing the following:
 - 1. Surveying locations of underground utilities for Record Documents.
 - 2. Testing and inspecting underground utilities.
 - 3. Removing concrete formwork.
 - 4. Removing trash and debris.
 - 5. Removing temporary shoring and bracing and sheeting.
- B. Place backfill on subgrades free of mud, frost, snow, or ice.

3.12 UTILITY TRENCH BACKFILL

- A. Place backfill on subgrades free of mud, frost, snow, or ice.
- B. Place and compact bedding course on trench bottoms and where indicated. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits.
- C. Backfill trenches excavated under footings and within 18-inches of bottom of footings with satisfactory soil; fill with concrete to elevation of bottom of footings. Concrete is specified in Division 3 Section "Cast-in-Place Concrete."
- D. Place and compact initial backfill of, free of particles larger than 1-inch in any dimension, to a height of 12-inches over the utility pipe or conduit.
 - 1. Carefully compact initial backfill under pipe haunches and compact evenly up on both sides and along the full length of utility piping or conduit to avoid damage or displacement of piping or conduit. Coordinate backfilling with utilities testing.
- E. Backfill voids with satisfactory soil while installing and removing shoring and bracing.
- F. Place and compact final backfill of satisfactory soil to final subgrade elevation.

3.13 SOIL FILL

- A. Plow, scarify, bench, or break up sloped surfaces steeper than 1-vertical to 4-horizontal so fill material will bond with existing material.
- B. Place and compact fill material in layers to required elevations as follows:
 - 1. Under grass and planted areas, use satisfactory soil material.
 - 2. Under walks and pavements, use satisfactory soil material.
 - 3. Under footings and foundations, use aggregate as per the plans.
- C. Place soil fill on subgrades free of mud, frost, snow, or ice.

3.14 SOIL MOISTURE CONTROL

- A. Uniformly moisten or aerate subgrade and each subsequent fill or backfill soil layer before compaction to within 2% of optimum moisture content.
 - 1. Do not place backfill or fill soil material on surfaces that are muddy, frozen, or contain frost or ice.
 - 2. Remove and replace or scarify and air dry otherwise satisfactory soil material that exceeds optimum moisture content by 2% and is too wet to compact to specified dry unit weight.

3.15 COMPACTION OF SOIL BACKFILLS AND FILLS

- A. Place backfill and fill soil materials in layers not more than 8-inches in loose depth for material compacted by heavy compaction equipment, and not more than 4-inches in loose depth for material compacted by hand-operated tampers.
- B. Place backfill and fill soil materials evenly on all sides of structures to required elevations, and uniformly along the full length of each structure.
- C. Compact soil materials to not less than the following percentages of maximum dry unit weight according to ASTM D 1557:
 - 1. Under structures, building slabs, and pavements, scarify and recompact top 12-inches of existing subgrade and each layer of backfill or fill soil material at 95%.
 - 2. Under walkways, scarify and recompact top 6-inches below subgrade and compact each layer of backfill or fill soil material at 92%.
 - 3. Under lawn or unpaved areas, scarify and recompact top 6-inches below subgrade and compact each layer of backfill or fill soil material at 90%.
 - 4. For utility trenches, compact each layer of initial and final backfill soil material at 90%.

3.16 GRADING

- A. General: Uniformly grade areas to a smooth surface, free of irregular surface changes. Comply with compaction requirements and grade to cross sections, lines, and elevations indicated.
 - 1. Provide a smooth transition between adjacent existing grades and new grades.
 - 2. Cut out soft spots, fill low spots, and trim high spots to comply with required surface tolerances.

- B. Site Grading: Slope grades to direct water away from buildings and to prevent ponding. Finish subgrades to required elevations within the following tolerances:
 - 1. Lawn or Unpaved Areas: Plus or minus 1-inch.
 - 2. Walks: Plus or minus 1-inch.
 - 3. Pavements: Plus or minus 1/2-inch.
- C. Grading inside Building Lines: Finish subgrade to a tolerance of 1/2-inch when tested with a 10-foot straightedge.

3.17 SUBBASE AND BASE COURSES

- A. Place subbase and base course on subgrades free of mud, frost, snow, or ice.
- B. On prepared subgrade, place subbase and base course under pavements and walks as follows:
 - 1. Place base course material over subbase course under hot-mix asphalt pavement.
 - 2. Shape subbase and base course to required crown elevations and cross-slope grades.
 - 3. Place subbase and base course 6-inches or less in compacted thickness in a single layer.
 - 4. Place subbase and base course that exceeds 6-inches in compacted thickness in layers of equal thickness, with no compacted layer more than 6-inches thick or less than 3-inches thick.
 - 5. Compact subbase and base course at optimum moisture content to required grades, lines, cross sections, and thickness to not less than 95% of maximum dry unit weight according to ASTM D 1557.

3.18 DRAINAGE COURSE

- A. Place drainage course on subgrades free of mud, frost, snow, or ice.
- B. On prepared subgrade, place and compact drainage course under cast-in-place concrete slabs-on-grade as follows:
 - 1. Place drainage course 6-inches or less in compacted thickness in a single layer.
 - 2. Place drainage course that exceeds 6-inches in compacted thickness in layers of equal thickness, with no compacted layer more than 6-inches thick or less than 3-inches thick.
 - 3. Compact each layer of drainage course to required cross sections and thicknesses to not less than 95% of maximum dry unit weight according to ASTM D 698.

3.19 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified independent geotechnical engineering testing agency to perform field quality-control testing.
- B. Allow testing agency to inspect and test subgrades and each fill or backfill layer. Proceed with subsequent earthwork only after test results for previously completed work comply with requirements.

- C. Footing Subgrade: At footing subgrades, at least one test of each soil stratum will be performed to verify design bearing capacities. Subsequent verification and approval of other footing subgrades may be based on a visual comparison of subgrade with tested subgrade when approved by Engineer.
- D. Testing agency will test compaction of soils in place according to ASTM D 1556, ASTM D 2167, ASTM D 2922, and ASTM D 2937, as applicable. Tests will be performed at the following locations and frequencies:
 - 1. Paved and Building Slab Areas: At subgrade and at each compacted fill and backfill layer, at least 1-test for every 2000-sq/ft or less of paved area or building slab, but in no case fewer than 3-tests.
 - 2. Foundation Wall and footings: At each compacted backfill layer, at least 1-test for each 100-feet or less of wall length, but no fewer than 2-tests.
 - 3. Trench Backfill: At each compacted initial and final backfill layer, at least 1-test for each 150-feet or less of trench length, but no fewer than 2-tests.
- E. When testing agency reports that subgrades, fills, or backfills have not achieved degree of compaction specified, scarify, and moisten or aerate, or remove and replace soil to depth required; recompact and retest until specified compaction is obtained.

3.20 PROTECTION

- A. Protecting Graded Areas: Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash and debris.
- B. Repair and reestablish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or where they lose compaction due to subsequent construction operations or weather conditions.
 - 1. Scarify or remove and replace soil material to depth as directed by Engineer; reshape and recompact.
- C. Where settling occurs before Project correction period elapses, remove finished surfacing, backfill with additional soil material, compact, and reconstruct surfacing.
 - 1. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

3.21 DISPOSAL OF SURPLUS AND WASTE MATERIALS

- A. Disposal: Remove surplus satisfactory soil and waste material, including unsatisfactory soil, trash, and debris, and legally dispose of it off Owner's property.

END OF SECTION 31 30 00

SECTION 32 12 73 - PAVEMENT JOINT SEALANTS

PART 1 GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. Joint Sealants shall be performed in accordance with the Department of Transportation Specifications, latest edition.

1.02 SUMMARY

- A. This Section includes the following:
 - 1. Joints between concrete and asphalt pavement.
- B. Related Sections include the following:
 - 1. Division 32 Section "Hot-Mix Asphalt Paving" for constructing joints between concrete and asphalt pavement.
 - 2. Division 32 Section "Cement Concrete Pavement" for constructing joints within concrete curb.

1.03 SUBMITTALS

- A. Product Data: For each joint-sealant product indicated.
- B. Samples for Verification: For each type and color of joint sealant required. Install joint-sealant samples in 1/2-inch-wide joints formed between two 6-inch-long strips of material matching the appearance of exposed surfaces adjacent to joint sealants.
- C. Product Certificates: For each type of joint sealant and accessory, signed by product manufacturer.
- D. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for sealants.

1.04 QUALITY ASSURANCE

- A. Installer Qualifications: An employer of workers trained and approved by manufacturer.
- B. Source Limitations: Obtain each type of joint sealant through one source from a single manufacturer.
 - 1. Testing Agency Qualifications: An independent testing agency qualified according to ASTM C 1021 for testing indicated, as documented according to ASTM E 548.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Deliver materials to Project site in original unopened containers or bundles with labels indicating manufacturer, product name and designation, color, expiration date, pot life,

curing time, and mixing instructions for multicomponent materials.

- B. Store and handle materials to comply with manufacturer's written instructions to prevent their deterioration or damage due to moisture, high or low temperatures, contaminants, or other causes.

1.06 PROJECT CONDITIONS

- A. Do not proceed with installation of joint sealants under the following conditions:
 - 1. When ambient and substrate temperature conditions are outside limits permitted by joint-sealant manufacturer.

PART 2 PRODUCTS

2.01 MATERIALS: GENERAL

- A. Compatibility: Provide joint sealants, backing materials, and other related materials that are compatible with one another and with joint substrates under conditions of service and application, as demonstrated by joint-sealant manufacturer based on testing and field experience.
- B. Colors of Exposed Joint Sealants: As indicated by manufacturer's designations. Color sample shall be submitted to Architect for approval before ordering any materials.

2.02 COLD-APPLIED JOINT SEALANTS

- A. Multi-component, Jet-Fuel-Resistant Sealant for Concrete: Pourable, chemically curing elastomeric formulation complying with the following requirements for formulation and with ASTM C 920 for type, grade, class, and uses indicated:
 - 1. Coal-Tar-Modified Polymer Formulation: Type M; Grade P; Class 25; Uses T and, as applicable to joint substrates indicated, O.
 - 2. Bitumen-Modified Urethane Formulation: Type M; Grade P; Class 25; Uses T, M, and, as applicable to joint substrates indicated, O.

2.03 PRIMERS

- A. Primers: Product recommended by joint-sealant manufacturer where required for adhesion of sealant to joint substrates indicated, as determined from preconstruction joint-sealant-substrate tests and field tests.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine joints indicated to receive joint sealants, with Installer present, for compliance with requirements for joint configuration, installation tolerances, and other conditions affecting joint-sealant performance.
 - 1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

- A. Surface Cleaning of Joints: Clean out joints immediately before installing joint sealants to comply with joint-sealant manufacturer's written instructions.
- B. Joint Priming: Prime joint substrates where indicated or where recommended in writing by joint-sealant manufacturer, based on preconstruction joint-sealant-substrate tests or prior experience. Apply primer to comply with joint-sealant manufacturer's written instructions. Confine primers to areas of joint-sealant bond; do not allow spillage or migration onto adjoining surfaces.

3.03 INSTALLATION OF JOINT SEALANTS

- A. General: Comply with joint-sealant manufacturer's written installation instructions for products and applications indicated unless more stringent requirements apply.
- B. Sealant Installation Standard: Comply with recommendations in ASTM C 1193 for use of joint sealants as applicable to materials, applications, and conditions indicated.
- C. Install backer materials of type indicated to support sealants during application and at position required to produce cross-sectional shapes and depths of installed sealants relative to joint widths that allow optimum sealant movement capability.
 - 1. Do not leave gaps between ends of backer materials.
 - 2. Do not stretch, twist, puncture, or tear backer materials.
 - 3. Remove absorbent backer materials that have become wet before sealant application and replace them with dry materials.
- D. Install sealants using proven techniques that comply with the following and at the same time backings are installed:
 - 1. Place sealants so they directly contact and fully wet joint substrates.
 - 2. Completely fill recesses provided for each joint configuration.
 - 3. Produce uniform, cross-sectional shapes and depths relative to joint widths that allow optimum sealant movement capability.
- E. Tooling of Non-sag Sealants: Immediately after sealant application and before skinning or curing begins, tool sealants according to requirements specified below to form smooth, uniform beads of configuration indicated; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint.
 - 1. Remove excess sealants from surfaces adjacent to joint.
 - 2. Use tooling agents that are approved in writing by joint-sealant manufacturer and that do not discolor sealants or adjacent surfaces.
- F. Provide joint configuration to comply with joint-sealant manufacturer's written instructions, unless otherwise indicated.
- G. Provide recessed joint configuration for silicone sealants of recess depth and at locations indicated.

3.04 CLEANING

- A. Clean off excess sealants or sealant-smears adjacent to joints as the Work progresses by methods and with cleaning materials approved by manufacturers of joint sealants and of products in which joints occur.

3.05 PROTECTION

- A. Protect joint sealants during and after curing period from contact with contaminating substances and from damage resulting from construction operations or other causes so sealants are without deterioration or damage at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, cut out and remove damaged or deteriorated joint sealants immediately and replace with joint sealant so installations with repaired areas are indistinguishable from the original work.

END OF SECTION 32 12 73

SECTION 32 13 13 - CONCRETE PAVING

PART 1 GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Concrete sidewalks.
 - 2. Aggregate base course.
- B. Related Sections:
 - 1. Section 312213 – Rough Grading: Preparation of site for paving and base course.
 - 2. Section 312323 – Fill: Compacted sub-base for paving.
 - 3. Section 321123 – Aggregate Base Courses.
 - 4. Section 321216 – Asphalt Paving.
 - 5. Section 329119 – Landscape Grading: Preparation of subsoil at pavement perimeter.

1.02 REFERENCES

- A. American Concrete Institute:
 - 1. ACI 301 – Specifications for Structural Concrete.
 - 2. ACI 304 – Guide for Measuring, Mixing, Transporting, and Placing Concrete.
- B. ASTM International:
 - 1. ASTM A185 – Standard Specification for Steel Welded Wire Fabric, Plain, for Concrete Reinforcement.
 - 2. ASTM A497 – Standard Specification for Steel Welded Wire Fabric, Deformed, for Concrete Reinforcement.
 - 3. ASTM A615/A615M – Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
 - 4. ASTM C33 – Standard Specification for Concrete Aggregates.
 - 5. ASTM C94/C94M – Standard Specification for Ready-Mixed Concrete.
 - 6. ASTM C150 – Standard Specification for Portland Cement.
 - 7. ASTM C260 – Standard Specification for Air-Entraining Admixtures for Concrete.
 - 8. ASTM C309 – Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
 - 9. ASTM C494/C494M – Standard Specification for Chemical Admixtures for Concrete.
 - 10. ASTM C1315 – Standard Specification for Liquid Membrane-Forming Compounds Having Special Properties for Curing and Sealing Concrete.
 - 11. ASTM D1751 – Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Non-extruding and Resilient Bituminous Types).
 - 12. ASTM D1752 – Standard Specification for Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction.

1.03 PERFORMANCE REQUIREMENTS: NOT USED

1.04 SUBMITTALS

- A. Section 013300 – Submittal Procedures: Requirements for submittals.
- B. Product Data: Submit data on joint filler, admixtures and curing compounds.

1.05 QUALITY ASSURANCE

- A. Perform Work in accordance with PennDOT Standards.
- B. Maintain one copy of PennDOT Standard Specifications on site.
- C. Obtain cementitious materials from same source throughout.

1.06 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing Products specified in this section with minimum 3-years documented experience.
- B. Installer: Company specializing in performing work of this section with minimum 5-years documented experience.

1.07 PRE-INSTALLATION MEETINGS

- A. Section 013100 – Project Management and Coordination: Pre-installation meeting.

1.08 ENVIRONMENTAL REQUIREMENTS

- A. Section 016000 – Product Requirements: Environmental conditions affecting products on site.
- B. Do not place concrete when base surface temperature is less than 40°F, or surface is wet or frozen.
- C. Any fill areas shall receive approved fill material in 6-inch lifts or as detailed in other applicable sections of these Specifications and mechanically compacted to the material's optimum density.
- D. In grassed areas, a minimum of 4-inches of topsoil, fertilizer, lime, seed and mulch shall be installed to an appropriate finish grade as directed by the Engineer. Topsoiling shall be in accordance with other applicable sections of these Specifications.

PART 2 PRODUCTS

2.01 FORM MATERIALS

- A. Form Materials: Conform to ACI 301.
- B. Joint Filler: ASTM D1751
 - 1. REINFORCEMENT

- C. Reinforcing Steel: ASTM A615/A615M; 40-ksi yield grade; deformed billet steel bars; galvanized finish.
- D. Welded Steel Wire Fabric: Plain type, ASTM A185 in flat sheets galvanized finish.
- E. Dowels: ASTM A615/A615M; 40-ksi yield grade, plain steel, galvanized finish.

2.02 CONCRETE MATERIALS

- A. Concrete Materials: Provide in accordance with PennDOT Standards.
- B. Fine and Coarse Mix Aggregates: ASTM C33.
- C. Exposed Aggregate: Gravel washed natural mineral aggregate, per PennDOT Standards, from a single source.
- D. Water: Potable, not detrimental to concrete.
- E. Air Entrainment: ASTM C260.
- F. Chemical Admixture: AASHTO M194 Type A- Water Reducing, Type B -Retarding, Type D - Water Reducing and Retarding
- G. The Contractor shall provide all labor, materials and equipment required to install concrete sidewalks, aprons and 6-inch x 8-inch x 18-inch vertical concrete curbing at the locations shown on the plans. Appropriate expansion and construction joints shall be installed under the direction of the Engineer.
- H. Concrete shall be PennDOT Class B 4500 psi and manufactured in accordance with American Society for Testing and Materials, C-94 (latest revision) "Specification for Ready-Mixed Concrete" and shall originate in a ready-mix plant that has been certified and approved by the National Ready-Mixed Concrete Association. The Contractor shall submit to the Engineer a copy of the certification prior to the delivery and placing of any concrete on this project. Coarse aggregate proportions shall conform to American Society for Testing and Materials, Concrete Aggregation C-33, Size No. 57 or 67. Concrete will be air-entrained, and the amount of air shall be 5%, plus or minus 1%. Concrete shall be placed to true grade. Subgrade shall be in accordance with the design details, but not less than 4-inches of 3/4-inch of clean crushed stone. Payment for stone subgrade shall be included in the price bid for the concrete sidewalks/slabs.

2.03 ACCESSORIES

- A. Curing Compound: Use the following Per PennDOT Standards:
 - 1. Burlap Cloth-made from jute or kenaf conforming to AASHTO M 182 Class 4.
 - 2. Liquid membrane-forming compound conforming to AASHTO M 148, Type 1-D clear or translucent with fugitive dye.
 - 3. White polyethylene sheeting conforming to AASHTO M 171 for white opaque polyethylene film.
- B. Liquid Surface Sealer: Per PennDOT Standards
- C. Surface Retarder: Per PennDOT Standards.
- D. Joint Sealers: Use the following Per PennDOT Standards:
 - 1. For sealing cracks and joints in concrete pavement use type IV sealer.
 - 2. For concrete pavements use cold-poured joint sealer that is listed on the QPL and conforms to ASTM D 5893, Type SL, except that the ultimate elongation is

- required to be a minimum of 1200%.
3. In vertical applications use cold-poured joint sealer that is listed on the QPL and conforms to ASTM D 5893, Type NS, except that the ultimate elongation is required to be a minimum of 600%. If recommended by the manufacturer, apply primer before applying the sealer.
 4. Use backer rod in conjunction with cold-poured joint sealer that conforms to ASTM D 5249, Type 1. Use backer rod with a width that is at least 25% greater than the width of the pavement joint or crack. Ensure that the backer rod is clean and dry at the time of installation.
 5. Submit a certificate of compliance for joint sealers and backer rods, along with test results.

2.04 CONCRETE MIX - BY PERFORMANCE CRITERIA

- A. Mix and deliver concrete in accordance with PennDOT Standards. Deliver concrete in accordance with PennDOT Standards.
- B. Select proportions for normal weight concrete in accordance with ACI 301 Method 1.
- C. Provide concrete to the following criteria:
 1. Compressive Strength: 4500-psi at 28-days.
 2. Slump: 1- to 3-inches
 3. Maximum Water/Cement Ratio: 0.488
 4. Air Entrained: per AASHTO M154.
- D. Use accelerating admixtures in cold weather only when approved by the Architect/Engineer in writing. Use of admixtures will not relax cold weather placement requirements.
- E. Use calcium chloride only when approved by the Architect/Engineer in writing.
- F. Use set retarding admixtures during hot weather only when approved by the Architect/Engineer in writing.

2.05 SOURCE QUALITY CONTROL AND TESTS

- A. Section 014000 – Quality Requirements Testing and Inspection Services:
- B. Submit proposed mix design of each class of concrete to appointed firm for review prior to commencement of Work.
- C. Tests on cement, aggregates, and mixes will be performed to ensure conformance with specified requirements.
- D. Test samples in accordance with PennDOT Standards.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Section 013100 – Project Management and Coordination: Verification of existing conditions before starting work.
- B. Verify compacted sub-grade is acceptable and ready to support paving and imposed loads.

- C. Verify gradients and elevations of base are correct.
- D. Concrete walks and driveways shall be rejected and ordered replaced by the Engineer if any or all of the following should occur or exist:
 - 1. Staining or discoloration of concrete sidewalk.
 - 2. Walk or driveway is out of alignment.
 - 3. Walk or driveway is out of grade.
 - 4. Joints and surfaces are improperly finished.
 - 5. Expansion joints protrude from concrete.
 - 6. Cracks, chips, or other damages occur during construction or maintenance period.
 - 7. Settlement of walk or driveway.
 - 8. Inspection not asked for prior to pouring of concrete.
 - 9. Improper vibration of concrete.
 - 10. Vandalism during initial setup of concrete.
- E. Separate payment will not be made for removal, disposal, and replacement of walks and driveways rejected due to the causes of rejection listed above.

3.02 SUBBASE

- A. Prepare sub-base in accordance with PennDOT Standards.

3.03 PREPARATION

- A. Moisten base to minimize absorption of water from fresh concrete.
- B. Coat surfaces of manhole and catch basin frames with oil to prevent bond with concrete pavement.
- C. Notify Architect/Engineer minimum 24-hours prior to commencement of concreting operations.

3.04 FORMING

- A. Place and secure forms to correct location, dimension, profile, and gradient.
- B. Assemble formwork to permit easy stripping and dismantling without damaging concrete.
- C. Place joint filler vertical in position, in straight lines. Secure to formwork during concrete placement.

3.05 REINFORCEMENT

- A. Place reinforcement as indicated.
- B. Interrupt reinforcement at contraction and expansion joints.
- C. Place dowels to achieve pavement and curb alignment as detailed.

3.06 PLACING CONCRETE

- A. Place concrete in accordance with PennDOT Standards.

- B. Ensure reinforcement, inserts, embedded parts, and formed joints are not disturbed during concrete placement.
- C. Place concrete continuously over the full width of the panel and between predetermined construction joints. Do not break or interrupt successive pours such that cold joints occur.

3.07 JOINTS

- A. The Contractor shall cut and remove sections of the existing pavement where indicated on the contract drawings or as directed by the Engineer. The work includes saw cutting or cutting by other means approved by the Engineer, of the existing concrete or bituminous pavement in a linear pattern, cutting of necessary re-bars, removal and spoiling existing pavement sections and excavated material. The Contractor shall be responsible to replace any curb section or other facilities damaged in the work as a result of the Contractor's workmanship at no additional compensation to the Contractor.
- B. Place expansion and contraction joints at intervals shown on Drawings. Align curb, gutter, and sidewalk joints.
- C. Place joint filler between paving components and building or other appurtenances.
- D. Provide scored joints at 3-foot intervals between sidewalks and curbs, and between curbs and pavement.
- E. Provide keyed joints as indicated on Drawings.

3.08 EXPOSED AGGREGATE

- A. Apply surface retarder where exposed aggregate finish is required.
- B. Wash exposed aggregate surface with clean water and scrub with stiff bristle brush, exposing aggregate.

3.09 FINISHING: NOT USED

3.10 JOINT SEALING

- A. Separate pavement from vertical surfaces with joint filler.
- B. Place joint filler in pavement pattern placement sequence. Set top to required elevations. Secure to resist movement by wet concrete.
 - 1. Extend joint filler from bottom of pavement to within 1/2-inch of finished surface. Conform to PennDOT Standards for finish joint sealer requirements.

3.11 TOLERANCES

- A. Section 014000 – Quality Requirements: Tolerances.
- B. Maximum Variation of Surface Flatness: 1/4-inch in 10-feet.
- C. Maximum Variation from true position: 1/4-inch

3.12 FIELD QUALITY CONTROL

- A. Section 014000 – Quality Requirements: Field inspecting, testing, adjusting, and balancing.
- B. Testing firm will take cylinders and perform slump and air entrainment tests in accordance with ACI 301 or PennDOT Standards.
- C. One additional test cylinder will be taken during cold weather and cured on site under same conditions as concrete it represents.
- D. One slump test will be taken for each set of test cylinders taken.
- E. Maintain records of placed concrete items. Record date, location of pour, quantity, air temperature, and test samples taken.

3.13 PROTECTION

- A. Immediately after placement, protect pavement from premature drying, excessive hot or cold temperatures, and mechanical injury.
- B. Do not permit pedestrian or vehicular traffic over pavement for 7-days minimum after finishing or until 75% design strength of concrete has been achieved.
- C. Transportation and disposal of the pavement removed shall be included and done in accordance with any applicable Federal, State, County or Local regulations.

END OF SECTION 32 13 13

SECTION 32 16 13 - SITE CONCRETE

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and all Divisions of these Specifications apply to this section.

1.02 DESCRIPTION OF WORK

- A. Furnish all labor, materials, equipment, and incidentals required for the provision and installation of all site concrete shown on the drawings and/or specified herein.
- B. The work includes, but is not necessarily limited to, the following:
 - 1. Soil aggregate base.
 - 2. Concrete Pavement.
 - 3. Concrete walks.
 - 4. Footings for furniture.
 - 5. Cutting and patching of existing work.
 - 6. Patching and repair of existing site concrete damaged or removed due to project work including installation of buried utility work and equipment.
 - 7. Stakeout.

1.03 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 312000 – Earth Moving.

1.04 QUALITY ASSURANCE

- A. All materials and work for concrete curbs, sidewalks, retaining walls etc., shall conform to the applicable Codes and Standards (latest editions) as noted herein or as otherwise governed by Local jurisdictions.
 - 1. Perform Work in accordance with ACI 301 and requirements of Section 033000.
 - 2. Obtain cementitious materials from same source throughout.
 - 3. Work in accordance with PennDOT Standard Specifications for Road and Bridge Construction, 2019, as amended.
 - 4. All ramps and sidewalks shall be in compliance with the Pennsylvania Barrier Free Code and ICC / ANSI A117.1.
 - 5. Definition of Terms: Whenever used in the above-referenced specifications, the following terms are herein defined:
 - a. Department shall mean the Owner.
 - 6. Cut sheets (grade sheets) prepared by a licensed Land Surveyor shall be submitted to the Project Manager for approval, 48-hours prior to construction.
- B. Concrete Testing:

1. The quality control, as specified, shall provide, direct, and control all sampling and testing of concrete for quality control during placement, in accordance with field quality control procedures specified therein.
2. Codes and Standards: Comply with provisions of the latest editions of the following codes, specifications, and standards, except where more stringent requirements are shown or specified:
 - a. ACI 301 "Specifications for Structural Concrete for Buildings".
 - b. ACI 318 "Building Code Requirements for Reinforced Concrete".
 - c. Concrete Reinforcing Steel Institute, "Manual of Standard Practice".
 - d. ACI 305 – Hot Weather Concreting.
 - e. ACI 306 – Standard Specifications for Cold Weather Concreting.
 - f. ACI 347 – Recommended Practices for Concrete Formwork.
 - g. ASTM A775 – Specification for Epoxy – Coated Reinforcing Steel.
 - h. ACI 308 – Standard Practice for Curing Concrete.
3. Concrete Testing Service: Employ, at Contractor's expense, a testing laboratory acceptable to Architect to design concrete mixes and perform material evaluation tests related to the concrete mixes.
4. Materials and installed work may require testing and retesting, as directed by Architect, at any time during the progress of work. Allow free access to material stockpiles and facilities. Tests, not specifically indicated to be done at Owner's expense, including retesting of rejected materials and installed work, shall be done at Contractor's expense.

PART 2 – PRODUCTS

2.01 MATERIALS

- A. Cast in Place Concrete:
 1. Portland cement shall comply with ASTM C150, Type IA or IIA. (Five to seven percent air entrained.)
 2. High early strength Portland cement shall comply with ASTM C150, Type IIIA.
- B. Stone Aggregate
 1. Subbase material: Graded mixture of crushed stone or gravel and sand, complying with ASTM D2940 with 90% passing a 1.5-inch sieve and not more than 12% passing a No. 200 sieve.
 2. Bedding material: Graded mixture of crushed stone or gravel and sand, complying with ASTM D2940 with 100% passing a 1-inch sieve and not more than 8% passing a No. 200 sieve.
- C. Forms:
 1. Steel, wood, or other suitable material of size and strength to resist movement during concrete placement and to retain horizontal straight forms, free of distortion and defects.
 2. Use flexible spring steel forms or laminated boards to form radius bends as required.
 3. Coat forms with a non-staining form release agent that will not discolor or deface the surface of the concrete.

- D. Expansion Joint Filler: Bituminous preformed cellular type, conforming to AASHTO M-213 or AASHTO M-33, and 3/4-inch thick by depth of slab.
- E. Concrete: 4500-psi air-entrained concrete.
- F. Anti-spalling Compound: Spencer-Kellogg or an equal, acceptable to the Architect.
- G. Aggregates for Concrete Mixing shall conform to ASTM C33. Coarse aggregate shall consist of crushed gravel, crushed stone, or other materials which have shown by actual service to produce concrete of the required quality.
- H. Concrete may contain a maximum size aggregate of 3/4-inches if spacing of the reinforcing steel permits.
- I. Water used in mixing concrete shall be potable and free from deleterious amount of acids, alkalis, or organic materials.
- J. Reinforcing steel shall conform to ASTM A 615, Grade 60 (epoxy coated).
- K. Ready-mixed concrete shall be mixed and delivered in accordance with the requirements set forth in "Specification for Ready-Mixed Concrete: (ASTM C94).
- L. Premolded expansion joint filler shall conform to ASTM D1751. The joint filler shall be of the thickness specified on the Drawings. The depth shall also permit a 1/4-inch (depth) application of joint sealer as specified.
- M. Joint sealer shall be an acrylic building sealant (meeting Federal Specifications TT-S-00230, Non-Sag 19-G05B AAMA 808.3) as manufactured by Tremco or approved equal.

PART 3 – EXECUTION

3.01 INSPECTION

- A. Installer must examine the subgrade and conditions under which the work is to be installed and notify the contractor in writing of conditions detrimental to the proper and timely completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected in a manner acceptable to the Installer.

3.02 JOB CONDITIONS

No base course construction shall be performed, no concrete slabs surface-placed, when the subgrade is frozen or thawing or during unfavorable weather conditions, when the temperature of the air is 40°F. and falling, or when temperatures of less than 40°F. are anticipated within 24-hours.

3.03 SOIL AGGREGATE BASE COURSE

- A. Base course shall be placed and compacted to a thickness of not less than 4 inches, unless otherwise indicated, and constructed in one layer. Spread base course material with no pockets or fines or otherwise segregated material. Completely remove all segregated material and replace with well graded material. Compact the base course with approved self-propelled rollers. Compact places inaccessible to rollers with approved mechanical tampers. Maintain material at optimum moisture. After final compaction, scrape the surface and roll with smooth wheel rollers until the surface is

thoroughly bound, free from defects, hard, even and at proper grade and contour. Finished surface shall not extend above nor below true grade at any point by more than 1/4-inch.

3.04 CONCRETE SIDEWALK

- A. Set forms accurately to line, radius, and grade. Securely stake to prevent movement.
- B. Thoroughly consolidate and screed to a minimum thickness of 4-inches except as otherwise shown.
- C. Set premolded joints at equal spacing, maximum 20-feet on center. Provide joint filler against foundation walls and other vertical surfaces. Set 3/4-inches below level of finish slab for walks with concrete finish and flush where brick finish is shown. Contractor shall cut pre-molded filler if it is set higher than 3/4-inches below level of concrete.
- D. Trowel concrete to remain exposed and finish with a fine wet broom drawing across the surface of walk. Provide transverse tooled control joints between expansion joints at intervals equal to sidewalk width, except as otherwise shown. Tool all edges including both sides of expansion joints.
- E. Damp cure all concrete in accordance with requirements specified standards.
- F. Protect surface from damage from pedestrians and traffic until fully cured.
- G. Cure and seal exposed surfaces of walks in accordance with requirements specified (anti-spalling compound).

3.05 POURED IN PLACE CONCRETE

- A. General
 - 1. All concrete shall develop a minimum 28-day strength of 4500-psi unless otherwise specified. The minimum cement factor shall be 6-bags of Portland cement per cubic yard of concrete. The water cement ratio in a concrete mix shall not exceed 0.50. The measurements shall be by weight.
 - 2. Methods of conveying, depositing, curing, and protecting concrete and installing reinforcing steel, welded wire mesh and other materials included in the concrete shall be in the accepted manner and best standards recommended and outlined by the American Concrete Institute and Portland Cement Association on these subjects as if they were quoted in full here.
 - 3. All concrete shall be properly spaded and vibrated, and wood spreaders removed as the concrete rises in the forms. Back-up vibrators shall be at the job site in case of malfunctions.
 - 4. Exterior entryway stoops, ramps and slabs be broom finished and sidewalk edged by tool.
- B. Forms
 - 1. All concrete must be formed. Forms shall be built true to the line and grades designated. They shall be substantially constructed, strong, rigid, mortar-tight, and adequately braced or tied. Forms shall be designed and constructed to withstand all loads and pressures, including those imposed by plastic concrete taking full account of the stresses due to the rate of pour, effective vibration and conditions brought about by construction methods.

2. Re-used forms shall be in good condition in all respects. Grooves and chamfers shall be formed with finished lumber or approved plastic strips. All exposed edges and corners of concrete above grade, not otherwise specified on the drawings, shall be chamfered.
- C. Removal of Forms
1. Removal of Forms: When the placing of concrete has been complete under cold weather conditions, forms and supports may be removed from surfaces carrying no loads after 24-hours, or as directed by the Architect.
 2. During cold weather, forms and supports shall remain in place at least 5-days for surfaces carrying no loads.
 3. Upon removal of forms all ties shall be cut back to a depth of approximately 1.5-inches. Any honeycomb concrete shall be cut back to sound concrete. These openings shall be grouted with a stiff mortar of the same composition as that used in the concrete.
 4. Anchor-bolts, sleeved and anchors, hangers, piping, and other work required to be built into the concrete shall be accurately set in the forms prior to placement of concrete.
- D. Cold Weather
1. Concreting in Cold Weather: During cold weather, concrete may be placed when the air temperature in the shade and away from artificial heat is 40°F or above and rising. It shall not be placed when the air temperature in the shade and away from artificial heat is 40°F and falling, except with the specific approval of the Architect. When such placing of concrete is approved by the Architect, concrete shall conform to the requirements of the latest issue of ACI 306, "Recommended Practices for Cold Weather Concreting."
 2. If the concrete is to be protected by insulation, the insulation material shall be of a thickness and have thermal conductivity properties such as will insure the maintenance of the required temperatures for the specified period of time throughout the entire mass of concrete.
 3. The exact methods of placing, protecting, and curing concrete to be followed during all such cold weather work shall be specifically approved by the Architect, for each type of construction before concreting will be permitted to start. The Contractor shall assume all risk connected with placing concrete under cold weather conditions and approval by the Architect of the methods adopted shall in no way relieve the Contractor of his responsibility for the production of satisfactory concrete. Should the concrete placed under such conditions prove unsatisfactory it shall be rejected, removed, and replaced with satisfactory concrete, and no payment shall be made for removing and replacing the defective concrete.
- E. Hot Weather
1. Hot Weather Concreting: Methods of producing, placing, and curing concrete during high temperature, low humidity environmental conditions shall be as outlined in the American Concrete Institute (ACI) Standard 305-72, Recommended Practice for Hot Weather Concreting.
 2. Scheduling and procedure planned for producing, placing, and curing concrete shall be submitted to the Architect for approval well in advance of date concreting is anticipated. Under no circumstance shall concrete delivery be scheduled until all formwork and groundwork is completed, and all equipment and materials required for placing, handling, and curing the concrete are present at the job site.

3. Plans shall include procedures as stated in ACI 305, such as precooling of aggregate and the use of ice instead of water, necessary to limit the temperature of concrete when placed to less than 90°F. Admixture for retarding and water reducing shall not be allowed unless previously approved by the Architect, and only those meeting ASTM C494-71, "Standard Specifications for Chemical Admixtures for Concrete," Types B and D shall be considered for approval.

F. Quality Control

1. If the results of seven-day cylinder test indicate that the concrete may not develop the minimum 28-day strength specified, The Architect reserves the right to order the Contractor to immediately core the portion of the concrete structure represented by that cylinder for testing purposes. The coring shall be made of the size and at the locations ordered by the Architect. Coring and filling core holes with concrete shall be done at the Contractor's expense; core testing shall be done at the Contractor's expense. If the results of the core tests indicate that, in the sole opinion of the Architect, the expected rate of increase in strength is not sufficient to produce a satisfactory strength at 28-days, the portion of the concrete structure represented by the core, as delineated by the Architect, shall be removed, and disposed of, at the Contractor's expense, and that portion replaced with new construction. If the results of the core tests indicate that satisfactory 28-day strength may yet be realized, possible rejection of concrete in question shall be deferred until the 28-day cylinders are tested. If a 28-day cylinder breaks at a strength below the required value, the Architect reserves the right to immediately reject the concrete represented by the cylinder, ordering such construction removed and replaced within designated limits, or he may permit the Contractor to perform additional coring. If additional coring is permitted, the Architect will either accept or reject the concrete represented on the basis of the 28-day core tests and all previous tests. The Architect's decision in these cases shall be final and conclusive.
2. In the event that, during the course of construction, and following satisfactory seven-day cylinder tests, a 28-day concrete cylinder breaks at a compressive strength lower than shown above for that age, the Architect reserves the right to immediately reject the concrete represented by the cylinder, ordering such construction removed and replaced within designated limits, or he may permit the Contractor to perform coring whenever ordered. If coring is permitted, the Architect will either accept or reject the concrete represented on the basis of the 28-day core tests and all previous tests. Coring and filling core holes with concrete shall be done at the Contractor's expense; core testing shall be done at the Architect's expense. The Architect's decision in these cases shall be final and conclusive.
3. Consistency: The slump range for concrete to be compacted by approved mechanical vibrators, shall conform to the following requirements (Testing laboratory shall perform all slump testing):
 - a. Test Cylinders: In order that the Architect can maintain a record of the strength gain of all concrete placed, Contractor shall have a certified testing laboratory make standard 6-inch by 12-inch concrete test cylinders for determining compressive strength, perform slump tests as required of the concrete used during the course of construction. The Contractor shall provide the concrete and mold for the test cylinders; also, he shall be responsible for the handling and protection of the cylinders on the job site and shall arrange for delivery of the cylinders to the testing laboratory as directed by the

Architect. The Architect will indicate the identification to be marked (or tagged) on each cylinder. When concreting during hot or cold weather conditions, test cylinders. Shall receive the same protection treatment as the concrete structure.

- b. general, one set of cylinders shall be made for each 30-cubic yards, or fraction thereof, of concrete placed each day and/or as directed by the Architect. Each set of cylinders shall consist of 4- or 6-cylinders. When 6-cylinders are made, two may be tested at three days, for the purpose of determining weather or not the concrete represented by the cylinders has acquired sufficient strength to support safely its own dead weight and any loads that may be imposed thereon. Normally, 2-cylinders of each set shall be tested at 7-days and 2-cylinders of each set shall be tested at 28-days.
- c. The cost of the concrete cylinder molds, preparing the cylinders, care of the cylinders on the site, and transporting the cylinders to the laboratory shall be at the expense of the Contractor. The Contractor will pay the costs of making the tests at the laboratory. All field and laboratory test data shall be delivered to the Architect.
- d. The period of time between mixing and delivery must be kept to an absolute minimum; therefore, attention shall be given to coordinating the dispatching of trucks with the rate of placement to avoid delays. The first batch in particular shall be placed promptly on arrival. Placement shall be in shallow layers and concrete shall be vibrated immediately after placement.
- e. Cast in Place Concrete, Allowable Slump:

Types of Construction	Slump in In.
Sidewalks and Driveways	3 +/- 1
Curb	4 +/- 1
Signposts, Posts, Guide Rails,	3 +/- 1
Footings	3 +/- 1

3.06 FIELD QUALITY CONTROL

- A. Perform inspection and testing of site concrete work in accordance with requirements specified in Articles 1.4 B and Article 3.

3.07 ALTERATIONS AND PATCHING

- A. Perform all necessary alterations and patching to existing adjacent work to obtain inconspicuous joints between existing and new work.

END OF SECTION 32 16 13

SECTION 32 91 13 - SOIL PREPARATION

PART 1 GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Preparation of subsoil.
 - 2. Placing topsoil.
- B. Related Sections:
 - 1. Section 310513 – Soils for Earthwork.
 - 2. Section 312213 – Rough Grading.
 - 3. Section 312317 – Trenching.
 - 4. Section 329119 – Landscape Grading.
 - 5. Section 329219 – Seeding.
 - 6. Section 329223 – Sodding.
 - 7. Section 329300 – Plants.

1.02 SUBMITTALS

- A. Test Reports: Indicate topsoil nutrient and pH levels with recommended soil supplements and application rates.

1.03 QUALITY ASSURANCE

- A. Perform Work in accordance with PennDOT Standard Specifications for Road and Bridge Construction, 2019, as amended.

PART 2 PRODUCTS

2.01 SOIL MATERIALS

- A. Topsoil: As specified in Section 310513.

2.02 SOURCE QUALITY CONTROL

- A. Provide recommendation for fertilizer and lime application rates for specified seed mix as result of testing.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify prepared soil base is ready to receive the Work of this section.

3.02 PREPARATION OF SUBSOIL

- A. Prepare sub-soil to eliminate uneven areas and low spots. Maintain lines, levels, profiles, and contours. Make changes in grade gradual. Blend slopes into level areas.
- B. Remove foreign materials, weeds and undesirable plants and their roots. Remove contaminated sub-soil.
- C. Scarify subsoil to depth of 6-inches where topsoil is to be placed. Repeat cultivation in areas where equipment, used for hauling and spreading topsoil, has compacted sub-soil.

3.03 PLACING TOPSOIL

- A. Spread topsoil to minimum depth of 8-inches over area to be seeded. Rake until smooth.
- B. Place topsoil during dry weather and on dry, unfrozen subgrade.
- C. Remove vegetable matter and foreign non-organic material from topsoil while spreading.
- D. Grade topsoil to eliminate rough, low, or soft areas, and to ensure positive drainage.

END OF SECTION 32 91 13

SECTION 32 91 19 - LANDSCAPE GRADING

PART 1 GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Final grade topsoil for finish landscaping.
- B. Related Sections:
 - 1. Section 329219 – Seeding.
 - 2. Section 329223 – Sodding.

1.02 SUBMITTALS

- A. Materials Source: Submit name of imported materials source and certification that Topsoil meets the specifications of PennDOT Section 917.01.

1.03 QUALITY ASSURANCE

- A. Furnish each topsoil material from single source throughout the Work.
- B. Perform work in accordance with PennDOT Standard Specifications for Road and Bridge Construction, 2019, as amended.

PART 2 PRODUCTS

2.01 MATERIAL

- A. Topsoil shall be in accordance with PennDOT Specifications (Section 917.01).

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify building and trench backfilling have been inspected.
- B. Verify substrate base has been contoured and compacted.

3.02 PREPARATION

- A. Protect landscaping and other features remaining as final Work.
- B. Protect existing structures, fences, sidewalks, utilities, paving, and curbs.

3.03 SUBSTRATE PREPARATION

- A. Eliminate uneven areas and low spots.
- B. Remove debris, roots, branches, stones, in excess of 1/2-inch in size. Remove contaminated subsoil.
- C. Scarify surface to depth of 3-inches where topsoil is scheduled. Scarify in areas where equipment used for hauling and spreading topsoil has compacted subsoil.

3.04 PLACING TOPSOIL

- A. Place topsoil in areas where seeding, planting, is required. Place topsoil during dry weather.
- B. Fine grade topsoil to eliminate rough or low areas. Maintain profiles and contour of subgrade.
- C. Remove roots, weeds, rocks, and foreign material while spreading.
- D. Manually spread topsoil close to plant material to prevent damage.
- E. Lightly compact placed topsoil.
- F. Remove surplus subsoil and topsoil from site.
- G. Leave stockpile area and site clean and raked, ready to receive landscaping.

3.05 TOLERANCES

- A. Top of Topsoil: Plus or minus 1/2-inch.

3.06 PROTECTION OF INSTALLED WORK

- A. Prohibit construction traffic over topsoil.

END OF SECTION 32 91 19

SECTION 32 92 19 - SEEDING

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

- A. Section Includes:
 - 1. Fertilizing.
 - 2. Seeding.
 - 3. Hydroseeding.
 - 4. Mulching.
 - 5. Maintenance.
- B. Related Sections:
 - 1. Section 312000 – Earthmoving.
 - 2. Section 312213 - Rough Grading.
 - 3. Section 329119 – Landscape Grading.
 - 4. Section 329223 - Sodding.

1.03 REFERENCES

- A. ASTM International:
 - 1. ASTM C602 – Standard Specification for Agricultural Liming Materials.
- B. NJDOT Standard Specifications for Road and Bridge Construction, 2019, as amended.

1.04 DEFINITIONS

- A. Weeds: Vegetative species other than specified species to be established in given area. Include Dandelion, Jimsonweed, Quackgrass, Horsetail, Morning Glory, Rush Grass, Mustard, Lambsquarter, Chickweed, Cress, Crabgrass, Canadian Thistle, Nutgrass, Poison Oak, Blackberry, Tansy Ragwort, Bermuda Grass, Johnson Grass, Poison Ivy, Nut Sedge, Nimble Will, Bindweed, Bent Grass, Wild Garlic, Perennial Sorrel, and Brome Grass.

1.05 SUBMITTALS

- A. Product Data: Submit data for seed mix, fertilizer and mulch, and other accessories.
- B. Provide certification that the seed mix is approved by the county Conservation District.

1.06 CLOSEOUT SUBMITTALS

- A. Section 017700 - Closeout Procedures: Requirements for submittals.
- B. Operation and Maintenance Data: Include maintenance instructions, cutting method and maximum grass height.

1.07 QUALITY ASSURANCE

- A. Provide seed mixture in containers showing percentage of seed mix, germination percentage, inert matter percentage, weed percentage, year of production, net weight, date of packaging, and location of packaging.
- B. Perform Work in accordance with NJDOT Standard Specifications for Road and Bridge Construction, 2019, as amended.
- C. Perform Work in accordance with the approved Soil Erosion and Sediment Control Plan and the county Conservation District requirements.

1.08 QUALIFICATIONS

- A. Seed Supplier: Company specializing in manufacturing Products specified in this section with minimum 3-years of experience.
- B. Seed Installer: Company specializing in performing work of this section with minimum 5-years of documented experience.
- C. Approved Suppliers, include, but are not necessarily limited to:
 - 1. Ernst Conservation Seeds, Inc.
 - 2. Pennington Seed.
 - 3. Or equivalent.

1.09 DELIVERY, STORAGE, AND HANDLING

- A. Section 016600 - Storage and Handling Requirements: Product storage and handling requirements.
- B. Deliver grass seed mixture in sealed containers. Seed in damaged packaging is not acceptable.
- C. Deliver fertilizer in waterproof bags showing weight, chemical analysis, and name of manufacturer.

1.10 MAINTENANCE SERVICE

- A. Section 017300 - Execution: Requirements for maintenance service.
- B. Maintain seeded areas immediately after placement until grass is well established and exhibits vigorous growing condition for two cuttings.

PART 2 – PRODUCTS

2.01 SEED MIXTURE

- A. Furnish materials in accordance with NJDOT Standard Specifications for Road and Bridge Construction, 2019, as amended.
- B. Lawn Seed Mixture: Per Soil Conservation District Standards..

2.02 ACCESSORIES

- A. Mulching Material: As specified on the project drawings.
- B. Fertilizer: As specified on the project drawings.
- C. Lime: ASTM C602, Class T agricultural limestone containing a minimum 80% calcium carbonate equivalent.
- D. Water: Clean, fresh, and free of substances or matter capable of inhibiting vigorous growth of grass.
- E. Stakes: Softwood lumber, chisel pointed.
- F. String: Inorganic fiber.

2.03 SOURCE QUALITY CONTROL

- A. Section 014000 - Quality Requirements: Testing, inspection, and analysis requirements.
- B. Analyze to ascertain percentage of nitrogen, phosphorus, potash, and soluble salt content, organic matter content, and pH value.
- C. Provide recommendation for fertilizer and lime application rates for specified seed mix as result of testing.
- D. Testing is not required when recent tests and certificates are available for imported topsoil. Submit these test results to the testing laboratory. Indicate, by test results, information necessary to determine suitability.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify prepared soil base is ready to receive the Work of this section.
- B. Any areas of soil compaction shall be scarified.

3.02 FERTILIZING

- A. Apply lime at the application rate recommended by soil analysis. Work lime into top 4-inches of soil.
- B. Apply fertilizer at application rate recommended by soil analysis.
- C. Apply after smooth raking of topsoil.
- D. Do not apply fertilizer at same time or with same machine used to apply seed.
- E. Mix fertilizer thoroughly into upper 4-inches of topsoil.
- F. Lightly water soil to aid dissipation of fertilizer. Irrigate the top level of soil uniformly.

3.03 SEEDING

- A. Apply seed at rate as specified on the plans evenly in two intersecting directions. Rake in lightly.
- B. Do not seed areas in excess of that which can be mulched on same day.
- C. Planting Season: Seeding shall take place only from March 1st to April 30th or August 15th, to October 15th. Seeding outside of those dates may only be performed if the Owner's consent is received.
- D. Do not sow immediately following rain, when the ground is too dry, or when winds are over 12-mph.
- E. Immediately following seeding and compacting, apply mulch to thickness of 1/8-inches. Maintain clear of shrubs and trees.
- F. Apply water with fine spray immediately after each area has been mulched. Saturate to 4-inches of soil.
- G. The contractor is responsible for watering of the seed and grass until project close-out.

3.04 HYDROSEEDING

- A. Apply fertilizer, mulch, and seeded slurry with hydraulic seeder at rate specified by the county Conservation District. Hydroseeding may only be performed during the optimum seeding season.
- B. After application, apply water with fine spray immediately after each area has been hydroseeded. Saturate to 4-inches of soil and maintain moisture levels 2- to 4-inches.

3.05 SEED PROTECTION

- A. Cover seeded slopes where grade is 4:1 or greater with erosion fabric. Roll fabric onto slopes without stretching or pulling.
- B. Lay fabric smoothly on surface, bury top end of each section in 6-inch deep excavated topsoil trench. Overlap edges and ends of adjacent rolls minimum 12-inches. Backfill trench and rake smooth, level with adjacent soil.
- C. Secure outside edges and overlaps at 36-inch intervals with stakes.
- D. Lightly dress slopes with topsoil to ensure close contact between fabric and soil.
- E. At the sides of ditches, lay fabric laps in the direction of water flow. Lap ends and edges minimum 6-inches.

3.06 MAINTENANCE

- A. Lawn:
 - 1. Mow grass at regular intervals to maintain at maximum height of 3-inches. Do not cut more than 1/3 of the grass blade at each mowing. Perform the first mowing when seedlings are 40% higher than desired height.
 - 2. Neatly trim the edges and hand clip where necessary.
 - 3. Immediately remove clippings after mowing and trimming. Do not let clippings lay in clumps.

4. Water to prevent grass and soil from drying out.
5. Control growth of weeds. Apply herbicides. Remedy damage resulting from improper use of herbicides.
6. Immediately reseed areas showing bare spots.
7. Repair washouts or gullies.
8. Protect seeded areas with warning signs during maintenance period.

END OF SECTION 32 92 19