Project Manual

Volume 3



Prepared for:
Reading School District
800 WASHINGTON STREET
READING, PA 19601

Project:
Renovation Construction of:
HS Athletics Facility Phase 3
801 NORTH 13TH STREET
READING, PA 19604

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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 insulation materials and accessories for insulating Plumbing piping and equipment.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity and jackets (both factory- and field-applied, if any).

1.4 QUALITY ASSURANCE

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

1. Insulation Installed Indoors: Flame-spread 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. Coordinate clearance requirements with piping Installer for insulation application.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Mineral-Fiber Plumbing Pipe Insulation: Glass fibers bonded with a thermosetting resin complying with the following:

1. Products: Subject to compliance with requirements, provide Johns Manville Micro-Loc insulation or equal products manufactured by one of the following:

a. Knauf Insulation.
b. Owens Corning Fiberglas Insulation.

2. Type I, 850 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ-SSL jacket.
3. Provide High-impact-resistant, UV-resistant PVC jacketed fitting covers complying with ASTM D 1784, Class 16354-C; Flame spread 25 or less; Smoke development 50 or less.

B. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied FSK jacket complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. (40 kg/cu. m) or more. Thermal conductivity (k-value) at 100 deg F (55 deg C) is 0.29 Btu x in./h x sq. ft. x deg F (0.042 W/m x K) or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, provide one of the following:

a. CertainTeed Corp.; CrimpWrap.
b. Johns Manville; MicroFlex.
c. Knauf Insulation; Pipe and Tank Insulation.
d. Manson Insulation Inc.; AK Flex.
e. Owens Corning; Fiberglas Pipe and Tank Insulation.

C. 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. Products: Subject to compliance with requirements, provide products manufactured by one of the following:

a. Aeroflex USA Inc.; Aerocel.
b. Armacell LLC; AP Armaflex.
c. RBX Corporation; Insul-Sheet 1800 and Insul-Tube 180.

2.2 FIELD-APPLIED JACKETS

A. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming.

B. Aluminum Jacket: Comply with ASTM B209 (ASTM B209M), Alloy 3003, 3005, 3105, or 5005, Temper H-14.

C. Self-Adhesive Indoor/Outdoor Jacket (Non-Asphaltic): Vapor barrier and waterproofing jacket for installation over insulation located aboveground outdoors or indoors. Specialized jacket with five layers of laminated aluminum and polyester film with low-temperature acrylic pressure-sensitive adhesive. Outer aluminum surface is coated with UV-resistant coating for protection from environmental contaminants.

2.3 CEMENTS, ADHESIVES AND MASTICS

A. Provide all required types of cements, adhesives, mastics and other accessories required to install all insulation materials and systems per the Manufacturer’s Installation Requirements. Prepare surfaces as required by the insulation manufacturers. Install cements, adhesives and mastics per manufacturer’s recommendations.

PART 3 - EXECUTION

3.1 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 (300 mm) 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- (75-mm-) 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 (100 mm) o.c.
3. Longitudinal Seams: Overlap jacket seams at least 1-1/2 inches (40 mm). 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 (100 mm) 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 (50 mm) 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 other Division 22 Sections.

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.

3.2 MINERAL-FIBER INSULATION APPLICATION

A. Insulation Installation on Straight Pipes and Tubes per manufacturer’s instructions. Where vapor barriers are required, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant. For insulation with factory-applied jackets on above ambient surfaces, secure laps with outward clinched staples at 6 inches (150 mm) o.c. For insulation with factory-applied jackets on below ambient surfaces, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Fittings, Elbows, Valves and Pipe Specialties:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
4. Install insulation to flanges as specified for flange insulation application.

3.3 INSTALLATION OF FIELD-APPLIED JACKETS

A. Where PVC jackets are indicated, install with 1-inch (25-mm) overlap at longitudinal seams and end joints. Seal with manufacturer's recommended adhesive.

B. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

C. Where metal jackets are indicated, install with 2-inch (50-mm) overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless steel bands 12 inches (300 mm) o.c. and at end joints.

3.4 FLEXIBLE ELASTOMERIC INSULATION APPLICATION

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated. Apply Insulation on Pipe Fittings, Elbows, Valves and Pipe Specialties.

3.5 INSULATION APPLICATION SCHEDULE, GENERAL

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

3.6 INTERIOR INSULATION APPLICATION SCHEDULE

A. Service: Domestic hot and re-circulated hot water.

1. Operating Temperature: 60 to 140 deg F.
2. Insulation Material: 1 ½” Mineral fiber.

B. Service: Domestic cold water.

1. Operating Temperature: 35 to 60 deg F.
2. Insulation Material: 1” thick Mineral fiber with vapor barrier.

C. Service: Rainwater conductors and roof drain bodies.

1. Insulation Material: 1” Mineral fiber with vapor barrier.

D. Service: Condensate drain piping.

1. Insulation Material: ¾” Flexible elastomeric.

E. Service: Sanitary drain piping and accessories, associated with condensate drains, where indicated on the drawings.

1. Insulation Material: ¾” Flexible elastomeric.

END OF SECTION 220700

SECTION 230010 - BASIC HVAC REQUIREMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes general administrative and procedural requirements for HVAC installations. Administrative and procedural requirements are included in this Section and in other Non-technical/Division 01 Specification Sections.

1.3 PERMITS AND FEES

A. Refer to Non-technical/Division 01 Specification Sections, General Conditions of The Contract, for information relating to permits and fees.

1.4 PROJECT SCHEDULE

A. Refer to Non-technical/Division 01 Specification sections for contract completion time and project construction schedule.

1.5 SHOP DRAWINGS AND SUBMITTALS

A. Follow the procedures specified in the Non-technical/Division 01 Specification Sections. Also refer to individual sections of the Division 23 specifications for additional shop drawing and submittal requirements.

B. It is the responsibility of the contractor to thoroughly review any and all shop drawings prior to submission to the Architect/Engineer. The contractor's review shall include verifying conformance to the project documents. The contractor will also be responsible for verifying the quantities of materials are adequate.

C. All shop drawings shall be submitted with a cover sheet indicating the name of the project, the Architects and Engineers name, the name of the vendor and the contractor. There must be sufficient space on the title sheet to allow the appropriate stamping by both the Architect and the Engineer. Shop drawings and submittals not conforming to the above may be returned without review.

D. All shop drawing submittals will include a listing of any and all exceptions to the requirements indicated in the specifications and on the drawings. Where there are no exceptions, the submittals shall indicate such. Submittals that do not have this listing will not be reviewed.

1.6 COORDINATION DRAWINGS

A. Coordination drawings are required. Refer to Non-technical/Division 01 Specification Sections for the work required by this Contractor in preparing Coordination Drawings.

1.7 INSTALLATION ACCESSIBILITY

A. The installation of all equipment and appurtenances shall be completed so that access and clearances meet the requirements of the equipment manufacturer as well as the requirements of all applicable codes.

1.8 ACCEPTABLE MANUFACTURES

A. The design of the mechanical systems is based on the equipment manufacturer indicated on the drawings. Although individual sections of the specifications may list other manufacturers, these manufacturers will be accepted only if the following occurs:

1. Performance, as judged by the engineer, must be equal to the design-based equipment.
2. Operating characteristics, as judged by the engineer, must be identical to those of the design-based equipment.
3. Physical size of the equipment must be such that it can be installed in the available space, maintaining all required clearances for access/maintenance and meet the architectural requirements of the project such as installed height, length, width and operating weight. The contractor shall be responsible for verifying the equipment meets this requirement.
4. The contractor will be responsible for any costs associated for adding additional supports, changes in electrical wiring, piping changes, ductwork changes and / or controls that may be required if equipment other than the design based is used.

1.9 RECORD DOCUMENTS

A. Prepare record documents, including Operating and Maintenance Manuals, in accordance with Non-technical/Division 01 Specification Sections. In addition to the requirements specified, indicate the following installed conditions:

1. Mains and branches of piping systems, with valves and control devices and numbered, concealed unions located, and with items requiring maintenance located (i.e., traps, strainers, expansion compensators, tanks, etc.). Valve location diagrams, complete with valve tag chart. Indicate actual inverts and horizontal locations of underground piping.
2. Equipment locations (exposed and concealed), dimensioned from prominent building lines.
3. Approved substitutions, Contract Modifications, and actual equipment and materials installed.
4. Contract Modifications, actual equipment and materials installed.
5. Record Documents are to be prepared and/or revised to indicate the room names and numbers to be used by the owner after the projects is complete.

1.10 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to the project properly identified with names, model numbers, types, grades, compliance labels, and other information needed for identification.

B. When materials and products are stored on site, provide protection from weather and temperatures that may cause damage to the items.

1.11 EXTRA MATERIALS

A. Various Division 23 Specification Sections may indicate extra materials (filters, fan belts, etc.) that are to be provided with the respective equipment. Where indicated, the contractor shall provide the required extra materials.

B. When directed by the owner's representative, the contractor shall install extra filters in the respective equipment. If no additional installation is required, the contractor shall forward, to the owner, all extra materials. When forwarding materials obtain a receipt for any materials forwarded.

C. The contractor shall also provide a list of all filter sizes for each type and size of unit provided on the project.

1.12 WARRANTY

A. All equipment, material and labor provided by the contractor shall be warranted for a minimum period of one year after the date of substantial completion. Refer to Division 23 Technical Specification sections for additional Warranties that may be required.

PART 2 - PRODUCTS

2.1 Not Applicable.

PART 3 - EXECUTION

3.1 ROUGH-IN

A. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.

B. Obtain equipment shop drawings for the various items that require rough-in.

3.2 HVAC INSTALLATIONS

A. Sequence, coordinate, and integrate the various elements of mechanical systems, materials, and equipment. Comply with the following requirements:

1. Coordinate mechanical systems, equipment, and materials installation with other building components.
2. Verify all dimensions by field measurements.
3. Coordinate requirements for chases slots, and openings in other building components during the progress of construction, to allow for mechanical installations.
4. Sequence, coordinate, and integrate installations of mechanical materials and equipment for efficient flow of the Work. Give particular attention to large equipment requiring positioning prior to closing in the building.
5. Where mounting heights are not detailed or dimensioned, install systems, materials, and equipment to provide the maximum headroom possible.
6. 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. Provide required connection for each service.
7. Install systems, materials, and equipment to conform with approved submittal data, including coordination drawings, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the Work are shown only in diagrammatic form. Where coordination requirements conflict with individual system requirements, refer conflict to the Engineer.
8. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components, where installed exposed in finished spaces.
9. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations. Extend grease fittings to an accessible location.
10. Install systems, materials, and equipment giving right-of-way priority to the systems required to be installed at a specified slope.
11. Seal all places where piping or ducts pass through walls and floors.

3.3 CUTTING AND PATCHING

A. Perform cutting, fitting, and patching of mechanical equipment and materials required to:

1. Uncover Work to provide for installation of ill-timed Work.
2. Removal and replacement of defective Work.
3. Remove and replace Work not conforming to requirements of the Contract Documents.
4. Remove samples of installed Work as specified for testing.
5. Install equipment and materials in existing structures.

B. Upon written instructions from the Architect, uncover and restore Work to provide for Architect/Engineer observation of concealed Work.

C. In areas of the building where new finishes are being provided, the patching required on a surface which is to receive a new finish will be to bring the underlying surface up to the finish required to receive the final finish. This contractor shall coordinate subsurface finish requirements with the finish trade contractor(s).

D. Provide and maintain temporary partitions or dust barriers adequate to prevent the spread of dust and dirt to adjacent areas.

E. Patch existing finished surfaces and building components using new materials matching existing materials and experienced Installers. Installers' qualifications refer to the materials and methods required for the surface and building components being patched.

3.4 CLEANING

A. This contractor shall be required to thoroughly clean all installed equipment, ductwork and piping. Cleaning shall be required before substantial completion on any phase of the project. Do not use cleaning materials and agents that are hazardous to health or property or that may damage the finished surfaces.

END OF SECTION 230010

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SECTION 230500 – COMMON HVAC WORK REQUIREMENTS

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 materials and methods that are common to various HVAC installations.

1.3 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and chases.

E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

1.4 SUBMITTALS

A. Product Data: For the following:

1. Mechanical sleeve seals.
2. Escutcheons.
3. Access Doors.

B. Welding certificates.

1.5 QUALITY ASSURANCE

A. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."

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

1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

C. Electrical Characteristics for HVAC Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

1.6 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 HVAC installations.

B. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.

C. Coordinate requirements for access panels and doors for HVAC items requiring access that are concealed behind finished surfaces.

PART 2 - PRODUCTS

2.1 PIPE, TUBE, AND FITTINGS

A. Refer to individual Division 23 piping Sections for pipe, tube, and fitting materials and joining methods.

B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.2 JOINING MATERIALS

A. Refer to individual Division 23 piping Sections for special joining materials not listed below.

B. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch (3.2-mm) maximum thickness unless thickness or specific material is indicated.

    a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
    b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

2. AWWA C110, rubber, flat face, 1/8 inch (3.2 mm) thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.

C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

D. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

E. Brazing Filler Metals: AWS A5.8, 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.

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

2.3 DIELECTRIC FITTINGS

A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

B. Insulating Material: Suitable for system fluid, pressure, and temperature.

2.4 MECHANICAL SLEEVE SEALS

A. Description: Pipe wall penetration seals to be of the modular link type. Seals shall consist of a series of interlocking, molded synthetic rubber links, with heavy-duty plastic pressure plates, and corrosion resistant nuts and bolts. Seals to be designed to provide a hydrostatic seal between the pipe and wall penetration. Seals shall be sized and selected per manufacturer recommendations. Mechanical pipe seals shall be fabricated of an EPDM elastomer for general service and a Nitrile/ Buna-N for hydrocarbon / petroleum-based applications. Provide stainless steel hardware as required.

B. Steel wall sleeve: Cast in place concrete wall sleeves to be fabricated from galvanized heavy wall welded or seamless carbon steel pipe. All sleeves to have a 2" wide, full perimeter water stop, welded on both sides.

C. Mechanical pipe seals and wall sleeves shall be manufactured by The Metraflex Company®, or Flexicraft Industries.

2.5 SLEEVES

A. Galvanized-Steel Sheet: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

B. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.

C. Cast Iron: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

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

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 and rough brass.

2.7 CONCRETE EQUIPMENT BASES

A. Minimum compressive strength: 3500 p.s.i. at 28 days.

B. Minimum cementitious material content: 520 lb/cu. Yd.

2.8 GROUT

A. Description: ASTM C 1107, Grade B, non-shrink and nonmetallic, dry hydraulic-cement grout.

1. Characteristics: Post-hardening, volume-adjusting, non-staining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
3. Packaging: Premixed and factory packaged.

2.9 ACCESS DOORS

A. Manufacturers: Subject to review, provide access doors manufactured by Milcor, Inc or equal.

B. Description: Steel access doors and frames for installation in masonry and/or drywall/gypsum board assemblies. Provide fire rated access doors when doors are installed in a fire rated assembly.

C. Frames: minimum 16 gage steel with exposed nominal 1” flange around the perimeter of the unit. Where doors are to be installed in drywall/gypsum board assemblies provide frames with a drywall bead. Doors to be installed in masonry shall be furnished with adjustable metal masonry anchors.

D. Flush Panel Doors: minimum 14-gauge steel with concealed spring or piano hinge(s) with a minimum swing of 175 degrees. Finished with a factory-applied primer, suitable for field painting. Provide flush cylinder lock with key. Key all locks alike.

E. Access door schedule: In addition to access door(s) that may be shown on the drawings provide the following access doors to be installed where directed by the architect or engineer:

1. Five 16” x 16” to be installed in drywall/gypsum construction.
2. Five 16” x 16” to be installed in masonry construction.

2.10 FIRESTOPPING

A. The contractor shall be responsible for providing permanent, UL approved firestopping systems for all penetrations through fire rated floor or fire rated wall assemblies. All firestopping shall meet the requirements of ASTM E-814 and UL 1479. Firestopping for ducts shall be installed with materials and methods identified in UL Ventilation Duct Assemblies (HNLJ), V Series as applicable to the wall assembly specified.

B. Subject to compliance with project requirements, firestopping materials may be provided by one of the following manufacturers:

1. Specified Technologies Inc. (STI) Somerville, NJ.
2. Tremco, Beechwood, OH.

PART 3 - EXECUTION

3.1 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping according to the following requirements and Division 23 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, 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. Where piping and ducts are exposed in areas such as mechanical rooms and boiler rooms the installation shall an unobstructed passageway of not less than 42” in width and 80” minimum head clearance, as required by code.

F. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal. Install piping to permit valve servicing. Install piping at indicated slopes. Install piping free of sags and bends.

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

H. Install piping and pipe supports to allow application of insulation.

I. Select system components with pressure rating equal to or greater than system operating pressure.

J. Install escutcheons for penetrations of walls, ceilings, and floors.

K. Sleeves are not required for core-drilled holes.

L. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor 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 (50 mm) above finished floor level.

2. Install sleeves in all new walls and floor slabs as walls and slabs are constructed.
3. Install sleeves that are large enough to provide sufficient annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:

    a. Steel 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.

        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.

M. Aboveground and Underground, Exterior-Wall Pipe Penetrations: Provide Mechanical Sleeve Seal and wall sleeve.

1. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and sized per manufacturer’s recommendations. 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.

N. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at all pipe and duct penetrations. Where required seal all pipe and duct penetrations with firestop materials.

O. Verify final equipment locations for roughing-in.

P. 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 23 Sections specifying piping systems.

B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.

F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

G. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.

H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.3 PIPING CONNECTIONS

A. Make connections according to the following, unless otherwise indicated:

1. Install unions, in piping NPS 2 (DN 50) and smaller, adjacent to each valve and at final connection to each piece of equipment.
2. Install flanges, in piping NPS 2-1/2 (DN 65) and larger, adjacent to flanged valves and at final connection to each piece of equipment.
3. 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 to maintain unobstructed passageway of not less than 42” in width and 80” minimum head clearance as required by code.

C. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

D. Install HVAC equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

E. Install equipment to allow right of way for piping installed at required slope.

3.5 INSTALLATION OF PIPING UNDER EXISITNG FLOORS

A. Where the drawings indicate new piping is to be installed under existing slab-on-grade construction, the installing contractor will be required to verify the location(s) of any existing pipes, conduits or any other system components, that are required to remain in service, before saw cutting existing slabs.

3.6 CONCRETE EQUIPMENT BASES

A. Provide concrete bases for all floor mounted mechanical equipment unless otherwise noted on the contract drawings.

1. Construct concrete bases with a minimum height of 6” and extend bases not less than 6” larger, in all directions, than supported equipment.
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 and according to anchor-bolt manufacturer's written instructions.
6. Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project when applicable.

3.7 GROUTING

A. Mix and install grout for HVAC equipment base bearing surfaces, pump and other equipment base plates, and anchors. Clean surfaces that will come into contact with grout.

B. Provide forms as required for placement of grout. Avoid air entrapment during placement of grout. Place grout, completely filling equipment bases. Place grout on concrete bases and provide smooth bearing surface for equipment.

C. Place grout around anchors. Cure placed grout.

3.8 ACCESS DOORS

A. Comply with manufacturer's written instructions for installing access doors and frames. Set frames accurately in position and attach securely to supports with plane of face panels aligned with adjacent finish surfaces. Install doors flush with adjacent finish surfaces or recessed to receive finish material.

B. Adjust doors and hardware after installation for proper operation. Remove and replace doors and frames that are warped, bowed, or otherwise damaged.

END OF SECTION 230500

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SECTION 230530 - METERS AND GAUGES 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 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes: Thermometers, Gauges, Test plugs and accessories.

1.3 SUBMITTALS

A. Submit Product Data for type of product.

B. Provide operation installation and maintenance data.

PART 2 - PRODUCTS

2.1 METAL-CASE, LIQUID-IN-GLASS THERMOMETERS

A. Manufacturers: Subject to compliance with requirements, provide fully adjustable angle thermometers by one of the following:

1. Palmer - Wahl Instruments Inc.
2. Trerice, H. O. Co.
3. Weiss Instruments, Inc.
4. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.
5. Miljoco Corporation.

B. Case: Cast aluminum with dark blue epoxy coating, 9 inches long.

C. Window: Clear acrylic for temperatures up to 300 deg. F; glass for higher temperatures.

D. Tube: blue reading, organic filled.

E. Window: Clear acrlylic.

F. Stem: brass for thermowell installation and of length to suit installation.

G. Accuracy: Plus or minus 1 scale division.

2.2 THERMOWELLS

A. Manufacturers: Same as manufacturer of thermometer being used.

B. Description: Pressure-tight, brass construction, socket-type metal fitting made for insertion into piping and of type, diameter, and length required to hold thermometer.

2.3 PRESSURE GAUGES

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

1. Palmer - Wahl Instruments Inc.
2. Trerice, H. O. Co.
3. Weiss Instruments, Inc.
4. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.
5. Miljoco Corporation.

B. Dial-Type Pressure Gauges: Indicating-dial type complying with ASME B40.100.

1. Case: Liquid-filled type, fiberglass reinforced polypropylene, 4-1/2-inch diameter, solid front, blow-out back.
2. Pressure-Element Assembly: Bronze tube.
3. Pressure Connection: Brass, NPS ¼ or ½".
4. Movement: Stainless steel rotary type with stainless steel bushings.
5. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings.
6. Pointer: Red or other dark-color metal.
7. Window: Acrylic plastic.
8. Accuracy: plus or minus .5 percent range.
9. Vacuum-Pressure Range: 30-in. Hg of vacuum to 150 psig of pressure.
10. Range for Fluids under Pressure: Two times operating pressure.
11. Temperature range: 250 deg. F for heating systems; 150 Deg. F for all other hydronic systems.

C. Pressure-Gauge Fittings:

1. Valves: NPS 1/4 brass or stainless-steel needle type valve.

2.4 TEST PLUGS

A. Manufacturers: Subject to compliance with requirements provide test plug (PT Plug) products by one of the following:

1. Flow Design, Inc.
2. Peterson Equipment Co., Inc.
3. Sisco Manufacturing Co.
4. Trerice, H. O. Co.
5. Watts Industries, Inc.; Water Products Div.

B. Description: Ports are to be suitable to accept thermometer stem or pressure gauge adapter and shall have dual EPDM internal seals, threaded brass cap with metal retainer strap. Ports are to be adequate length and suitable for installation in insulated or non-insulated piping.

C. Construction: Brass body with dual EPDM seals.

D. Minimum Pressure and Temperature Rating: 1000 psig at 270 deg F.

PART 3 - EXECUTION

3.1 THERMOMETER APPLICATIONS

A. Install thermometers where indicated on the drawings, see plans and detail drawings.

B. Provide the following temperature ranges for thermometers

1. Heating Hot Water System: 30 to 240 deg. F, with 2-degree scale divisions.
2. Chilled Water System: 0 to 100 deg. F, with 2-degree scale divisions.

3.2 GAUGE APPLICATIONS

A. Install pressure gauges, where indicated in other Division 23 Sections, and where indicated on the drawings plans and detail drawings.

3.3 INSTALLATIONS

A. Install direct-mounting thermometers and adjust vertical and tilted positions.

B. Install thermowells with socket extending to center of pipe and in vertical position in piping tees where thermometers are indicated.

C. Install pressure gauges in piping tees with pressure gauge located on pipe at most readable position.

D. Install shut-off needle-valve and snubber fitting in piping for each pressure gauge and thermometer.

E. Install test plugs in tees in piping.

3.4 CONNECTIONS

A. Install meters and gauges adjacent to machines and equipment to allow service and maintenance for meters, gauges, machines, and equipment.

3.5 ADJUSTING

A. Calibrate meters according to manufacturer’s written instructions, after installation.

B. Adjust faces of meters and gauges to proper angle for best visibility.

END OF SECTION 230530

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SECTION 230540 – 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 this Section.

1.2 SUMMARY

A. This section includes various types of general duty valves used in HVAC systems.

1.3 SUBMITTALS

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

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain each type of valve from the same manufacturer.

B. ASME Compliance:

1. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
2. ASME B31.9 for building services piping valves.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping per the manufacturer’s recommendations and to prevent damage during shipping.

B. Store valves per the manufacturer’s recommendations.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

A. Refer to Part 3 for HVAC valve schedule and applications of valves.

B. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

C. Valve Sizes: Same as upstream piping unless otherwise indicated.

2.2 BRONZE BALL VALVES

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

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

   a. Conbraco Industries, Inc.
   b. Crane Co.; Crane Valve Group.
   c. Hammond Valve.
   d. Milwaukee Valve Company.
   e. NIBCO INC.

2. Description:

   a. Manufactured to comply with standard MSS SP-110.
   b. Rated for 150 psig SWP and 600 psig CWP.
   c. Two-piece cast bronze body.
   d. Seats: TFE.
   e. Anti-blowout stem and chrome plated bronze ball.

3. Where valves are to be installed in insulated piping, provide extended handles with memory stop, and made of a non-thermal conductive material. Provide a protective sleeve to allow operation of the valve without damaging the insulation.

2.3 BUTTERFLY VALVES

A. Cast-iron body butterfly Valves:

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

   a. Conbraco Industries, Inc.
   b. Crane Co.; Crane Valve Group.
   c. Hammond Valve.
   d. Milwaukee Valve Company.
   e. NIBCO INC.
   f. Watts Regulator Co, Inc.

2. Description:

   a. Manufactured to comply with MSS SP-67.
   b. 200 PSI CWP Rating.
   c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
   d. Body Material: ASTM A 126, cast iron.
   e. Seat: EPDM.
   f. Stem: 400 series stainless steel.
   g. Disc: Aluminum bronze.
   h. Operation: 6” and smaller, 10 position lever operator; 8” and larger gear operator.

3. Where valves are to be installed in insulated piping, provide extended neck.

2.4 BRONZE SWING CHECK VALVES

A. Class 150, Bronze Swing Check Valves with Bronze Disc:

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

   a. Crane Co.
   b. Milwaukee Valve Company.
   c. NIBCO INC.

2. Description:

   a. Manufactured to comply with MSS SP-67.
   b. CWP Rating: 300 psig.
   c. Body Design: Horizontal flow.
   d. Body Material: bronze.
   e. Disc: bronze.

2.5 IRON SWING CHECK VALVES

A. Class 125, Iron Swing Check Valves with Metal Seats:

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

   a. Crane Co.; Crane Valve Group; Crane Valves.
   b. Milwaukee Valve Company.
   c. NIBCO INC.

2. Description:

   a. Standard: MSS SP-71, Type I.
   b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
   c. Body Design: Clear or full waterway.
   d. Body Material: ASTM A 126, gray iron with bolted bonnet.
   e. Ends: Flanged.
   f. Trim: Bronze.

2.6 IRON, GROOVED-END SWING CHECK VALVES

A. 300 CWP, Iron, Grooved-End Swing Check Valves:

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

   a. Anvil International, Inc.
   b. Victaulic Company.

2. Description:

a. CWP Rating: 300 psig.
b. Body Material: ASTM A 536, ductile iron.
c. Seal: EPDM.
d. Disc: Spring operated, ductile iron or stainless steel.

2.7 LUBRICATED PLUG VALVES

A. Class 125, Regular-Gland, Lubricated Plug Valves with Threaded Ends:

1. Description:

a. Standard: MSS SP-78, Type II.
b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
c. Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
d. Plug: Cast iron or bronze with sealant groove.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

C. Examine threads on valve and mating pipe for form and cleanliness.

D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

E. Do not attempt to repair defective valves; replace with new valves.

3.2 VALVE INSTALLATION

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

B. Locate valves for easy access and provide separate support where necessary.

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

D. Install valves in position to allow full stem movement.

E. Install chain wheels on operators for ball and butterfly valves NPS 4 (DN 100) and larger and more than 96 inches (2400 mm) above floor. Extend chains to 60 inches (1520 mm) above finished floor.

3.3 ADJUSTING

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

3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valve applications are not indicated, use the following:

1. Shutoff Service: Ball or butterfly valves.
2. Throttling Service except Steam: Ball, or butterfly valves.
3. Pump-Discharge Check Valves:

    a. NPS 2 and Smaller: Bronze swing check valves with bronze disc.
    b. NPS 2-1/2 and Larger: Iron swing check valves with lever and weight or with spring or iron, center-guided, resilient-seat check valves.

B. If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP classes or CWP ratings may be substituted.

END OF SECTION 230540

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SECTION 230570 - IDENTIFICATION FOR HVAC SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following identification materials:

1. Equipment markers.
2. Pipe markers.
3. Duct markers.
4. Valve tags.
5. Valve schedules.
6. Warning tags.

B. Refer to other Division 23 Specification Sections for requirements to label and identify materials, equipment and accessories relating to other components of the HVAC System(s).

1.3 SUBMITTALS

A. Submit Product Data for type of marker and tag along with a schedule where each type will be installed.

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 MANUFACTURERS:

A. Provide identification materials available through Craftmark Pipe Markers or equal.

2.2 EQUIPMENT MARKERS

A. Equipment Markers: 1/8” thick black plastic tag with engraved data in white letters, pre-drilled holes for permanent attachment on equipment.

1. Minimum marker size: 4” wide by 2” high. Length and width to be larger if required for marker content.
2. Minimum letter size: ½”.
3. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate material.
4. Marker content: equipment name tag as shown on the drawings (i.e., AHU-1).

2.3 PIPING IDENTIFICATION DEVICES

A. Manufactured self-adhesive pipe markers: Preprinted, color-coded, with lettering indicating service, and showing direction of flow. Provide markers for all piping systems.

1. Colors: Comply with ASME/ANSI A13.1.
2. Lettering: Use standard piping system terms 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.

2.4 DUCTWORK IDENTIFICATION

A. Manufactured self-adhesive vinyl peel off markers, 4” x 24” with bold 2” letters. Include airflow direction, duct service (such as supply, return, and exhaust and air handling system identification (i.e. AHU-2 SUPPLY AIR).

2.5 VALVE TAGS

A. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and ½-inch numbers, with numbering scheme reviewed and approved by the owner’s representative. Provide 5/32-inch hole for fastener.

1. Material: 0.032-inch- thick brass.
2. Valve-Tag Fasteners: Brass wire-link or beaded chain.

2.6 VALVE SCHEDULES

A. Valve Schedules: For each piping system, on standard-size bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.

1. Valve-Schedule Frames: Glazed display frame for removable mounting on masonry walls for each page of valve schedule. Include mounting screws.
2. Frame: Extruded aluminum.
3. Glazing: ASTM C 1036, Type I, Class 1, Glazing Quality B, 2.5-mm, single-thickness glass.

PART 3 - EXECUTION

3.1 EQUIPMENT IDENTIFICATION

A. Install and permanently fasten equipment markers on each major item of HVAC equipment. Locate nameplates where accessible and visible. Nameplates are not required for HVAC equipment that is exposed to view in finished areas such as corridors, stairs, offices and classrooms. Include nameplates for the following general categories of equipment:

1. Modular Air Handling Units.
2. Destratification Fans.
3. Terminal Heating Units.

3.2 PIPING IDENTIFICATION

A. Provide labels for all piping systems including:

1. Chilled water.
2. Heating hot water.
3. Condensate piping.

B. Locate pipe markers where piping is above accessible ceilings, exposed in machine and/or equipment rooms and in maintenance spaces such as shafts, tunnels, and plenums 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.

3.3 DUCT IDENTIFICATION

A. Install duct markers with permanent adhesive on air ducts according to the following:

1. Supply ducts.
2. Return ducts.

3. Outside air intake ducts.
4. Exhaust ducts.

B. Locate duct markers where ducts are above accessible ceilings, exposed in machine and\or equipment rooms and in maintenance spaces such as shafts, tunnels, and plenums as follows:

1. Near each branch connection.
2. Near penetrations through walls, floors, ceilings, and non-accessible enclosures.
3. At access doors and similar access points.
4. Near major equipment items and other points of origination and termination.
5. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.

3.4 VALVE-TAG INSTALLATION

A. Install tags on all valves and control devices valves and control devices in all piping systems. List all tagged valves in a valve schedule.

B. Valve-Tag Application Schedule:

1. Valve-Tag Size and Shape for all piping systems:

a. 1-1/2 inches, round.

2. Valve-Tag Color: Natural.

C. The location of all valves shall be indicated by locator tags on the ceiling tile. Provide equipment locator tags in a color suitable to the owner. Tags to be push tack type with 7/8” diameter head as manufactured by Marketing Services Inc. or equal.

3.5 VALVE-SCHEDULE INSTALLATION

A. Mount valve schedule on wall in accessible location in each major equipment room. Provide a complete valve schedule in the O and M manuals.

END OF SECTION 230570

SECTION 230600 - HVAC 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. Testing, Adjusting and Balancing (TAB) work is to be provided a qualified TAB firm and shall be part of the HVAC Contractor's work.

B. Work under this section includes, but is not limited to, Testing, Adjusting and Balancing (TAB) of the following air systems, water systems and HVAC equipment:

1. All constant-volume and variable air volume systems.
2. All constant-flow hydronic systems and variable flow hydronic systems.
3. Indoor air handling units.
4. Terminal units such as cabinet heaters, unit heaters and convectors.
5. Existing air and water systems, where noted on the drawings.

C. All TAB work shall comply with the requirements of TAB procedures required by the Associated Air Balancing Council, National Environmental Balancing Bureau, Testing Adjusting and Balancing Bureau and ASHRAE.

D. Coordinate and witness the installation work of the HVAC Contractor including all sub-contractors working for the HVAC Contractor and Electrical Contractor. Provide progress inspections of the work to ensure the installation of all systems is progressing as required and will operate as specified when completed. Report results of the progress inspection to the Owner's Representative.

E. Submit balancing reports for all air and water systems.

F. Validate the start-up and operation of all HVAC equipment and systems by the HVAC Contractor.

G. Validate the start-up and operation of the HVAC Controls system. Submit reports indicating the operation of all equipment, throughout the range of operation, meets the requirement of the Sequence of Operations.

H. Refer to Commissioning specifications in Div 01 and 23 for additional work and coordination required by the TAB contractor.

1.3 DEFINITIONS

A. AABC: Associated Air Balance Council.

B. NEBB: National Environmental Balancing Bureau.

C. TABB: Testing Adjusting and Balancing Bureau.

D. TAB: Testing, adjusting, and balancing.

1.4 SUBMITTALS

A. Qualification Data: Within 45 days of Contractor's Notice to Proceed, submit documentation that the TAB contractor and this Project's TAB team members meet the qualifications specified herein.

1.5 QUALITY ASSURANCE

A. TAB Contractor Qualifications: Engage a TAB entity certified by NEBB, AABC and/or TABB in the testing, adjusting and balancing of both air and water systems. The firm shall guarantee that all work will be performed in accordance with the applicable NEBB, AABC and/or TABB procedures. Evidence of the firm's certification shall be provided to the engineer or designated owner's representative.

B. Instrumentation Type, Quantity, Accuracy, and Calibration: As described in ASHRAE 111, Section 5, "Instrumentation."

C. The TAB firm shall have a minimum of 5 years’ experience with projects of a similar size and scope.

1.6 PROJECT CONDITIONS

A. Full Owner Occupancy: Owner will occupy the site and portions of the existing building during entire TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations. Review the project’s construction phasing plan and provide the necessary number of TAB visits to comply with the phasing plan.

B. Review the project’s construction phasing plan and provide the necessary number of site visits to comply with the phasing plan and complete all tab work before each phase is scheduled to be complete.

PART 2 - PRODUCTS

2.1 DUCT ACCESSORY HARDWARE

A. Instrument Test Ports: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit the specified eternal duct insulation thickness. Provide special gaskets where test holes are to be installed in round or oval ducts. Test Ports to be Duro-Dyne model TH1, IP2 and/or IP4.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper TAB of systems and equipment. Examine systems for installed balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are accessible.

B. Refer to the Contract Drawings for notes that relate to balancing of the air and water systems.

C. Examine the approved shop drawing submittals for all HVAC systems and equipment prior to starting the TAB work.

D. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC system and equipment controls.

E. Examine ceiling plenums and underfloor air plenums used for supply, return, or relief air to verify that they meet the leakage class of connected ducts as specified in Division 23 Section Metal Ducts, and are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.

F. Examine equipment performance data including fan and pump curves.

1. 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.
2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.

G. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.

H. Examine test reports specified in individual system and equipment Sections.

I. Examine HVAC equipment and filters and verify that bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.

J. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning.

K. Examine strainers. Verify that startup screens are replaced by permanent screens with indicated perforations.

L. Examine three-way valves for proper installation for their intended function of diverting or mixing fluid flows.

M. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

N. Examine operating safety interlocks and controls on HVAC equipment.

O. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.2 PREPARATION

A. Verify all systems are complete, including controls, before starting the TAB work.

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.

1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
2. After testing and balancing, install test ports and duct access doors where required.
3. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish to meet the requirements of the installation.

B. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.

C. Take and report testing and balancing measurements in inch-pound (IP) units.

3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.

B. For variable-air-volume systems, develop a plan to simulate diversity.

C. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.

D. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.

E. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

F. Verify that motor starters are equipped with properly sized thermal protection.

G. Check dampers for proper position to achieve desired airflow path.

H. Check for airflow blockages.

I. Check condensate drains for proper connections and functioning.

J. Check for proper sealing of air-handling-unit components.

K. Where required, verify that air duct system is sealed as specified in Division 23 Section "Metal Ducts."

L. Install instrument test holes in ducts at all required locations for testing and balancing purposes.

M. Air Handling Unit(s) filters: Provide verification of controls and provide set points for monitoring the filter pressure drop in all air handling units where indicated in Specification Section 230900, Sequence of Operation. Provide adjustment when necessary.

N. Building Pressurization: Provide verification of controls and provide set points for building pressurization control in various systems as indicated in Section 230900, Sequence of Operation. Provide adjustment when necessary.

O. Verify performance of air flow monitors. Measure outdoor air flow at all air flow monitors and verify the measured air flows are within 5% of the air flow indicated on the BMS. Provide verification in the final balancing report.

3.5 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.

1. Measure total airflow. Measure air flows in main ducts and at terminal outlets and inlets.
2. Measure fan static pressures as follows to determine actual static pressure:

    a. Measure outlet static pressure as far downstream from the fan as practical 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 the 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.

3. Measure static pressure across each component that makes up an air-handling unit, rooftop unit, and other air-handling and -treating equipment.

    a. Report the cleanliness status of filters and the time static pressures are measured.

4. Measure static pressures entering and leaving other devices, such as sound traps, heat-recovery equipment, and air washers, under final balanced conditions.
5. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
6. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload will occur. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.

B. Adjust volume dampers for main duct, and major branch ducts to indicated airflows within specified tolerances.

1. Measure airflow of branch ducts.
2. Measure static pressure at a point downstream from the balancing damper, and adjust volume dampers until the proper static pressure is achieved.
3. Re-measure each branch duct after all have been adjusted. Continue to adjust branch ducts to indicated airflows within specified tolerances.

C. Measure air outlets and inlets without making adjustments. Measure terminal outlets using a direct-reading hood or outlet manufacturer's written instructions and calculating factors.

D. Adjust air outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using branch volume dampers rather than extractors and the dampers at air terminals. Adjust each outlet in same room or space to within specified tolerances of indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents. Adjust patterns of adjustable outlets for proper distribution without drafts.

E. Measure and verify ventilation air flows are as indicated on the equipment schedules.

3.6 GENERAL 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 the approved pump flow rate. Correct variations that exceed plus or minus 5 percent.

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 liquid level in expansion tank.
3. Check makeup water-station pressure gage for adequate pressure for highest vent.
4. Check flow-control valves for specified sequence of operation, and set at indicated flow.

5. Set differential-pressure control valves at the specified differential pressure. Do not set at fully closed position when pump is positive-displacement type unless several terminal valves are kept open.
6. Set system controls so automatic valves are wide open to heat exchangers.
7. Check pump-motor load. If motor is overloaded, throttle main flow-balancing device so motor nameplate rating is not exceeded.
8. Check air vents for a forceful liquid flow exiting from vents when manually operated.

3.7 PROCEDURES FOR CONSTANT-FLOW HYDRONIC SYSTEMS

A. Measure water flow at pumps. Use the following procedures except for positive-displacement pumps:

1. Verify impeller size by operating the pump with the discharge valve closed. Read pressure differential across the pump. Convert pressure to head and correct for differences in gage heights. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
2. Check system resistance. With all valves open, read pressure differential across the pump and mark pump manufacturer's head-capacity curve. Adjust pump discharge valve until indicated water flow is achieved. Monitor motor performance during procedures and do not operate motors in overload conditions.
3. Verify pump-motor brake horsepower. Calculate the intended brake horsepower for the system based on pump manufacturer's performance data. Compare calculated brake horsepower with nameplate data on the pump motor. Report conditions where actual amperage exceeds motor nameplate amperage.
4. Report flow rates that are not within plus or minus 10 percent of design.

B. Measure flow at all automatic flow control valves to verify that valves are functioning as designed.

C. Measure flow at all pressure-independent characterized control valves, with valves in fully open position, to verify that valves are functioning as designed.

D. Set calibrated balancing valves, if installed, at calculated presettings.

E. Measure flow at all stations and adjust, where necessary, to obtain first balance. System components that have Cv rating or an accurately cataloged flow-pressure-drop relationship may be used as a flow-indicating device.

F. Measure flow at main balancing station and set main balancing device to achieve flow that is 5 percent greater than indicated flow.

G. Adjust balancing stations to within specified tolerances of indicated flow rate as follows:

1. Determine the balancing station with the highest percentage over indicated flow.
2. Adjust each station in turn, beginning with the station with the highest percentage over indicated flow and proceeding to the station with the lowest percentage over indicated flow.
3. Record settings and mark balancing devices.

H. Measure pump flow rate and make final measurements of pump amperage, voltage, rpm, pump heads, and systems' pressures and temperatures including outdoor-air temperature.

I. Measure the differential-pressure-control-valve settings existing at the conclusion of balancing.

J. Check settings and operation of each safety valve. Record settings.

3.8 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

A. Provide locations of piping system pressure sensors to be installed in variable flow piping systems. Review the piping system layout for each system. Provide an initial pressure setting and adjust the final setting as required, when balancing is complete.

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

3.9 PROCEDURES FOR MOTORS

A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:

1. Manufacturer's name, model number, and serial number.
2. Motor horsepower rating.
3. Motor rpm.
4. Efficiency rating.
5. Nameplate and measured voltage, each phase.
6. Nameplate and measured amperage, each phase.
7. Starter thermal-protection-element rating.

B. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass of the controller to prove proper operation. Record observations including name of controller manufacturer, model number, serial number, and nameplate data.

C. ECM Motors: Obtain and review manufacturer’s information which indicates methods and procedures to balance air flow.

3.10 PROCEDURES FOR HEAT-TRANSFER COILS

A. Measure, adjust, and record the following data for each water coil:

1. Entering- and leaving-water temperature.
2. Water flow rate.
3. Water pressure drop.
4. Dry-bulb temperature of entering and leaving air.
5. Wet-bulb temperature of entering and leaving air for cooling coils.

6. Airflow.
7. Air pressure drop.

B. Measure, adjust, and record the following data for each electric heating coil:

1. Nameplate data.
2. Airflow.
3. Entering- and leaving-air temperature at full load.
4. Voltage and amperage input of each phase at full load and at each incremental stage.
5. Calculated kilowatt at full load.
6. Fuse or circuit-breaker rating for overload protection.

C. Measure, adjust, and record the following data for each steam coil:

1. Dry-bulb temperature of entering and leaving air.
2. Airflow.
3. Air pressure drop.
4. Inlet steam pressure.

D. Measure, adjust, and record the following data for each refrigerant coil:

1. Dry-bulb temperature of entering and leaving air.
2. Wet-bulb temperature of entering and leaving air.
3. Airflow.
4. Air pressure drop.
5. Refrigerant suction pressure and temperature.

3.11 PROCEDURES FOR TESTING, ADJUSTING, AND BALANCING EXISTING SYSTEMS

A. Perform a preconstruction inspection of existing equipment that is to remain and be reused.

1. Measure and record the operating speed, airflow, and static pressure of each fan.
2. Measure motor voltage and amperage. Compare the values to motor nameplate information.
3. Check the refrigerant charge.
4. Check the condition of filters.
5. Check the condition of coils.
6. Check the operation of the drain pan and condensate-drain trap.
7. Check bearings and other lubricated parts for proper lubrication.
8. Report on the operating condition of the equipment and the results of the measurements taken. Report deficiencies.

B. Before performing testing and balancing of existing systems, inspect existing equipment that is to remain and be reused to verify that existing equipment has been cleaned and refurbished. Verify the following:

1. New filters are installed.
2. Coils are clean and fins combed.
3. Drain pans are clean.

4. Fans are clean.
5. Bearings and other parts are properly lubricated.
6. Deficiencies noted in the preconstruction report are corrected.

C. Perform testing and balancing of existing systems to the extent that existing systems are affected by the renovation work.

1. Compare the indicated airflow of the renovated work to the measured fan airflows, and determine the new fan speed and the face velocity of filters and coils.
2. Verify that the indicated airflows of the renovated work result in filter and coil face velocities and fan speeds that are within the acceptable limits defined by equipment manufacturer.
3. If calculations increase or decrease the air flow rates and water flow rates by more than 5 percent, make equipment adjustments to achieve the calculated rates. If increase or decrease is 5 percent or less, equipment adjustments are not required.
4. Balance each air outlet.

3.12 FINAL REPORT

A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer. Include a list of instruments used for procedures, along with proof of calibration.

B. Final Report Contents: In addition to certified field-report data, include the following:

1. Pump curves.
2. Fan curves.
3. Manufacturers' test data.
4. Field test reports prepared by system and equipment installers.
5. Other information relative to equipment performance; do not include Shop Drawings and product data.

C. General Report Data: In addition to form titles and entries, include the following general data:

1. Title page.
2. Name and address of the TAB contractor.
3. Project name and location.
4. Architect's and Engineer’s name and address.
5. Contractor's name and address.
6. Report date.
7. Signature of TAB supervisor who certifies the report.
8. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
9. Summary of contents.
10. Data for terminal units, including manufacturer's name, type, size, and fittings.
11. Notes to explain why certain final data in the body of reports vary from indicated values.

12. Test conditions for fans and pump performance forms.

D. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:

1. Quantities of outdoor, supply, return, and exhaust airflows.
2. Water and steam flow rates.
3. Duct, outlet, and inlet sizes.
4. Pipe and valve sizes and locations.
5. Terminal units.
6. Balancing stations.
7. Position of balancing devices.

E. Air Handling Unit Test Reports: For air-handling units with coils, include the following:

1. Unit Data:

    a. Unit identification.
    b. Location.
    c. Make and type.
    d. Model number and unit size.
    e. Manufacturer's serial number.
    f. Unit arrangement and class.
    g. Discharge arrangement.
    h. Sheave make, size in inches, and bore.
    i. Center-to-center dimensions of sheave, and amount of adjustments in inches.
    j. Number, make, and size of belts.
    k. Number, type, and size of filters.

2. Motor Data:

    a. Motor 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. Center-to-center dimensions of sheave, and amount of adjustments in inches.

3. Test Data (Indicated and Actual Values):

    a. Total air flow rate in cfm.
    b. Total system static pressure in inches w.g.
    c. Fan rpm.
    d. Discharge static pressure in inches w.g.
    e. Filter static-pressure differential in inches w.g.
    f. Dirty filter setpoint.
    g. Preheat-coil static-pressure differential in inches w.g.
    h. Cooling-coil static-pressure differential in inches w.g.
    i. Heating-coil static-pressure differential in inches w.g.

j. Outdoor airflow in cfm.
k. Return airflow in cfm.
l. Outdoor-air damper position.
m. Return-air damper position.

F. Apparatus-Coil Test Reports:

1. Coil Data:

a. System identification.
b. Location.
c. Coil type.
d. Number of rows.
e. Fin spacing in fins per inch o.c.
f. Make and model number.
g. Face area in sq. ft.
h. Tube size in NPS.
i. Tube and fin materials.
j. Circuiting arrangement.

2. Test Data (Indicated and Actual Values):

a. Total supply air flow.
b. Total system static pressure in inches w.g.
c. Fan(s) rpm.
d. Discharge static pressure in inches w.g.
e. Filter static-pressure differential in inches w.g.
f. Dirty filter set point.
g. Preheat-coil static-pressure differential in inches w.g.
h. Cooling-coil static-pressure differential in inches w.g.
i. Heating-coil static-pressure differential in inches w.g.
j. Outdoor airflow in cfm.
k. Return airflow in cfm.
l. Outdoor-air damper position.
m. Return-air damper position.
n. Airflow monitor verification.

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

1. Fan Data:

a. System identification.
b. Location.
c. Make and type.
d. Model number and size.
e. Manufacturer's serial number.
f. Arrangement and class.
g. Sheave make, size in inches and bore.
h. Center-to-center dimensions of sheave, and amount of adjustments in inches.

2. Motor Data:

    a. Motor 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. Center-to-center dimensions of sheave, and amount of adjustments in inches.
    g. Number, make, and size of belts.

3. Test Data (Indicated and Actual Values):

    a. Total airflow rate in cfm.
    b. Total system static pressure in inches w.g.
    c. Fan rpm.
    d. Discharge static pressure in inches w.g.
    e. Suction static pressure in inches w.g.

H. Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:

1. Report Data:

    a. System and air-handling-unit number.
    b. Location and zone.
    c. Traverse air temperature in deg. F.
    d. Duct static pressure in inches w.g.
    e. Duct size in inches.
    f. Duct area in sq. ft.
    g. Indicated air flow rate in cfm.
    h. Indicated velocity in fpm.
    i. Actual air flow rate in cfm.
    j. Actual average velocity in fpm.
    k. Barometric pressure in psig.

I. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:

1. Unit Data:

    a. System and air-handling-unit identification.
    b. Location and zone.
    c. Room or riser served.
    d. Coil make and size.
    e. Flowmeter type.

2. Test Data (Indicated and Actual Values):

    a. Air flow rate in cfm.
    b. Entering-water temperature in deg. F.

c. Leaving-water temperature in deg. F.
d. Water pressure drop in feet of head or psig.
e. Entering-air temperature in deg. F.
f. Leaving-air temperature in deg. F.

J. Instrument Calibration Reports:

1. Report Data:

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

3.13 INSPECTIONS

A. Initial Inspection:

1. After testing and balancing is complete, operate each system and randomly check measurements to verify that the system is operating according to the final test and balance readings documented in the final report.

B. Final Inspection:

1. After initial inspection is complete and documentation by random checks verify that testing and balancing are complete and accurately documented in the final report, submit the final report for review.
2. The Owner may select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.
3. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."
4. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.

C. TAB Work will be considered defective if it does not pass final inspections. If TAB Work fails, proceed as follows:

1. Recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection.
2. If the second final inspection also fails, Owner may contract the services of another TAB contractor to complete TAB Work according to the Contract Documents and deduct the cost of the services from the original TAB contractor's final payment.

D. Prepare test and inspection reports.

3.14 ADDITIONAL TESTS

A. Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

END OF SECTION 230600

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SECTION 230700 - HVAC SYSTEM INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes insulation materials and accessories for insulating HVAC system piping, ductwork, and equipment.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, thickness, and jackets (both factory and field applied, if any).

1.4 QUALITY ASSURANCE

A. Duct and pipe insulation, including adhesives, shall have a flame spread index not more than 25 and a smoke-developed index of not more than 50 when tested in accordance with ASTM E 84 or UL 723, using the procedures of ASTM E2231. Duct coverings shall not flame, glow, smolder or smoke when tested in accordance with ASTM C 411 at the temperature to which they are exposed in service. The test temperature shall not fall below 250 degrees F.

B. All insulation values are to meet the requirements of the applicable edition of the International Energy Conservation Code.

C. Insulation installed on the exterior of ducts, located within the building, shall bear identification at intervals not greater than 36-inches, with the name of the manufacturer, the R value at the specified installed thickness and the flame spread and smoke developed indexes of the composite materials.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature. Store materials providing protection from the elements.

1.6 COORDINATION

A. Coordinate size and location of supports, hangers, and insulation shields. Coordinate clearance requirements with the duct and piping.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials. Insulation conductivity (k) shall not exceed 0.27 Btu per inch/h – ft2 – deg. F.

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

a. Armacell LLC; AP Armaflex.
b. Aeroflex USA Inc.; Aerocel.

B. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 1136 with factory-applied FSK jacket. Insulation conductivity (k) shall not exceed 0.27 Btu per inch/h – ft2 – deg. F.

1. Products: Subject to compliance with requirements, provide Johns Manville Microlite insulation or equal products manufactured by one of the following:

a. CertainTeed Corp.
b. Knauf Insulation.
c. Owens Corning.

C. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. For duct and plenum applications, provide insulation with factory-applied FSK jacket.

1. Subject to compliance with requirements, provide Johns Manville 800 Series Spin-Glas insulation or equal products manufactured by one of the following:

a. CertainTeed Corp.
b. Knauf Insulation.
c. Owens Corning.
d. Manson Insulation.

D. Mineral-Fiber, Preformed Pipe Insulation:

1. Subject to compliance with requirements, provide Johns Manville Micro-Lok insulation or equal products manufactured by one of the following:

a. Knauf Insulation; 1000 Pipe Insulation.
b. Owens Corning; Fiberglas Pipe Insulation.

2. Type I, 850 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ-SSL.
3. Provide High-impact-resistant, UV-resistant PVC jacketed fitting covers complying with ASTM D 1784, Class 16354-C; Flame spread 25 or less; Smoke development 50 or less.

E. Mineral-Fiber Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semi-rigid board material with factory-applied FSK jacket.

1. Subject to compliance with requirements, provide Johns Manville Micro-Flex insulation or equal products manufactured by one of the following:

a. Knauf Insulation; Pipe and Tank Insulation.
b. Owens Corning; Fiberglas Pipe and Tank Insulation.

F. Polyisocyanurate Board: Closed cell polyiso-foam board bonded on each side with a foil face. Flame Spread 25 or less: smoke development less than 450.

1. Subject to compliance with requirements, provide Johns Manville XSPECT Polyiso Foam Board. Exterior use only.

2.2 CEMENTS, ADHESIVES, SEALANTS AND MASTICS

A. Provide all required types of cements, adhesives, sealants, mastics and other accessories required to install all insulation materials and systems. Prepare surfaces as required by the insulation manufacturers. Install cements, adhesives, sealants and mastics per manufacturer's recommendations.

2.3 PVC JACKETING

A. Provide High-impact-resistant, UV-resistant PVC jacketed fitting covers complying with ASTM D 1784, Class 16354-C; Flame spread 25 or less; Smoke development 50 or less. Temperature rating 150 degrees F.

1. Subject to compliance with requirements, provide Johns Manville Zeston Jacketing or equal.

2.4 CORRUGATED ALUMINIUM JACKETING

A. Corrugated aluminum jacketing, 0.020-inch thickness. ASTM Standard C1729.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes per the manufacturer's instruction with smooth, straight, and even surfaces; free of voids throughout the length of equipment, ducts and fittings, and piping including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment, duct system, and pipe system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Keep insulation materials dry during application and finishing.

H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

I. Install insulation with least number of joints practical.

J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

L. Install insulation with factory-applied jackets per manufacturer’s instructions.

M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

3.2 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations. Seal penetrations with flashing sealant.

B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.

C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions. Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches.

F. Insulation Installation at Floor Penetrations:

1. Duct: Install insulation continuously through floor penetrations that are not fire rated. For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches.
2. Pipe: Install insulation continuously through floor penetrations.
3. Seal penetrations through fire-rated assemblies.

3.3 GENERAL PIPE INSULATION INSTALLATION

A. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Union and other specialties with continuous thermal and vapor-retarder integrity, unless otherwise indicated. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.

1. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
2. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.

3. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below ambient services, provide a design that maintains vapor barrier.
4. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
5. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below ambient services and a breather mastic for above ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
6. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
7. Stencil or label the outside insulation jacket of each union with the word "UNION." Match size and color of pipe labels.

B. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes, vessels, and equipment. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

3.4 FLEXIBLE ELASTOMERIC INSULATION INSTALLATION

A. Seal longitudinal seams and end joints with adhesives to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulate all pipe fittings, elbows, valves and pipe specialties.

C. Apply weather resistant coating on all exterior insulation to protect the insulation from ultraviolet rays. Provide Armaflex WB Finish water based coating or equal.

3.5 MINERAL-FIBER INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes per manufacturer’s instructions. Where vapor barriers are required, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant. For insulation with factory-applied jackets on above ambient surfaces, secure laps with outward clinched staples at 6 inches o.c. For insulation with factory-applied jackets on below ambient surfaces, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Fittings, Elbows, Valves and Pipe Specialties:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
4. Install insulation to flanges as specified for flange insulation application.

C. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins, apply adhesives according to manufacturer's recommended coverage rates per unit area.

1. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
2. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
3. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

D. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins. Apply adhesives according to manufacturer's recommended coverage rates per unit area.

1. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
2. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

3.6 DUCT INSULATION SCHEDULE, GENERAL

A. Duct systems requiring insulation on the exterior of the ducts:

1. Indoor exposed and concealed supply air and outdoor air ducts.
2. Indoor, exposed and concealed return air ducts located in an unconditioned space.
3. Indoor, exposed and concealed exhaust between isolation damper and penetration of building exterior.
4. Indoor, exposed and concealed, Type I kitchen hood exhaust.
5. Supply and return ducts located on the exterior of the building.
6. Other locations noted on the drawings.

B. Items Not Insulated:

1. Ducts with interior duct liner, unless otherwise noted.
2. Indoor exposed supply air ducts in heating only systems located in a conditioned space.
3. Indoor, exposed and concealed return ducts located in conditioned space.
4. Factory-insulated flexible ducts.
5. Factory-insulated plenums and casings.
6. Flexible connectors.
7. Factory-insulated access panels and doors.
8. Other locations noted on the drawings.

3.7 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

A. Concealed supply air ducts and plenums, hydronic coils furnished on VAV air terminal units and hydronic duct coils shall be insulated with:

1. Mineral-Fiber Blanket: 2-inches thick and 1.5-lb/cu. ft. nominal density; uncompressed “R” value 8.0; with vapor barrier having a maximum permeance of 0.05 perm.

B. Concealed return air ducts and plenums shall be insulated with:

1. Mineral-Fiber Blanket: 1-1/2-inches thick and 1.5-lb/cu. ft. nominal density; uncompressed “R” value 6.0; with vapor barrier having a maximum permeance of 0.05 perm.

C. Concealed outdoor air ducts and plenums shall be insulated with:

1. Mineral-Fiber Blanket: 2-inches thick and 1.5-lb/cu. ft. nominal density; uncompressed “R” value 8.0; with vapor barrier having a maximum permeance of 0.05 perm.

D. Concealed exhaust air ducts and plenums shall be insulated with:

1. Mineral-Fiber Blanket: 1-1/2-inches thick and 1.5-lb/cu. ft. nominal density; uncompressed “R” value 6.0; with vapor barrier having a maximum permeance of 0.05 perm.

E. Exposed supply-air ducts, plenums and all hydronic coils shall be insulated with:

1. Mineral-Fiber Board: 2-inches thick, 3-lb/cu. ft. density, “R” 8.7 with vapor barrier.

F. Exposed return-air ducts and plenums shall be insulated with:

1. Mineral-Fiber Board: 1-1/2-inches and 3-lb/cu. ft. density, “R” 6.5 with vapor barrier.

G. Exposed exhaust air ducts and plenums shall be insulated with:

1. Mineral-Fiber Board: 1-1/2 inches thick and 3-lb/cu. ft. density, “R” 6.5 with vapor barrier.

H. Exposed outdoor-air ducts and plenums shall be insulated with:

1. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft. density, “R” 8.7 with vapor barrier.

3.8 PIPING INSULATION SCHEDULE, GENERAL

A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:

1. Drainage piping located in crawl spaces.
2. Underground piping.
3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.9 INDOOR PIPING INSULATION SCHEDULE

A. Condensate and Equipment Drain Water Piping

1. All Pipe Sizes: Insulation shall be Flexible Elastomeric, ¾-inch thick.

B. Chilled Water Piping

1. NPS 1½-inches and smaller: Insulation shall be Mineral-Fiber with vapor barrier, 1½-inches thick.
2. NPS 2-inches and larger: Insulation shall be Mineral-Fiber with vapor barrier, 2-inches.

C. Dual Temperature Piping

1. NPS 1¼-inches and smaller: Insulation shall be Mineral-Fiber with vapor barrier, 1½-inches thick.
2. NPS 1½-inches and larger: Insulation shall be Mineral-Fiber with vapor barrier, 2“-thick.

D. Heating-Hot-Water Supply and Return Piping

1. NPS 1¼-inches and smaller: Insulation shall be Mineral-Fiber, 1½-inches thick.
2. NPS 1½-inches and larger: Insulation shall be Mineral-Fiber, 2-inches thick.

END OF SECTION 230700

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SECTION 230815 – HVAC SYSTEMS COMMISSIONING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. HVAC System Commissioning is required for various HVAC systems installed on the project. HVAC System Commissioning will be performed by a Commissioning firm experienced the commissioning process. The Commissioning firm will be hired by the School District.

B. The HVAC Contractor shall be responsible for installation of fully complete systems and sub-systems. The entire HVAC system shall be fully functional and shall meet the design intent indicated in the Contract Documents.

C. The HVAC Contractor shall provide start-up of all HVAC Systems. The work performed by the Owner's Commissioning Agent does not relieve or lessen this responsibility of the HVAC Contractor to provide a complete and fully functional system.

1.3 QUALITY ASSURANCE

A. The HVAC contractor shall identify a commissioning supervisor. The commissioning supervisor should have a minimum of ten years' experience in HVAC contracting. The commissioning supervisor shall become familiar with the design intent and the requirements of the commissioning process. The commissioning supervisor shall attend all commissioning meetings and coordinate the commissioning schedule as outlined by the Commissioning Agent. The commissioning supervisor shall assist the Commissioning Agent in coordinating and performing the commissioning activities.

1.4 HVAC CONTRACTOR RESPONSIBILITIES

A. Include an itemized cost of commissioning participation in the Application for Payments.

B. Assemble all contract drawings and shop drawings. The HVAC contractor shall review operation and maintenance information and as-built drawings and obtain all documentation from tests for review. The contractor shall document warranty start and end dates.

C. The HVAC commissioning supervisor shall be responsible for scheduling, supervising, and coordinating the startup and testing of all systems with the Commissioning Agent.

1.5 SUBMITTALS

A. Construction Checklists for the systems being commissioned.

B. At the completion of the tests, turn over all documentation to the local authority having jurisdiction and the owner. All test forms must be dated. All documentation must be turned over to the owner no later than 90 days from the date of the receipt of the certificate of occupancy.

1.6 PROJECT CONDITIONS

A. Partial Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during the Commissioning process to minimize conflicts with Owner's operations.

B. Project Phasing: Refer to the Non-Technical specifications which indicate the various phases of construction. Provide Commissioning services so that all mechanical systems located within or serving a particular area of the building are complete when the respective area is scheduled for occupancy.

PART 2 - PRODUCTS
Not Applicable

PART 3 - EXECUTION

3.1 GENERAL TESTING REQUIREMENTS

A. Mechanical systems to be commissioned on this project include, but are not limited to, the following:

1. HVAC System controls including verification that all systems are operating as described in Section 230900, Sequence of Operation.
2. Indoor air handling units.
3. Convectors, cabinet heaters and other terminal heating units.
4. Variable frequency drives.
5. Airflow monitoring units.

3.2 PRE-FUNCTIONAL TESTING PLAN

A. Pre-functional test forms will be provided by the Owner’s Commissioning Agent for all systems and equipment to ensure that the equipment and systems are properly installed and ready for operation, so that functional performance testing to may proceed without delays.

B. The pre-functional testing for all equipment and subsystems shall be successfully completed and documented prior to functional performance testing of the system. The HVAC Contractor and sub-contractors shall sign off on the Commissioning Agent’s pre-functional test sheets that they are complete and the system is ready. The

Commissioning Agent will verify and conduct their own independent verification and start-up in parallel to the contractor's verification. Any deficiencies identified during this process shall be noted, reviewed and corrected by the HVAC Contractor. Start-up and functional testing shall not proceed until all the deficiencies are corrected and verified by the Commissioning Agent.

3.3 FUNCTIONAL PERFORMANCE TESTING

A. Functional Performance Testing is the complete and total testing of all HVAC Systems and will be performed and completed by the Owner's Commissioning Agent.

B. All HVAC systems will be tested under various loads. The systems will be operated through all the anticipated sequences and components are verified to be responding as the design intent and documents.

C. The HVAC Contractor is required is supply personnel to assist during the functional performance testing when applicable.

D. No system shall be tested until the contractor and has certified, in writing, that the system, equipment and all components are complete, have been tested, adjusted and balanced and are ready for validating and performance testing.

E. Functional Performance Verification is scheduled by the Commissioning Agent after the pre-functional testing requirements are complete and signed-off by the Commissioning Agent. Functional Performance Verification will not be conducted until a written notice of completion by the contractor confirming that the system is ready Functional Performance Testing.

F. The HVAC Contractor shall provide personnel to operate the systems while functional performance testing is in progress.

G. The HVAC Contractor shall review the commissioning functional performance testing procedure supplied by the Commissioning Agent. After functional testing begins, the HVAC Contractor and the Commissioning Agent shall sign the functional test record and provide the Owner a copy for review. All deficiencies either corrected in the field or outstanding shall be documented on the functional test forms for review by all parties.

H. The Commissioning Agent shall clearly list any outstanding items on the initial start-up and pre-functional procedures that were not completed successfully. Any outstanding deficiencies shall be provided to The Owner within two days of test completion. The Commissioning Agent shall review the contractor's startup testing reports and shall submit either a non-compliance report or an approval form to the contractor. The Commissioning Agent shall work with the contractor and others as necessary, to correct and retest deficiencies or uncompleted items. The contractor shall correct all areas that are deficient or incomplete in the checklists and tests in a timely manner, and shall notify the Commissioning Agent as soon as outstanding items have been corrected and resubmit an updated start-up report. When all requirements are satisfactorily completed, the Commissioning Agent shall recommend approval of the startup and pre-functional testing of each system and schedule the functional testing of the equipment or system.

3.4 RETESTING

A. The cost for Commissioning Agent personnel to conduct any retesting of a functional performance test necessitated because a specific pre-functional or startup test item, reported to have been successfully completed, but found to be incomplete or faulty, shall be the responsibility of the contractor. For a deficiency identified during the functional testing, not related to any pre-functional checklist or start-up fault, the Commissioning Agent and Contractor shall direct the retesting of the equipment once at “no charge” for their time. However, all costs for any subsequent retesting shall be the responsibility of the HVAC Contractor. Items left incomplete, which later cause deficiencies or delays during functional testing may result in back-charges to the responsible party.

END OF SECTION 230815

SECTION 230900 – HVAC SYSTEM CONTROLS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. Refer to other HVAC Specification Sections which describe the requirements of the HVAC system components.

1.2 SUMMARY

A. This Section includes direct digital control (DDC) equipment for control of HVAC systems and various other systems.

B. Refer to all Division 23 specification sections for controls that may be provided with the associated equipment.

C. Work under this section includes, but is not limited to, providing the required controls and accessories to accomplish the method of control as indicated in Section 230905, Sequence of Operation, for the following HVAC equipment:

1. Modular air handling units.
2. Hydronic finned-tube terminal heating units.
3. Variable frequency drives.
4. Sequence(s) that are indicated on the construction drawings.

D. The controls sub-contractor will be required to participate in the Start-Up as well as the Testing, Adjusting, Balancing and Commissioning of the HVAC System. Refer to other HVAC specifications for the work required by the controls sub-contractor.

E. The Building Management System (BMS) installer / supplier shall furnish and install a fully integrated building automation system, incorporating direct digital control (DDC) for energy management, equipment monitoring and control, and subsystems as specified. Provide a complete and fully operational system. The system shall allow the Owner to have access through the internet with password security to suite the Owner's needs. The installation of the control system shall be performed under 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.

F. The BMS shall be an extension to the existing Johnson Controls, Metasys based controls system currently used by the Reading School District.

G. The BMS manufacturer/supplier shall be responsible for all BMS control and power wiring for a complete and operable system. All wiring shall be done in accordance with all applicable local, state and national codes.

H. The BMS installation must be supervised by personnel directly employed by the manufacturer/supplier.

I. All existing controls, both pneumatic and electronic, are to remain operational during construction. At the completion of the project all existing pneumatic controls and the associated components will be removed. Provide the following to accommodate the phased construction schedule:

1. Temporary control and power wiring as required to accommodate the renovation phasing schedule.
2. Temporary extensions to the existing pneumatic tubing where required.
3. Remove control system components (i.e., wiring, pneumatic tubing, actuators) as phasing allows.
4. Where existing pneumatic controls are to remain, verify the tubing and other system components are fully functional. Repair or replace components as required.
5. Cap existing pneumatic tubing as needed.
6. As construction phasing progresses provide extensions to the control system as needed and remove existing components that are no longer required.

1.3 DEFINITIONS

A. DDC: Direct Digital Control

B. BMS: Building Management System.

C. BAS: Building Automation System.

D. EMS: Energy Management System.

E. PC: Personal computer.

1.4 SUBMITTALS

A. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated.

B. DDC System Hardware: Bill of materials of equipment indicating quantity, manufacturer, and model number. Include technical data for operator workstation equipment, interface equipment, control units, transducers/transmitters, sensors, actuators, valves, relays/switches, control panels, and operator interface equipment.

C. Control System Software: Include technical data for operating system software, operator interface, color graphics, and other third-party applications.

D. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.

E. Shop Drawings: Provide detailed equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection. Include the following:

1. Bill of materials of equipment indicating quantity, manufacturer, and model number.
2. Schematic flow diagrams showing fans, pumps, coils, dampers, valves, and control devices.
3. Wiring Diagrams: Power, signal, and control wiring.
4. Details of control panel faces, including controls, instruments, and labeling.
5. Written description of sequence of operation.
6. Schedule of dampers including size, leakage, and flow characteristics.
7. Schedule of valves including flow characteristics.
8. DDC hardware including:

    a. Wiring diagrams for control units with termination numbers.
    b. Schematic diagrams and floor plans for field sensors and control hardware.
    c. Schematic diagrams for control, communication, and power wiring, showing trunk data conductors and wiring between operator workstation and control unit locations.

9. Control System Software: List of color graphics indicating monitored systems, data (connected and calculated) point addresses, output schedule, and operator notations.
10. Controlled Systems including:

    a. Schematic diagrams of each controlled system with control points labeled and control elements graphically shown, with wiring.
    b. Scaled drawings showing mounting, routing, and wiring of elements including bases and special construction.
    c. Written description of sequence of operation including schematic diagram.
    d. Points list.

F. Software and Firmware Operational Documentation: Include the following:

1. Interconnection wiring diagrams with identified and numbered system components and devices.
2. Keyboard illustrations and step-by-step procedures indexed for each operator function.
3. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
4. Calibration records and list of set points.

G. Operation and Maintenance Data: For HVAC instrumentation and control system to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 1, include the following:

1. Interconnection wiring diagrams with identified and numbered system components and devices.
2. Keyboard illustrations and step-by-step procedures indexed for each operator function.

3. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
4. Calibration records and list of set points.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Automatic control system manufacturer's authorized representative who is trained and approved for installation of system components required for this Project.

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

C. UL listed to Standards UL864 (Fire), UL2017 (Signaling Systems), UL916 (Energy Management Systems), UL1017 (Security), UL1610 (Central Station) and UL 294 (Access Control).

1.6 CODES AND STANDARDS

A. Meet the requirements of all applicable standards and codes, except when more detailed or stringent requirements are indicated by the Contract Documents, including requirements of this Section.

B. Underwriters Laboratories: Products shall be UL-916-PAZX listed.

C. Federal Communications Commission -- Part J.

D. ASHRAE/ANSI 135-2016 (BACnet) - (System Level Devices) - Building Controllers shall conform to the listed version of the BACnet specification in order to improve interoperability with various building system manufacturers' control systems and devices.

E. ASHRAE/ANSI 135-2016 (BACnet) - (Unit Level Devices) - Unit Controllers shall conform to the listed version of the BACnet specification in order to improve interoperability with various building system manufacturers' control systems and devices.

1.7 DELIVERY, STORAGE AND HANDLING

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

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

1.8 COORDINATION

A. Coordinate location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation.

1.9 WARRANTY

A. The BMS supplier/installer shall warrant all work per the following:

1. All control systems labor, equipment and materials shall be warranted to be free from defects for a period of twelve (12) months after the date of substantial completion. Control system failures during the warranty period shall be adjusted, repaired, or replaced at no charge to the Owner. The BMS manufacturer/installer shall respond to the Owner's request for warranty service within 24 hours of the initiated call.
2. At the end of the final start-up/testing, if equipment and systems are operating satisfactorily to the Owner and Engineer, the Owner shall sign certificates certifying that the BMS is operational, and has been tested and accepted in accordance with the terms of this specification. The date of Owner's acceptance shall be the start of the warranty period.
3. Operator workstation software, project specific software, graphics, database, and firmware updates shall be provided to the Owner at no charge during the warranty period. Written authorization by the Owner must be granted prior to the installation of these updates.
4. The BMS manufacturer shall provide a web-accessible Users Network for the proposed System and give the Owner free access to question/answer forum, user tips, upgrades, and training schedules for a one-year period of time correlating with the warranty period.

PART 2 - PRODUCTS

2.1 INSTALLERS

A. Subject to compliance with requirements provide a DDC Control Systems with products furnished, engineered, and installed by a corporate branch office of Johnson Controls.

2.2 DDC EQUIPMENT

A. Control Units: Modular, comprising processor board with programmable, nonvolatile, random-access memory; local operator access and display panel; integral interface equipment; and backup power source.

1. Units monitor or control each I/O point; process information; execute commands from other control units, devices, and operator stations; and download from or upload to operator workstation or diagnostic terminal unit.
2. Stand-alone mode control functions operate regardless of network status. Functions include the following:

a. Global communications.
b. Discrete/digital, analog, and pulse I/O.
c. Monitoring, controlling, or addressing data points.
d. Software applications, scheduling, and alarm processing.
e. Testing and developing control algorithms without disrupting field hardware and controlled environment.

3. Standard Application Programs:

    a. Electric Control Programs: Demand limiting, duty cycling, automatic time scheduling, start/stop time optimization, night setback/setup, on-off control with differential sequencing, staggered start, anti-short cycling, PID control, DDC with fine tuning, and trend logging.
    b. HVAC Control Programs: Optimal run time, supply-air reset, and enthalpy switchover.
    c. Programming Application Features: Include trend point; alarm processing and messaging; weekly, monthly, and annual scheduling; energy calculations; run-time totalization; and security access.
    d. Remote communications.
    e. Maintenance management.
    f. Units of Measure: Inch-pound.

4. Local operator interface provides for download from or upload to operator workstation or diagnostic terminal unit.
5. ASHRAE 135 Compliance: Control units shall use ASHRAE 135 protocol and communicate using ISO 8802-3 (Ethernet) datalink/physical layer protocol.

B. I/O Interface: Hardwired inputs and outputs may tie into system through controllers. Protect points so that shorting will cause no damage to controllers.

1. Binary Inputs: Allow monitoring of on-off signals without external power.
2. Pulse Accumulation Inputs: Accept up to 10 pulses per second.
3. Analog Inputs: Allow monitoring of low-voltage (0- to 10-V dc), current (4 to 20 mA), or resistance signals.
4. Binary Outputs: Provide on-off or pulsed low-voltage signal, selectable for normally open or normally closed operation with three-position (on-off-auto) override switches and status lights.
5. Analog Outputs: Provide modulating signal, either low voltage (0- to 10-V dc) or current (4 to 20 mA) with status lights, two-position auto-manual switch, and manually adjustable potentiometer].
6. Tri-State Outputs: Provide two coordinated binary outputs for control of three-point, floating-type electronic actuators.
7. Universal I/Os: Provide software selectable binary or analog outputs.

C. Power Supplies: Transformers with Class 2 current-limiting type or overcurrent protection; limit connected loads to 80 percent of rated capacity. DC power supply shall match output current and voltage requirements and be full-wave rectifier type with the following:

1. Output ripple of 5.0 mV maximum peak to peak.
2. Combined 1 percent line and load regulation with 100-mic.sec. response time for 50 percent load changes.
3. Built-in overvoltage and overcurrent protection and be able to withstand 150 percent overload for at least 3 seconds without failure.

D. Power Line Filtering: Internal or external transient voltage and surge suppression for workstations or controllers with the following:

1. Minimum dielectric strength of 1000 V.
2. Maximum response time of 10 nanoseconds.
3. Minimum transverse-mode noise attenuation of 65 dB.
4. Minimum common-mode noise attenuation of 150 dB at 40 to 100 Hz.

2.3 UNITARY CONTROLLERS

A. Unitized, capable of stand-alone operation with sufficient memory to support its operating system, database, and programming requirements, and with sufficient I/O capacity for the application.

B. Configuration: Local keypad and display; diagnostic LEDs for power, communication, and processor; wiring termination to terminal strip or card connected with ribbon cable; memory with bios; and 72-hour battery backup.

C. Operating System: Manage I/O communication to allow distributed controllers to share real and virtual object information and allow central monitoring and alarms. Perform scheduling with real-time clock. Perform automatic system diagnostics; monitor system and report failures.

D. ASHRAE 135 Compliance: Communicate using read (execute and initiate) and write (execute and initiate) property services defined in ASHRAE 135. Reside on network using MS/TP datalink/physical layer protocol and have service communication port for connection to diagnostic terminal unit.

E. BACnet Compliance: Communicate using EIA/CEA 709.1 datalink/physical layer protocol using LonTalk protocol.

F. Enclosure: Waterproof rated for operation at 40 to 150 deg F.T

2.4 PROGRAMABLE CONTROLLERS

A. Performance - Each PC shall have a minimum of 64K of Non-volatile Flash memory for control applications and 128K non-volatile flash memory for storage with an 8-bit processor. The PC shall have a minimum ambient operating temperature range of -0°C to 70°C or 32°F to 158°F.

B. Inputs - Analog inputs shall have the following minimum level of performance: 16-bit A to D resolution; allow monitoring of platinum 100 ohms, platinum 1000-ohm, nickel 1000 ohms, thermistor 10K type II, thermistor 10K type III, voltage input0-10VDC, current input 4-20mA, digital input, pulsed input minimum 2 Hz.

C. Outputs - Outputs shall be either software configurable to be either analog or digital or dedicated digital only - Analog outputs shall be selectable as voltage of 0-10 VDC (linear) or 4-20mA or Digital outputs shall be 0-12 VDC (off/on), floating or PWM. Outputs shall have an adjustable range of 2 seconds to 15 minutes. Output Resolution shall be a minimum 8 bits digital/analog converter. All individual outputs and power supply shall be protected by an auto reset fuse. There shall be an LED status indicator on each of the outputs.

D. Programmable Controller Features:

1. Provide an onboard network communication jack.
2. The PC shall be provided with a diagnostic indicator light for power and network communication of transmit and receive along with a light indication position for each output.
3. Hand/Off/Auto Switches - For all controllers applied to an AHU, Chiller, Pumps, Cooling Tower or Boiler, provide for the manual override and adjustment of all Analog and Digital outputs through a three-position switch giving the selection of Hand, Off and Auto (HOA). A HOA shall be provided for each separate digital and analog output from the controller and be an integral part of the controller. HOA switches external from the controller shall not be accepted. For the Analog outputs the Hand position of the switch shall provide for the adjustment of the output signal through a linear scaled potentiometer. The position of the HOA shall be monitored and an alarm shall be delivered to the Graphical User Interface should the switch be in an Off or Hand position. An indicating LED shall be provided on the controller for each HOA indicating position of the switch. For all Analog outputs, the indicating LED shall provide a linear indication of the position of the Potentiometer through a variation in the intensity of the indicator LED and be provided as a numerical value that can be viewed at the Graphical User Interface.
4. Enclosures - Provide for a plastic enclosure with a separate back plate with terminals such that the electronic portion of the controller can be easily removed for ease of installation and servicing.

E. Fan-Speed Controllers: Solid-state model providing field-adjustable proportional control of motor speed from maximum to minimum of 55 percent and on-off action below minimum fan speed. Controller shall briefly apply full voltage, when motor is started, to rapidly bring motor up to minimum speed. Equip with filtered circuit to eliminate radio interference.

2.5 ELECTRONIC SENSORS

A. Description: Vibration and corrosion resistant; for wall, immersion, or duct mounting as required.

B. Humidity Sensors: Bulk polymer sensor element.

1. Duct sensor: 20 to 80 percent relative humidity range with element guard and mounting plate.
2. Outside-Air Sensor: 20 to 80 percent relative humidity range with mounting enclosure, suitable for operation at outdoor temperatures of minus 22 to plus 185 deg F.

C. Static pressure transmitters: non-directional sensor with suitable range for expected input, and temperature compensated.

1. Accuracy: 2 percent full range with repeatability of 0.5 percent.
2. Output: 4 to 20 mA.
3. Building Static-Pressure Range: 0- to 0.25-inch wg.
4. Duct Static-Pressure Range: 0- to 5-inch wg.

D. Water Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig operating pressure.

E. Water Differential-Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig operating pressure and tested to 300-psig.

F. Differential-Pressure Switch (Air or Water): Snap acting, with pilot-duty rating and with suitable scale range and differential.

G. Pressure Transmitters: Direct acting for gas, liquid, or steam service; range suitable for system.

2.6 ROOM SENSORS

A. Sensors shall be of the thermistor type and shall be recessed wall box mounting type per the following:

1. LCD display to indicate sensed values
2. Set points: warmer/cooler adjustment, which can be programmed in the system to a maximum number of +/- degrees of adjustment
3. Temperature sensing accuracy:

    a. Range: 40 to 104 deg. F.
    b. Accuracy: +/- 1 deg. F.

4. Humidity sensing accuracy:

    a. Range: 20% to 90%
    b. Accuracy: +/- 3%.

5. Where noted in the sequence of operations, provide override pushbutton on the room sensor. The override time to be programmed through the BMS.

2.7 STATUS SENSORS

A. Status Inputs for Fans: Differential-pressure switch with pilot-duty rating and with adjustable range of 0- to 5-inch wg.

B. Status Inputs for Pumps: Differential-pressure switch with pilot-duty rating and with adjustable pressure-differential range of 8 to 60 psig, piped across pump.

C. Status Inputs for Electric Motors: Comply with ISA 50.00.01, current-sensing fixed- or split-core transformers with self-powered transmitter, adjustable and suitable for 175 percent of rated motor current.

D. Voltage Transmitter (100- to 600-V ac): Comply with ISA 50.00.01, single-loop, self-powered transmitter, adjustable, with suitable range and 1 percent full-scale accuracy.

E. Power Monitor: 3-phase type with disconnect/shorting switch assembly, listed voltage, and current transformers, with pulse kilowatt hour output and 4- to 20-mA kW output,

with maximum 2 percent error at 1.0 power factor and 2.5 percent error at 0.5 power factor.

F. Current Switches: Self-powered, solid-state with adjustable trip current, selected to match current and system output requirements.

G. Electronic Valve/Damper Position Indicator: Visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.

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

2.8 ACTUATORS

A. Modulating valves and dampers: provide proportional modulating control capable of positioning the valve or damper at all points across the full range of operation with continuous control action. The sensor, controller, and control device (damper, valve, etc.) shall act as one unit to maintain a constant and precise control of the controlled medium. Actuator drives proportional to input signal and modulates throughout its angle of rotation.

B. Two-position valves and damper: provide two-position actuators only where indicated.

C. Electric Motors: Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.

1. Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.
2. Non-spring Return Motors for Valves Larger than NPS 2-1/2: Size for running torque of 150 in. x lbf and breakaway torque of 300 in. x lbf.
3. Spring-Return Motors for Valves Larger than NPS 2-1/2: Size for running and breakaway torque of 150 in. x lbf.
4. Non-spring Return Motors for Dampers Larger than 25 Sq. Ft.: Size for running torque of 150 in. x lbf and breakaway torque of 300 in. x lbf.
5. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft. Size for running and breakaway torque of 150 in. x lbf.

D. Electric Actuators: Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.

1. Provide full modulating damper and valves actuators unless otherwise noted.
2. Valves: Size for torque required for valve close off at maximum pump differential pressure.
3. Dampers: size for required torque calculated as follows:

    a. Opposed-Blade Damper with Edge Seals: 5 inch-lb/sq. ft. of damper.
    b. Opposed-Blade Damper without Edge Seals: 3 inch-lb/sq. ft. of damper.

c. Dampers with 2- to 3-Inch wg of Pressure Drop or Face Velocities of 1000 to 2500 fpm: Increase running torque by 1.5.

4. Coupling: V-bolt and V-shaped, toothed cradle.
5. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
6. Fail-Safe Operation: Mechanical, spring-return mechanism. Provide external, manual gear release on non-spring return actuators.
7. Power Requirements (Modulating): Maximum 10 VA at 24-V ac or 8 W at 24-V dc.

2.9 CONTROL VALVES

A. Control Valves: Factory fabricated, of type, body material, and pressure class based on maximum pressure and temperature rating of piping system, unless otherwise indicated.

B. Unless otherwise indicated, heating system control valves on systems with outdoor air connections shall fail in the open position. Heating system control valves on systems without an outdoor air connection shall fail in the last position. Chilled water system control vales are to fail in the last position.

C. Hydronic system globe valves to have the following characteristics:

1. NPS 2 and Smaller: Class 125 bronze body, bronze trim, rising stem, renewable composition disc, and screwed ends with back seating capacity repackable under pressure.
2. NPS 2-1/2 and Larger: Class 125 iron body, bronze trim, rising stem, plug-type disc, flanged ends, and renewable seat and disc.
3. Sizing: 5 psi maximum pressure drop at design flow rate.
4. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics.
5. Close-off (Differential) Pressure Rating: Combination of actuator and trim shall provide minimum close-off pressure rating of 150 percent of total system (pump) head for two-way valves and 100 percent of pressure differential across valve or 100 percent of total system (pump) head.

D. Butterfly valves: 150-psig maximum pressure differential, ASTM A 126 cast-iron or ASTM A 536 ductile-iron body and bonnet, extended neck, stainless-steel stem, field-replaceable EPDM or Buna N sleeve and stem seals. Size at 1 psig max pressure drop at design flow rate.

E. Terminal unit control valves: bronze body, bronze trim, two or here ports, replaceable plus and seats with union and threaded ends.

1. Rating: Class 125 for service at 125 psig and 250 deg F operating conditions.
2. Sizing: 3 psig maximum pressure drop at design flow rate, to close against pump shutoff head.
3. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics.

2.10 DAMPERS

A. Dampers: AMCA-rated, opposed blade design; 0.108-inch minimum thick, galvanized-steel frames with holes for duct mounting; damper blades shall not be less than 0.064-inch-thick galvanized steel with maximum blade width of 8 inches and length of 48 inches.

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

2.11 AIR FLOW MONITORING

A. Where indicated and/or scheduled on the drawings provide duct mounted airflow monitoring stations capable of continuously monitoring air flows.

B. Each element shall be designed and built to comply with, and provide results in accordance with, accepted practice for duct system traversing as defined in the ASHRAE Handbook of Fundamentals, AMCA publication #203, as well as the Industrial Ventilation Handbook. The number of sensing ports on each element, and the quantity of elements utilized at each installation, shall comply with ASHRAE Standard #111 for equal area duct traversing.

C. Each airflow measuring element shall contain multiple total and static pressure sensing ports placed along the leading edge of the cylinder. The static pressure chamber shall incorporate dual offset static taps on opposing sides of the averaging chamber, so as to be insensitive to flow angle variations of as much as ± 20 degrees in the approaching airstream.

D. The airflow traverse elements shall be capable of producing steady, non-pulsating signals of true total and static pressure, with an accuracy of 2% of actual flow for operating velocities as low as 100 feet per minute.

E. The airflow traverse elements shall not induce a measurable pressure drop, greater than 0.18 inch at 4,000 fpm. The units shall have a self-generated sound rating of less than NC40 and the sound level within the duct shall not be amplified, nor shall additional sound be generated.

F. The probes shall be manifolded together in a 16-gauge galvanized steel duct section with 90-degree undrilled flanges, fabricated to the duct size, and shall contain multiple airflow traverse elements interconnected as required.

G. Where the stations are installed in insulated ducts, the airflow passage of the station shall be the same size as the inside airflow dimension of the duct. Station flanges shall be sized to facilitate matching connecting ductwork.

2.12 PRESSURE TRANSDUCERS

A. Transducer shall have linear output signal. Zero and span shall be field adjustable. Sensor accuracy shall be 1 percent of full scale with repeatability/long-term stability of 0.25 percent.

B. Transducer sensing elements shall withstand continuous operating conditions of positive or negative pressure 50% greater than calibrated span without damage.

C. Water pressure transducer shall have stainless steel diaphragm construction, proof pressure of 150 psi minimum. Transducer shall be complete with 4 to 20 mA output, required mounting brackets, and block and bleed valves.

D. Water differential pressure transducer shall have stainless steel diaphragm construction, proof pressure of 150 psi minimum. Over-range limit (differential pressure) and maximum static pressure shall be 300 psi. Transducer shall be complete with 4 to 20 mA output, required mounting brackets, and five-valve manifold.

E. Selectable rate pulse output for kWh reading, 4-20 mA output for kW reading, N.O. alarm contact, and the ability to operate with 5.0 amp current inputs or 0-0.33 volt inputs.

F. 1.0% full-scale true RMS power accuracy, +0.5 Hz, voltage input range 120-600V, and auto range select.

G. Under voltage/phase monitor circuitry.

H. NEMA 1 enclosure.

I. Current transformers having a 0.5% FS accuracy, 600 VAC isolation voltage with 0 - 0.33 V output. If 0-5 A current transformers are provided, a three-phase disconnect/ shorting switch assembly is required.

2.13 SYSTEM COMMUNICATIONS

A. System components shall communicate via low voltage control wiring. The use of wireless devices shall only be allowed with prior authorization from the Owner and Architect/Engineer.

B. While the system is expected to have a few connections to the Owner’s data network, the quantity of connections shall be kept to a minimum, unless otherwise permitted by the Owner and Architect/Engineer.

1. The Division 27 Contractor will provide up to ten (10) data connections to the Owner’s network. Should additional data wiring be required, the HVAC Systems Controls installer shall provide, meeting all requirements of Division 27 “Communications Cabling.”

C. All low voltage control wiring provided as part of the HVAC System Controls shall meet requirements of Division 27 “Communications Cabling.”

1. HVAC system controls wiring shall be provided with a gray jacket.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Electrical power:

1. Verify that power supply is available to the operator workstation, all actuators, valves and all other components of the HVAC Control System. Where required, provide low and/or line voltage power from the nearest electrical panel.
2. Unless noted otherwise, line voltage power for system equipment shall be derived from the nearest electrical panel, and shall not be common with other HVAC, plumbing, electrical or architectural equipment. Unless noted otherwise, low voltage power shall be derived from transformers/drivers associated with the system equipment only, and shall not be connected to control power transformers associated with other HVAC equipment (i.e. air handling units, chillers, etc.). System equipment may share transformers/drivers with other system equipment, provided the transformers/drivers are sized to handle the total load.
3. Control panels for equipment being fed from the emergency generator, including, but not limited to boilers, heating pumps, selected air handling and terminal equipment, etc., power shall be derived from the nearest 120/208 volt normal/emergency panel. Verify equipment that is connected to emergency power with the Electrical Contractor.
4. Install all power and control wiring and cable per the National Electric Code and applicable Division 26 and 27 Sections. Install raceways, boxes, cabinets according to Division 26 and 27 Sections.
5. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.
6. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

B. Low Voltage Control Wiring:

1. Install low voltage control wiring per applicable Division 26 and 27 sections.
2. Wiring shall be installed concealed above accessible ceilings and within wall cavities. When run in wall cavities, install in 1” EMT conduit (flexible non-metallic conduit may not be used).

    a. Low voltage control wiring may be installed in cable tray, when available; however, it shall be bundled together, neatly trained with Velcro straps, separated from the data wiring.

3. All backboxes for sensors and other wall devices shall be full power rated galvanized boxes. Low voltage rings may not be used.
4. Wiring installed in spaces with open structure, i.e. mechanical spaces, etc., shall be installed in minimum 1” EMT conduit. Conduit shall be painted to match structure.
5. In existing construction, open cavity walls (gyp, open core CMU, etc.) shall be fished. Surface metallic raceway (Wiremold V700 series) may be used where walls cannot be fished.

6. Where data cabling (category 5e or 6) is installed, cables shall be terminated on their own patch panel, and meet all requirements of Division 27 “Communications Cabling,” including, but not limited to terminations, labeling, testing and warranty.

C. Install software in control units and operator workstation(s). Implement all features of programs to specified requirements and as appropriate to sequence of operation.

D. Connect and configure equipment and software to achieve sequence of operation specified.

E. Install averaging elements in ducts and plenums in crossing or zigzag pattern.

F. Install heavy duty cast aluminum guards on thermostats and other sensors in the following areas:

1. Entrances.
2. Public areas.
3. All Gymnasiums.
4. Locker Rooms.
5. Where indicated.

G. Install damper motors on outside of duct in warm areas, not in locations exposed to outdoor temperatures.

H. Furnish and install hydronic instrument wells, valves, and other accessories where required.

I. Install refrigerant instrument wells, valves, and other accessories where required.

J. Space sensors:

1. Verify location of thermostats, humidistats, and other control sensors with Drawings and room details before installation. Mount sensors in occupied spaces to match mounting height of light switches unless otherwise indicated on Drawings. Mounting height shall comply with codes and accessibility requirements.
2. Conceal assembly in an electrical box of sufficient size to house sensor and transmitter, if provided.
3. Install electrical box with a faceplate to match sensor cover if sensor cover does not completely cover electrical box.
4. In finished areas, recess electrical box within wall.
5. In unfinished areas, electrical box may be surface mounted if electrical light switches are surface mounted.
6. Align electrical box with other electrical devices such as visual alarms and light switches located in the vicinity to provide a neat and well-thought-out arrangement. Where possible, align in both horizontal and vertical axis.

K. Control Valves:

1. Install pipe reducers for valves smaller than line size. Position reducers as close to valve as possible but at distance to avoid interference and impact to performance. Install with manufacturer recommended clearance.
2. Install flanges or unions to allow drop-in and -out valve installation.

3. Install pressure temperature taps in piping upstream and downstream of each control valve.

L. Air Flow Monitoring:

1. Install monitors in straight sections of duct with manufacturer recommended straight duct upstream and downstream of the monitors. Installed sensors shall be accessible for visual inspection and service. Install access door(s) in duct or equipment located upstream of sensor, to allow service personnel to hand clean sensors.
2. Provide all wiring and controls for duct mounted and air handling unit mounted air flow monitors.

3.2 QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust all control system components. Report results in writing to the owner's representative.

B. Perform field tests and inspections. At a minimum perform the following:

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

C. DDC System Verification:

1. Verify that instruments are installed before calibration, testing, and loop or leak checks.
2. Check instruments for proper location and accessibility.
3. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.
4. Check instrument tubing for proper fittings, slope, material, and support.
5. Check pressure instruments, piping slope, installation of valve manifold, and self-contained pressure regulators.
6. Check temperature instruments and material and length of sensing elements.
7. Check control valves. Verify that they are in correct direction.
8. Check dampers. Verify that proper blade alignment, either parallel or opposed, has been provided.
9. Verify that DDC controller power supply is from emergency power supply, if applicable.

10. Verify that wires at control panels are tagged with their service designation and approved tagging system.
11. Verify that spare I/O capacity has been provided.
12. Verify that DDC controllers are protected from power supply surges.

3.3 CALIBRATION AND ADJUSTMENTS

A. Calibrate instruments. Make three-point calibration test for both linearity and accuracy for each analog instrument. Calibrate equipment and procedures using manufacturer's written recommendations and instruction manuals. Use test equipment with accuracy at least double that of instrument being calibrated.

1. Verify control system inputs and outputs:

    a. Check analog inputs at 0, 50, and 100 percent of span.
    b. Check analog outputs using milliampere meter at 0, 50, and 100 percent output.
    c. Check digital inputs using jumper wire.
    d. Check digital outputs using ohmmeter to test for contact making or breaking.
    e. Check resistance temperature inputs at 0, 50, and 100 percent of span using a precision-resistant source.

2. Verify flow:

    a. Set differential pressure flow transmitters for 0 and 100 percent values with 3-point calibration accomplished at 50, 90, and 100 percent of span.
    b. Manually operate flow switches to verify that they make or break contact.

3. Pressure:

    a. Calibrate pressure transmitters at 0, 50, and 100 percent of span.
    b. Calibrate pressure switches to make or break contacts, with adjustable differential set at minimum.

4. Temperature:

    a. Calibrate resistance temperature transmitters at 0, 50, and 100 percent of span using a precision-resistance source.
    b. Calibrate temperature switches to make or break contacts.

5. Stroke and adjust control valves and dampers without positioners, following the manufacturer's recommended procedure, so that valve or damper is 100 percent open and closed.
6. Stroke and adjust control valves and dampers with positioners, following manufacturer's recommended procedure, so that valve and damper is 0, 50, and 100 percent closed.
7. Provide diagnostic and test instruments for calibration and adjustment of system.
8. Provide written description of procedures and equipment for calibrating each type of instrument. Submit procedures review and approval before initiating startup procedures.

B. Adjust initial temperature and humidity set points.

3.4 SYSTEM DEMONSTRATION AND ON-SITE ASSISTANCE

A. Pre-installation demonstration: the BMS Installer shall provide a complete demonstration of the proposed control system software architecture prior to final programming of the software. This demonstration is required to have the owner's representative agree on the system architecture including providing information on initial temperature set points desired by the Owner. The method and location of the demonstration shall be acceptable to the owner. The BMS Installer will be required to make any changes in the proposed system architecture, if desired by the owner's representative.

B. Post installation demonstration: provide documented (paper or electronic) proof of testing prior to scheduling post-installation demonstration. Documentation to provide proof of testing/verification of all system inputs and outputs, including verification of analog input values (temp, CO2, etc.) with independent handheld NIST calibrated device. Post installation testing will engage a factory-authorized service representative to train the Owner's maintenance personnel to adjust, operate, and maintain HVAC instrumentation and controls. The training shall be comprised of a minimum of 8 hours on-site training at a time suitable to the owner's representative.

3.5 FINAL REVIEW

A. Submit written report to Architect and Owner’s representative when DDC system is 100% complete. Report shall state the following:

1. DDC system has been thoroughly inspected for compliance with contract documents and found to be in full compliance.
2. DDC system has been calibrated, adjusted and tested and found to comply with requirements of operational stability, accuracy, speed and other performance requirements indicated.
3. DDC system monitoring and control of HVAC systems results in operation according to sequences of operation indicated.
4. DDC system is complete and ready for final review.

PART 4 - SEQUENCE OF OPERATIONS

4.1 BUILDING MANAGEMENT SYSTEM

A. The BMS shall include all hardware, software and programming required to fully execute all control sequences and monitor all control points described in this specification. The BMS shall have the capabilities to perform the control strategies, energy management functions, and building management functions. All BMS software shall reside on the Operator Workstation to be located within the building at a location to be determined.

1. Set Point Control: The BMS shall have full editing capabilities for any set point listed in these control sequences regardless of whether set point control logic resides in a local control unit or the building management software. All controls

shall be capable of fully executing all control sequences in the event of a communication loss between the BMS operator workstation and any local control unit(s).

2. Operating Mode Control: The BMS shall have full 24 hr./365-day scheduling capabilities for occupied/unoccupied modes of operation for all systems regardless of whether sequencing logic resides in a local control unit or the building management software. Provide programming that utilizes various global commands for zoning portions of the building as required by the owner. The control system shall be capable of fully executing all schedule sequences in the event of a communication loss between the operator workstation and any local control unit(s).
3. Control Offset: The BMS shall be capable of offsetting the control set points for any heating/cooling system equipment by an operator adjustable amount. This capability will allow for automatic set point changes based on system requirements, such as demand limiting.
4. Alarm Management: The BMS shall monitor, buffer, and direct alarm reports to operator devices and memory files. Alarms shall be prioritized to minimize nuisance reporting and to speed operator response to critical alarms. A minimum of three (3) priority levels shall be provided. Each local control unit as well as the BMS software shall be capable of performing distributed, independent alarm analysis and filtering based on priority level.

    a. The conditions under which alarms need to be acknowledged by an operator, and/or sent to follow-up files for retrieval and analysis at a later date shall be definable by the user.
    b. Report Routing: Alarm, reports, messages, and files will be directed to a user-defined list of operator devices for archiving alarm information. Alarms shall also be automatically directed to a default device in the event a primary device is found to be off-line.
    c. Alarm Messages: In addition to the point's descriptor and the time and date, the user shall be able to print, display or store a 65-character alarm message to more fully describe the alarm condition or direct operator response.
    d. Auto-Dial Alarm: The user shall define which critical alarms shall initiate a call to a remote operator device.

5. Historical Data and Trending: The BMS shall be capable of automatically sampling, storing, and displaying system data and as a minimum do so in the flowing ways:

    a. Continuous Point Histories: A point history routine shall continuously and automatically sample the value of all analog and binary inputs and outputs at fifteen-minute intervals. Samples shall be stored for the past 72 hours to allow the user to immediately analyze equipment performance and all problem-related events. History files shall include a continuous record of the last ten status changes or commands for each point.
    b. Control Loop Performance Trends: Operator adjustable resolution sampling of 10-300 seconds in 1-second increments for verification of control loop performance.
    c. Extended Sample Period Trends: Measured and calculated analog and binary data shall also be assignable to user-definable trends for the purpose

of collecting performance data over extended periods of time. Sample intervals of 1-minute to 2-hours, in 1-minute intervals, shall be provided.

d. Data Storage and Archiving: Trend data shall be uploaded from local unit controllers to the Operator Workstation at user-defined intervals or when the trend buffers become full. All trend data shall be available in disk file form for use in third party personal computer applications.

6. Totalization: The BMS shall be capable of automatically sampling, storing, and displaying totals as follows:

a. Runtime: Automatically accumulate, store, and display runtime hours for binary input and output points as specified in sequence of operations specifications. The totalization routine shall have a sampling resolution of 1-minute or less. The user shall have the ability to define a warning limit. Unique, user-specified messages shall be generated when the limit is reached.
b. Analog/Pulse: Automatically sample, calculate, store and display consumption totals on a daily basis for user selected analog and binary pulse input-type points. The totalization routine shall have a sampling resolution of 1-minute or less. The user shall have the ability to define a warning limit. Unique, user-specified messages shall be generated when the limit is reached.
c. Event: Automatically count, store, and display event occurrences (such as the number of times a pump or fan system is cycled) on a daily basis for user selected events.

4.2 TEMPERATURE SETTINGS

A. All temperatures shown in the control sequences are indicated in degrees Fahrenheit and the settings shall be fully adjustable through the use of simple key stokes on the operator workstation.

B. Unless otherwise indicated in the following sequences, the initial temperature and humidity settings are to be as follows:

1. Unoccupied heating: 60 degrees F.
2. Unoccupied cooling: 80 degrees F.
3. Occupied heating: 70 degrees F.
4. Occupied cooling: 75 degrees F.
5. Space humidity: 58%.

4.3 CONTROL SEQUENCE: MODULAR AIR HANDLING UNITS

A. The system is a single zone variable air volume system. The air handling unit contains a variable speed supply, chilled-water cooling coil, hydronic pre-heat coil, hydronic reheat coil, filters, and air flow monitoring as well as other components.

B. Control of the units will be through the BMS system with all controls furnished by the BMS supplier / Installer. The units shall be indexed to the occupied and unoccupied settings at the fully adjustable programmed times. Provide optimal start/stop programing.

C. Provide a temperature/humidity sensor with adjustable set points. The minimum and maximum set points shall be set through the BMS.

D. Freeze Protection: Provide a freeze stat, with automatic reset, serpentined across the leaving air side of the heating coil and provide programming per the following sequence if the leaving air temperature falls below 35 deg. F. (adjustable):

1. Signal an alarm on the operator workstation.
2. Close the outdoor air dampers and open the return air damper.
3. Fully open the heating coil control valve.
4. Stop the fan.

E. Provide control wiring between the unit starter and a relay furnished by the electrical contractor to allow for fan(s) shut down when the fire alarm system activates. If activated close all outdoor air dampers.

F. Provide fully modulating heating valves that are to fail in the open position. Control valves on reheat coils shall fail in the last position. Provide fully modulating cooling valves that are to fail in the last position. Outdoor air dampers and relief vent dampers are to fail in the closed position and return dampers shall fail in the open position.

G. Provide a transducer to monitor and record pressure drop across the MERV 13 filters in the air-handling unit. An alarm will be activated at the BMS workstation if the actual filter pressure drop exceeds the dirty filter pressure drop established by the TAB Contractor.

H. Provide duct-mounted airflow monitoring stations, where indicated on drawings, to measure and record the total outdoor airflow for each air handling unit.

I. Provide pressure transducer(s) on all supply fan piezo rings to measure and record total supply airflow for each unit.

J. Provide CO2 Control. Use standard factory calibrated CO2 sensors in locations shown on the drawings or as indicated in sequence of operations.

K. Dual-damper return air control: AHU-2A and 2B shall have two return air dampers; a low return for normal operation and a high return when additional return air is needed. Calculate the return airflow by subtracting the total supply air from the total outdoor air. When the return airflow exceeds 15,000 cfm on either unit, open the respective secondary (high) return air damper.

L. Unoccupied heating cycle:

1. The air handling unit fan will be off. Outdoor air damper will be closed and the return air damper open.
2. When the space temperature falls below the unoccupied set point temperature of 60 deg. F. (adjustable) start the supply fan at full speed and open the preheat coil control valve to provide a 95 deg. F. leaving air temperature.

3. The outside air damper will remain closed. The return air damper shall remain fully open. When setback temperature has been restored, reverse this sequence.

M. Unoccupied cooling cycle: Two modes of operation shall be available. One mode is to have no cooling with all fans off and the outside air damper closed. The second choice is for a higher space cooling set point, which is described as follows:

1. The air handling unit fan will be off. Outdoor air damper will be closed and the return air damper open.
2. When the space temperature rises above the unoccupied set point of 80 deg. F. (adjustable) start the supply fan at the minimum speed and open the cooling coil control valve to supply a 54 deg. F. leaving air temperature. If required to maintain space temperature, slowly increase the fan speed and simultaneously modulate open the cooling coil control valve to maintain a 54 deg. F. (adjustable) leaving air temperature.
3. The outside air damper will remain closed. The return air damper shall remain fully open. When setback temperature has been restored, reverse this sequence.
4. Provide controls for economizer cooling. If the enthalpy of the outdoor air is less than the enthalpy of the respective indoor space, allow the unit to operate in an economizer mode. Start the supply fan at the minimum speed and open the outdoor air damper to provide a 54 deg. F. (adjustable) leaving air temperature. If required to maintain space temperature, slowly increase the supply fan speed, and simultaneously modulate open the outdoor air damper to maintain a 54 deg. F. leaving air temperature. Modulate the associated relief vent damper to maintain a building pressure differential, with relationship to the atmosphere, of no more than +0.02" w.c. (adjustable). Close the chilled water coil control valve when the system is in an economizer mode.

N. Occupied heating cycle:

1. Warm-up: provide optimal start through the BMS to index the respective zone to the occupied status. At this time the unit will operate in the same mode as the unoccupied heating cycle. When the space temperature reaches the occupied set point the unit will operate in the occupied cycle.
2. During the occupied cycle the supply fan shall run continuously, modulating from low to high speed to maintain the space temperature. Modulate the preheat coil control valve in unison with the supply fan VFD, to maintain a leaving air temperature of 95 deg. F. (adjustable).
3. Provide ventilation control per the CO2 sequence.

O. Occupied cooling cycle:

1. Cool-down: provide optimal start through the BMS to index the respective zone to the occupied status. At this time the unit will operate in the same mode as the unoccupied cooling cycle. When the space temperature reaches the occupied set point the unit will operate in the occupied cycle.
2. During the occupied cycle the supply fan shall run continuously, modulating from low to high speed to maintain space temperature. The cooling coil control valve shall modulate in unison with the supply fan to maintain a 54 deg. F. (adjustable) leaving air temperature.

3. Provide controls for economizer cooling. If the enthalpy of the outdoor air is less than the enthalpy of the respective indoor space, allow the unit to operate in an economizer mode. Start the supply fan at the minimum speed and open the outdoor air damper to provide a 54 deg. F. (adjustable) leaving air temperature. If required to maintain space temperature, slowly increase the supply fan speed, and simultaneously modulate open the outdoor air damper to maintain a 54 deg. F. leaving air temperature. Modulate the associated relief vent damper to maintain a building pressure differential, with relationship to the atmosphere, of no more than +0.02" w.c. (adjustable). Close the chilled water coil control valve when the system is in an economizer mode.
4. Provide ventilation control per the CO2 sequence.

P. CO2 Ventilation Control: Provide ventilation control during the occupied cycles. When the space is indexed to the occupied cycle open the outdoor air damper to minimum outdoor airflow as indicated on the drawings. If the space CO2 controller senses an increased CO2 level above 800 p.p.m. slowly modulate open the outside air damper to maintain the space CO2 level below 1000 p.p.pm. At any time during the occupied cycle the outdoor air damper shall not open past the position to allow more than the scheduled amount of design outside air, as indicated on the drawing schedule, unless the unit is in an economizer cycle. Modulate the associated relief vent damper to maintain a building pressure differential, with relationship to the atmosphere, of no more than +0.02" w.c. (adjustable).

Q. Dehumidification: At any time the space humidity is above 60% RH, run the supply fan at cooling airflow, open the cooling coil control valve to provide a 54 deg. F. (adjustable) leaving air temperature and modulate open the duct-mounted reheat coil control valve to maintain the space temperature set point. When the space humidity level falls below 55% RH, reverse the sequence. Dehumidification shall be available during unoccupied cycles with the outdoor air damper closed.

R. The BMS shall monitor, record, and display the following monitoring points on a custom graphic at the operator work station:

1. System status (Occupied / Unoccupied): indication and adjustment.
2. Supply fan status: indication, adjustment, and alarm.
3. V.F.D. status: indication and alarm.
4. Preheat coil control valve position: indication and adjustment.
5. Cooling coil control valve position: indication and adjustment.
6. Reheat coil control valve position: indication and adjustment.
7. Supply air temperature: indication and adjustment.
8. Return air temperature: indication.
9. Mixed air temperature: indication
10. Outdoor airflow (cfm): indication.
11. Supply airflow (cfm): indication.
12. Return airflow (cfm): indication.
13. Smoke detector status: indication and alarm.
14. Freezestat status: indication and alarm.
15. Filter differential pressure: indication and alarm.
16. Building pressurization: indication and adjustment.
17. Space temperature set point: indication and adjustment.

18. Space temperature: indication and alarm.
19. Space humidity set point: indication, adjustment.
20. Space humidity level: indication and alarm.
21. Space CO2 set point: indication and adjustment.
22. Space CO2 level: indication and alarm.
23. Economizer: indication.

4.4 CONTROL SEQUENCE: TERMINAL UNITS

A. All terminal units shall be controlled by the BMS. The respective unit(s) shall be indexed to occupied and unoccupied settings at the programmed times.

B. Provide a temperature sensor with adjustable set points. The minimum and maximum heating set points shall be set at the operator workstation.

C. Provide a two-position control valve for all terminal units. Refer to the drawings for the required valve configurations. Valves are to fail in the last position.

D. Hydronic Baseboard / Finned Tube Control: Provide a thermostat/sensor to maintain occupied and unoccupied space temperature by opening the two-position heating control valve.

E. The BMS shall monitor, record, and display the following points on a custom graphic at the operator workstation:

1. Status (occupied / unoccupied): indication and adjustment.
2. Space set point: indication and adjustment.
3. Space temperature: indication and adjustment.

END OF SECTION 230900

SECTION 232110 - 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 pipe and fitting materials, joining methods, special-duty valves, and specialties for the piping systems.

B. Water treatment work is part of the HVAC contract and shall be completed by Water Treatment By Design. Contact Jordan Givler, phone 717-579-5286.

1.3 SUBMITTALS

A. Product Data: For each type of the following:

1. Valves. Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves.
2. Air control devices.
3. Hydronic specialties.
4. Grooved joint pipe couplings and fitting.

B. Refer to Division 01 Specification Section Coordination Drawings, for the work required by the HVAC Contractor in preparing Coordination Drawings.

C. Shop Drawings: Detail the piping layout indicating dimensions and elevations of all piping.

D. Operation and Maintenance Data: For air control devices, hydronic specialties, and special-duty valves to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

A. The installation is to conform to the requirements of the 2018 International Mechanical Code and any applicable local codes. Verify local code requirements with the Authority Having Jurisdiction.

B. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX.

1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

C. 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 ASME Boiler and Pressure Vessel Code: Section VIII, Division 01.

D. All grooved joint couplings, fittings, valves and other specialties shall be provided from a single manufacturer. Grooving tools shall be from the same manufacturer as the grooved components. All castings used for coupling housings, valve bodies, fittings, etc. shall be date stamped for traceability and quality control.

E. Pressure seal piping systems: Installer shall be a qualified installer, licensed within the jurisdiction, and familiar with the installation of the copper press joint system. The copper press fittings shall be installed using the proper tool, actuator, jaws and rings as instructed by the press fitting manufacturer. The installation of copper tubing in Hydronic systems shall conform to the requirements of the ICC International Mechanical Code.

1.5 EXTRA MATERIALS

A. Water Treatment Chemicals: Furnish enough chemicals for initial system startup and for preventive maintenance for one year from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature unless otherwise indicated:

1. Hot-Water Heating Piping: 125 psig at 200 deg. F.
2. Chilled-Water Piping: 125 psig at 100 deg F.
3. Condensate-Drain Piping: 150 deg. F.
4. Air-Vent Piping: 200 deg. F.

2.2 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tubing: ASTM B 88, Type L.

B. Wrought-Copper Fittings and Unions: ASME B16.22.

C. DWV Copper Tubing: ASTM B 306, Type DWV.

2.3 PRESSURE SEAL PIPING SYSTEMS

A. Subject to compliance with requirements, provide products manufactured by Veiga LLC or NIBCO Inc.

1. Copper tubing shall conform to ASTM B 75 or ASTM B88.
2. Copper fittings shall conform to ASME B16.18, ASME B16.22 or ASME B16.26.

3. Press Fitting: Copper and copper alloy press fittings shall conform to material requirements of ASME B16.18 or ASME B16.22. Sealing elements for press fittings shall be EPDM. Sealing elements shall be factory installed.
4. System to have minimum 200-psig working-pressure rating at 250 deg F.

2.4 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53, black steel with plain ends; type, grade, and wall thickness as indicated in Part 3 "Piping Applications" Article.

B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250 as indicated in Part 3 "Piping Applications" Article.

C. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300 as indicated in Part 3 "Piping Applications" Article.

D. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in Part 3 "Piping Applications" Article.

E. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced as indicated in Part 3 "Piping Applications" Article.

F. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.

G. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

1. Material Group: 1.1.
2. End Connections: Butt welding.
3. Facings: Raised face.

H. Grooved Mechanical-Joint Piping Systems:

1. Manufacturers: Subject to compliance with requirements, provide products by Victaulic Company of America or Anvil International.
2. Steel Pipe: ASTM A 53, carbon steel, schedule 40, roll or cut grooved ends.
3. Fittings: ASTM A 395, grade 65-45-12 ductile iron; ASTM A 536, grade 65-45-12 wrought steel conforming to ASTM A-235/A 53M, Type F, E, or S, Grade B factory fabricated steel; or ASTM A 234, Grade WPB steel fittings with grooves or shoulders constructed to accept grooved-end couplings; with nuts, bolts, to secure grooved pipe and fittings.
4. Couplings: Ductile iron conforming to ASTM A-536, Grade 65-45-12.

    a. NPS 2 through NPS 8; rigid coupling with high temperature range (-30 degrees F to 250 degrees F; Grade EP EPDM gasket.
    b. NPS 10 through NPS 12; rigid coupling with Grade EP EPDM gasket (-30 degrees F to 230 degrees F).
    c. NPS 2 through NPS 12: flexible coupling for use in locations where vibration attenuation and stress relief is required. Three flexible couplings may be used in lieu of a flexible connector.

I. Mechanical-Joint Piping Systems:

1. Manufacturers: Victaulic Company of America, Quick-Vic Systems.
2. Steel Pipe: ASTM A 53, schedule 40.
3. Couplings and Fittings: ASTM A 536, grade 65-45-12.
4. Gaskets: Grade EHP EPDM (-30 degrees F to +250 degrees F).

J. Carbon Steel Press-Connect Fittings

1. Manufacturers: Subject to compliance with requirements, provide products by Veiga LLC.
2. Listed to ASTM F3226, ICC-ES AC156, ASME B31.1, B31.3, and B31.9 standards.
3. Approved for use with ASTM A53 Schedule 5 to 40 carbon steel pipe with up to 50% Ethylene / Propylene glycol mix.
4. Carbon steel alloy fitting with corrosion-resistant zinc/nickel coating.
5. Sealing element shall be uniform in size/width and free from manufactured deformities or indentations.
    a. NPS 3/4 through NPS 2; EPDM sealing element rated to 200 psi (max) with a temperature range of 0-250 degrees (F) and ≤50% Ethylene / Propylene glycol.
    b. NPS 3/4 through NPS 4; FKM sealing element rated to 200 psi (max) with a temperature range of 14-284 degrees (F) and temperature spikes (24hr) up to 356 degrees (F) and ≤50% Ethylene / Propylene glycol.
6. 420 stainless steel grip ring.
7. 304 stainless steel separator ring for 1/2“ to 2“, graphite separator ring for 2-1/2“ to 4“.
8. Color-coded markings on exterior of fitting for readily identifying/inspecting sealing element type.
9. Press Connect fitting shall have the Viega Smart Connect feature to detect unpressed fittings during the testing process.
10. Single source manufacturer. Technology and installation instructions vary between manufacturers. Installers shall have current training credentials issued from selected manufacturer by on-site representative.
11. Join pipe and press-connect fittings with recommended tooling.

2.5 JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch (3.2-mm) maximum thickness unless thickness or specific material is indicated.
    a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
    b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

C. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

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

E. Grooved Joint Lubricants: lubricate gaskets using a lubricant supplied by the coupling manufacturer. Lubricant shall be suitable for the gasket elastomer and fluid media.

1. Gasket Material: Thickness, material, and type suitable for fluid to be handled and working temperatures and pressures.

2.6 EXPANSION FITTINGS AND COMPENSATORS

A. Grooved Mechanical-Joint Piping Systems:

1. Victaulic Style 150 Mover slip type expansion joint with 3” axial movement. Designed for service temperature to 230 degrees F and a working pressure of 350 psi maximum. Provide Grade “E” EPDM gaskets.
2. Victaulic Flexible Loop Series 159 with 4’ axial movement: Designed for service temperatures to 350 degrees F. maximum and working pressure of 150 psi. Schedule 40 carbon steel end connections and 321 stainless steel corrugated hose.

B. Welded or Soldered Joint Piping Systems: Provide in-line expansion compensators manufactured by Hyspan Precision Products or Metraflex Inc. Compensators to be rated for a maximum pressure of 175 psi and 230 degrees F. operating temperature.

2.7 DIELECTRIC FITTINGS

A. Description: Combination fitting of copper-alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

B. Insulating Material: Suitable for system fluid, pressure, and temperature.

C. Dielectric Flanges:

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

a. Capitol Manufacturing Company.
b. Central Plastics Company.
c. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Factory-fabricated companion-flange assembly, for 150- or 300-psig minimum working pressure as required to suit system pressures.

D. Dielectric Couplings:

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

a. Calpico, Inc.
b. Lochinvar Corporation.

2. Galvanized-steel coupling with inert and non-corrosive thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225 deg. F.

E. Dielectric Nipples:

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

a. Perfection Corporation; a subsidiary of American Meter Company.
b. Victaulic Company of America.

2. Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig minimum working pressure at 225 deg. F.

2.8 VALVES AND SPECIALTIES

A. Calibrated Balancing Valves:

1. Provide pressure independent and field adjustable venture type manual balancing valves.
2. Valves ½" to 2": to have venturi type bronze body, chrome plated ball, EPDM seals. Provide pressure & temperature test ports across valve measurement area. Ports to be fitted with dual durometer EPDM cores, brass cap & O-ring seal. Valves to have drain/purge port. Provide valve with memory stop, memory lock & calibrated position indicator. Valves to be rated at 200 PSIG at 250º F and be 100% positive shut-off. Measurement accuracy to be +/- 3%.
3. Valves 2-1/2" & Larger: to have venturi type cast carbon steel/ductile iron body, with SS steam, EPDM seat & Buna seals. Provide memory stop, memory lock & calibrated position indicator. Valves to be rated at 200 PSIG at 225º F and be 100% positive shut-off. Measurement accuracy to be +/- 3%.

B. Coil hook-up kits

1. The contractor may provide coil hook-up kits for connections to coils. The kits shall be comprised of the following items:

a. Calibrated balancing valves as indicated in 2.9.A.
b. Shut-off valves.
c. Strainers.
d. Other components indicated on the drawings.

2.9 AIR CONTROL DEVICES

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

1. Amtrol, Inc.
2. Bell & Gossett Domestic Pump; a division of ITT Industries.
3. Taco.

B. Manual Air Vents:

1. Body: Bronze.
2. Internal Parts: Nonferrous.
3. CWP Rating: 150 psig (1035 kPa).
4. Maximum Operating Temperature: 225 deg. F.

C. Automatic Air Vents:

1. Body: Bronze or cast iron.
2. Internal Parts: Nonferrous.
3. Operator: Noncorrosive metal float.
4. Inlet Connection: NPS 1/2.
5. Discharge Connection: NPS 1/4.
6. CWP Rating: 150 psig.
7. Maximum Operating Temperature: 240 deg. F.

2.10 WATER TREATMENT

A. HVAC System water treatment shall be provided by the firm indicated in Paragraph 1.2.B

B. Scope of Maintenance Service: Provide chemicals and service program to maintain water conditions required above to inhibit corrosion, scale formation, and biological growth for chilled water systems, hydronic heating systems, hot-water piping and equipment. Services and chemicals shall be provided for a period of one year from the date of Substantial Completion, and shall include the following:

1. Initial water analysis and HVAC water-treatment recommendations.
2. Startup assistance to flush the systems, clean with detergents, and initially fill systems with required chemical treatment prior to operation.
3. Periodic field service and consultation consisting of a minimum of one site visit per month.
4. Provide reports indicating the type of treatment and date of the site visit.
5. Analyses and reports of all chemical items concerning safety and compliance with government regulations.

2.11 CHEMICAL TREATMENT AND EQUIPMENT

A. Chemicals: Provide specially formulated, based on analysis of makeup water, to prevent accumulation of scale and corrosion in piping and connected equipment.

2.12 HYDRONIC PIPING SPECIALTIES

A. Y-Pattern Strainers: Subject to compliance with requirements, provide products by Metraflex, Hoffman Specialty, Armstrong or equal:

1. Body: ASTM A126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded or sweat for NPS 2 and smaller: grooved or flanged for NPS 2-1/2 and larger.
3. Strainer Screen: perforated stainless steel with 50 percent total free area.
4. CWP Rating: 150 psig.

2.13 ALIGNMENT GUIDES AND ANCHORS

A. Alignment Guides: Where required provide alignment guides manufactured by Metraflex Inc or equal. Guides to be factory-fabricated alignment guides suitable for installation with insulated piping where applicable.

B. Anchors: Provide factory fabricated anchors manufactured by Metraflex or equal. In lieu of factory fabricated anchors provide field fabricated anchors fabricated from ASTM A36 / A36M steel shapes and plates.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Hot-water heating, chilled water piping and dual temperature system piping, aboveground, NPS 2 and smaller, shall be one of the following:

1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
2. Schedule 40 steel pipe; Class 125, cast-iron fittings; cast-iron flanges and flange fittings; and threaded joints.
3. Pressure seal piping systems.
4. Victaulic Quick-Vic systems.
5. Carbon steel press-connect fittings.

B. Hot-water heating, chilled water piping and dual temperature system piping, aboveground, NPS 2-1/2 and larger, shall be:

1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
2. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, welded and flanged joints, and carbon steel press-connect fittings.
3. Schedule 40 steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.

C. Condensate-Drain Piping:

1. Type M, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
2. Install condensate drain piping at a minimum slope of 1% in the direction of flow.

D. Air-Vent Piping:

1. Inlet: Same as service, where installed with metal-to-plastic transition fittings for plastic piping systems according to the piping manufacturer's written instructions.
2. Outlet: Type K (A), annealed-temper copper tubing with soldered or flared joints.

3.2 VALVE APPLICATIONS

A. Install shut off-duty valves at each branch connection to supply mains, and at supply and return connection to each piece of terminal equipment and at other locations indicated on the drawings. All valves are to be installed in an accessible location.

B. Install calibrated balancing valves in the return pipe of each heating or cooling terminal and elsewhere as shown on the drawings. Valves are to be installed with the test ports facing 40 degrees to vertical above the centerline of the pipe.

C. Install check valves at each pump discharge and elsewhere as required to control flow direction.

D. Install safety valves at hot-water generators and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install drip-pan elbow on safety-valve outlet and pipe without valves to the outdoors; and pipe drain to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.

E. Where indicated, install pressure-reducing valves at makeup-water connection to regulate system fill pressure.

3.3 PIPING INSTALLATIONS

A. Drawing plans, schematics, and diagrams indicate general routing, location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved on Coordination Drawings. Provide offsets where required to clear steel, electrical conduit and / or other construction components.

B. Install cast-iron sleeve with water stop and provide Mechanical Sleeve Seal where HVAC piping penetrates a foundation wall or exterior. Select number of interlocking rubber links required to make installation watertight.

C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping 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 fittings for changes in direction and branch connections. Install piping to allow application of insulation.

H. Select system components with pressure rating equal to or greater than system operating pressure.

I. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

J. Install drains, consisting of a tee fitting, NPS 3/4 ball valve, and threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

K. Install piping at a uniform grade of 0.2 percent upward in direction of flow.

L. Reduce pipe sizes using eccentric reducer fitting installed with level side up.

M. Install branch connections to mains using tee fittings in main pipe, with the branch connected to the bottom of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.

N. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.

O. Install unions or flanges at the inlet and outlet of all control valves.

P. Install strainers on inlet side of each control valve, pressure-reducing valve, solenoid valve, in-line pump, and elsewhere as indicated. Install NPS 3/4 nipple, ball valve and hose connection in blowdown connection of strainers. Match size of strainer blow-off connection for strainers smaller than NPS 2.

Q. Identify piping as specified in Division 23 Section "Identification for HVAC Piping and Equipment."

R. Provide Firestopping at all rated partitions. Provide a caulked and sealed installation at all non-rated partitions.

S. Provide expansion compensator joints or expansion loops for cooper and/or steel piping, where indicated on the drawings. Provide the quantity of pipe anchors and alignment guides as required by the expansion compensator manufacturer. Provide shut-off valves at the inlet and outlet of the expansion compensators and/or expansion loops. Install expansion joints, guides and anchors per the manufacturer’s installation requirements. Install anchors per the following:

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

3.4 HANGERS AND SUPPORTS

A. Support all HVAC system piping to conform to ASME B31.9. Provide adjustable clevis hangers for all horizontal piping. Each hanger shall allow for adjustment, after installation, while supporting the pipe. Attach hangers to structural steel in accordance

with MSS SP-69 and MSS SP-89. Install piping hangers and supports to provide the indicated pipe slopes.

B. Provide miscellaneous structural steel for support of HVAC equipment and piping. In areas with exposed construction, install miscellaneous supports prior to painting of ceiling and walls.

C. Provide a 12” long 18 gage protective saddle for all clevis hangers that support insulated piping.

D. Use carbon-steel pipe hangers and supports and attachments for general service applications.

E. Use stainless-steel pipe hangers or fiberglass pipe hangers and stainless-steel or corrosion-resistant attachments for hostile environment applications.

F. Use copper-plated pipe hangers and copper attachments for copper piping and tubing.

G. Install hangers for steel piping with the following maximum spacing:

1. NPS 3/4 to NPS 2: 8 feet maximum horizontal spacing.
2. NPS 2 and larger: 12 feet maximum horizontal spacing.
3. Vertical supports at roof, at each floor, and at 10-foot maximum intervals.

H. Install hangers for drawn-temper copper tubing with the following maximum spacing: a

1. NPS 1-1/4 and smaller: 6 feet maximum horizontal spacing.
2. NPS 1-1/2 and larger: 10 feet maximum horizontal spacing.
3. Vertical supports at roof, at each floor, and at 10-foot maximum intervals.

3.5 PIPE JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements.

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: 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.
4. 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:

    a. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
    b. 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.

B. Welded Joints: Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.

C. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

D. Grooved Joints: Assemble joints with coupling and gasket, lubricant, and bolts in accordance with the manufacturer’s written instructions. Cut or roll grooves in ends of pipe based on pipe and coupling manufacturer's written instructions for pipe wall thickness. Use grooved-end fittings and rigid, grooved-end-pipe couplings of the same manufacturer.

1. The grooved couplings factory trained representative shall provide on-site training for the contractor’s field personnel in the use of grooving tools and the installation of grooved joints.
2. The representative shall visit the job site periodically to review the installation and verify the system is being installed per the manufacturer’s recommendations.
3. A direct employee of the grooved piping system manufacturer must conduct the training and site visits. A distributor representative is not acceptable.

3.6 HYDRONIC SPECIALTIES INSTALLATION

A. Install manual air vents at all high points in all piping systems, at heat-transfer coils, where required for system air venting and at locations indicated on the drawings.

B. Install automatic air vents at high points of system piping in mechanical equipment rooms only.

C. Install piping from boiler air outlet, air separator, or air purger to expansion tank with a 2 percent upward slope toward tank.

3.7 TERMINAL EQUIPMENT CONNECTIONS

A. Sizes for supply and return piping connections shall be the same as or larger than equipment connections. Install control valves in accessible locations close to connected equipment.

B. Provide shut-off valves on the supply and return connections to all terminal equipment. Where indicated, install bypass piping with ball or butterfly valve around control valve.

C. Install ports for pressure gages and thermometers at coil inlet and outlet connections according to Division 23 Section "Meters and Gages for HVAC Piping."

D. Connections to any control valve, shut-off valve, strainer, balancing devices or other similar devices with bronze construction shall be made with an adapter fitting and/or nipple made of the same material.

3.8 CHEMICAL TREATMENT

A. For the initial system fill perform an analysis of makeup water to determine type and quantities of chemical treatment needed to keep the chilled water and heating hot water system free of scale, corrosion, and fouling, and to sustain the proper water characteristics. Sample water at one-week intervals after equipment startup for a period of six weeks, and prepare test report. Sample water at four-week intervals following the testing noted above to show that automatic chemical-feed systems are maintaining water quality within performance requirements.

B. At four-week intervals following Substantial Completion, perform separate water analyses on all hydronic systems to show that automatic chemical-feed systems are maintaining water quality within performance requirements.

C. Fill 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 refill with fresh water.

D. Prior to start-up of any HVAC equipment, provide the required type of water treatment for all closed loop and open systems including but not limited to

1. Closed loop heating system.
2. Closed loop chilled water system.

E. Provide initial chemical treatment of all systems and maintain the required water quality within the proper ranges for a period of one year after the date of substantial completion. If the project has multiple construction phases, the date of substantial completion for the final phase of construction shall be used to begin the time period for water treatment.

3.9 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 all strainer screens. If the project has multiple construction phases provide the necessary labor and materials for flushing and cleaning of the hydronic system for each phase.
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 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 air. Use drains installed at low points for complete draining of test liquid.
3. Isolate expansion tanks and determine that hydronic system is full of water.
4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working 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 90 percent of specified minimum yield strength or 1.7 times "SE" value in Appendix A in 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.

C. Perform the following before operating the system:

1. Clean all new and existing to remain strainer screens installed throughout the building prior to hydronic system balancing. This includes strainer screens at system pumps and all air handling units and terminal equipment. All system screens shall be free of substantial dirt, debris, metal filings, and other contaminants at substantial completion.
2. Open manual valves fully.
3. Inspect pumps for proper rotation.
4. Set makeup pressure-reducing valves for required system pressure.
5. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
6. Set temperature controls so all coils are calling for full flow.
7. Verify lubrication of motors and bearings.

END OF SECTION 232110

SECTION 233110 - METAL DUCTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes metal ducts and accessories for various types of air distribution systems.

1.3 SUBMITTALS

A. Coordination Drawings: Coordination drawings are required. Refer to the applicable Division 1 Specification Section, for the work required by the HVAC Contractor in preparing Coordination Drawings.

B. Shop Drawings: Provide ductwork shop drawings to indicate the dimensioned locations and elevations of all ducts and duct accessories.

C. Provide submittal data for Cable Support Systems with SMACNA STRI verification.

D. Product data for each of the following products:

1. Duct liner and adhesives.
2. Duct sealants.

1.4 PERFORMANCE REQUIREMENTS

A. Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated in "Duct Schedule" Article as indicated in Part 3 of this specification.

B. Refer to the contract drawings for any notes that indicate requirements for duct construction that may differ from the SMACNA standard requirements. Where indicated provide duct construction that meets requirements.

1.5 QUALITY ASSURANCE

A. Comply with the requirements of NFPA 90A and 90B.

B. The installation of all ductwork shall comply with the requirements of the 2018 International Mechanical Code and all applicable local codes and code amendments.

1.6 DELIVERY, STORAGE AND HANDLING

A. Protect all ductwork, accessories and purchased products from damage during shipping, storage and handling. Prevent dirt and moisture from entering ducts and duct fittings. Store ductwork in an area which is protected from the weather. All ductwork shall be shipped with a protective polyethylene film or other watertight covering at the ends of all ducts and fittings. To prevent condensation in the ducts, the covering shall not be added while excessive moisture is present in the duct.

B. While ducts are stored on-site the protective covering shall remain in place with the ducts stores on skids and placed such that the duct openings are not subject to water infiltration.

PART 2 - PRODUCTS

2.1 SINGLE WALL RECTANGULAR DUCTS AND FITTINGS

A. Refer to and comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 2, "Rectangular Duct Construction," for fabrication of ducts based on the static-pressure class indicated in Part 3 of this specification.

B. Unless otherwise indicated on the drawings fabricate ducts with a gauge thickness per the requirements of Chapter 2.

C. Longitudinal Seam, Traverse Joints and Reinforcements: Select and fabricate seam, joint, reinforcement types and sealing requirements and according to the requirements in Chapter 2 for required static-pressure class, applicable sealing requirements, duct-support intervals, and other provisions in the SMACNA Standard."

D. Duct fittings: fabricate elbows, turning vanes, branch connecters, offsets and transitions in accordance with Chapter 4 of the SMACNA "HVAC Duct Construction Standards - Metal and Flexible."

1. Radius elbows: type RE 1 with a center line radius equal to 1.5 times the duct width.
2. Square throat elbows: type RE 2 with turning vanes per figure 4-3 and 4.4.
3. Branch connections: 45-degree entry.

2.2 SINGLE WALL ROUND DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.

B. Unless otherwise indicated on the drawings fabricate ducts with a gauge thickness per the requirements of Chapter 3.

C. Longitudinal Seam, Traverse Joints and Reinforcements: Select seam, joint, reinforcement types and sealing requirements and fabricate according to the

requirements in Chapter 3 for required static-pressure class, applicable sealing requirements, duct-support intervals, and other provisions in the SMACNA Standard."

D. Duct fittings: fabricate elbows and tees in accordance with Chapter 3.

1. Elbows: fabricate with a center line radius equal to 1.5 times the duct diameter.
2. Tees and laterals: fabricate per figure 3-5

2.3 SPIRAL SEAM SINGLE WALL ROUND AND FLAT-OVAL DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.

B. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension) of the inner duct.

C. Unless otherwise indicated on the drawings fabricate ducts with paintable G60 galvanized steel. Duct gauge thickness to be per the requirements of Chapter 3.

D. Longitudinal Seam shall be a spiral lock seam per figure 3-2 of Chapter 3.

E. Traverse Joints and Reinforcements: Select seam, joint, reinforcement types and sealing requirements and fabricate according to the requirements in Chapter 3 for required static-pressure class, applicable sealing requirements, duct-support intervals, and other provisions in the SMACNA Standard."

F. Duct fittings: fabricate elbows and tees in accordance with Chapter 3.

1. Elbows: fabricate with a center line radius equal to 1.5 times the duct diameter.
2. Conical tees and laterals: fabricate per figure 3-6.

G. Provide spiral duct and fittings with a PVC coating, where indicated on the drawings. PVC coating to be 4 mils thick and applied to the interior and exterior of the ducts and fittings.

2.4 SPIRAL SEAM DOUBLE-WALL ROUND AND OVAL DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.

B. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension) of the inner duct.

C. Outer Duct: Comply with SMACNA requirements in Chapter 3. based on indicated static-pressure class unless otherwise indicated. Unless otherwise indicated on the drawings fabricate ducts with paintable G60 galvanized steel. Duct gauge thickness to be per the requirements of Chapter 3.

D. Longitudinal Seam shall be a spiral lock seam per figure 3-2.

E. Traverse Joints and Reinforcements: Select seam, joint, reinforcement types and sealing requirements and fabricate according to the requirements in Chapter 3 for required static-pressure class, applicable sealing requirements, duct-support intervals, and other provisions in the SMACNA Standard."

F. Duct fittings: fabricate elbows and tees in accordance with Chapter 3.

1. Elbows: fabricate with a center line radius equal to 1.5 times the duct diameter.
2. Conical tees and laterals: fabricate per figure 3-6.

G. Inner Duct: Minimum 0.028-inch perforated galvanized sheet steel having 3/32-inch-diameter perforations, with overall open area of 23 percent.

H. Interstitial Insulation: Fibrous-glass liner as indicated in paragraph 2.6.

2.5 SHEET METAL MATERIALS

A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation: G60 for interior ductwork conveying non-hazardous materials; G90 for interior ductwork conveying hazardous materials; G90 for exterior ducts without exterior insulation.
2. Finishes for Surfaces Exposed to View: Mill phosphatized and suitable for painting.

C. PVC-Coated, Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation: G90.
2. Minimum Thickness for Factory-Applied PVC Coating: 4 mils thick on sheet metal surface of ducts and fittings exposed to corrosive conditions.
3. Coating Materials: Acceptable to authorities having jurisdiction for use on ducts listed and labeled by an NRTL for compliance with UL 181, Class 1.

D. Carbon-Steel Sheets: Comply with ASTM A 1008/A 1008M, with oiled, matte finish for exposed ducts.

E. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304 or 316, as indicated in the "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in the "Duct Schedule" Article.

F. Aluminum Sheets: Comply with ASTM B 209 (ASTM B 209M) Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.

G. 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.

H. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.6 DUCT LINER

A. Fibrous-Glass Duct Liner: Comply with, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."

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

a. CertainTeed Corporation.
b. Johns Manville.
c. Knauf Insulation.
d. Owens Corning.

2. Materials: ASTM C 1071; surfaces exposed to airstream shall have a factory applied coating to prevent erosion of glass fibers and a factory applied coating on the edge of the liner.

a. Thickness: 1 inch or as noted on the drawings.
b. Density: 2.0 pcf.
c. Thermal performance: “R” equals 4.2 for 1” thick; 6.0 for 1.5” thick; 8.0 for 2” thick.
d. Sound Absorption Coefficient (NRC): 0.70 for 1” thick; 0.80 for 1.5” thick; 0.85 for 2” thick.
e. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
f. Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.
g. Antimicrobial Erosion-Resistant Coating: Apply to the surface of the liner that will form the interior surface of the duct to act as a moisture repellent and erosion-resistant coating. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.

B. Shop Application of Duct Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," and manufacturer’s instructions.

1. Where lined ducts are indicated, the duct dimensions indicated on the drawings are the metal size. The net free area size of the duct is the metal size minus the liner thickness.
2. Adhere to a single layer of liner with adhesive coverage per the manufacturer’s recommendations.

3. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.
4. Butt-transverse joints without gaps, and coat joint with adhesive.
5. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted edge overlapping.
6. Secure liner with mechanical fasteners per SMACNA standards and the manufacturer's recommendations.
7. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:

    a. Fan discharges.
    b. Intervals of lined duct preceding unlined duct.

8. 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 SEALANT AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.

B. Water-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Solids Content: Minimum 65 percent.
3. Shore A Hardness: Minimum 20.
4. Water resistant.
5. Mold and mildew resistant.
6. VOC: Maximum 75 g/L (less water).
7. Maximum Static-Pressure Class: 10-inch wg (2500 Pa), positive and negative.
8. Service: Indoor or outdoor.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

C. Solvent-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Base: Synthetic rubber resin.
3. Solvent: Toluene and heptane.
4. Solids Content: Minimum 60 percent.
5. Shore A Hardness: Minimum 60.
6. Water resistant.
7. Mold and mildew resistant.
8. For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
9. VOC: Maximum 395 g/L.

10. Maximum Static-Pressure Class: 10-inch wg (2500 Pa), positive or negative.
11. Service: Indoor or outdoor.
12. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

D. Flanged Joint Sealant: Comply with ASTM C 920.

1. General: Single-component, acid-curing, silicone, elastomeric.
2. Type: S.
3. Grade: NS.
4. Class: 25.
5. Use: O.
6. For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

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

F. Round Duct Joint O-Ring Seals:

1. Seals shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg (0.14 L/s per sq. m at 250 Pa) and shall be rated for 10-inch wg (2500-Pa) static-pressure class, positive or negative.
2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.8 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.

B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," "Rectangular Duct Hangers Minimum Size," - "Minimum Hanger Sizes for Round Duct."

D. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

E. Trapeze and Riser Supports:

1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
2. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.
3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

F. Cable Support Systems: Provide cable support systems and accessories that have been verified through the SMACNA Testing and Research Institute (STRI).

1. Manufacturers:

    a. Duro Dyne.
    b. Gripple Hang-Fast Systems.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

A. Fabricate, install and support ductwork and accessories according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

B. The installing contractor is required to field verify all duct locations and elevations prior to fabrication of the ductwork.

C. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.

D. Electrical Equipment Spaces: Route ducts to avoid passing through transformer vaults and electrical equipment spaces and enclosures. Do not locate ducts over electrical panels.

E. Ship and store all ductwork with a protective closure at the ends of all ducts and fittings. During construction, provide temporary polyethylene film enclosures at all openings in the duct systems, at the time of ductwork installation, to prevent entrance of dust and debris until final connections are completed.

    1. Protective film shall be applied only after excessive moisture has been removed from ductwork, including moisture generated from sealants and adhesives. If moisture levels are not acceptable within the sealed ductwork, provide relief vent in temporary film.
    2. Failure to protect duct systems from construction dust and debris will result in the installing contractor being required to Mechanically Clean the affected duct system(s) as indicated in this specification.

F. Install round and flat-oval ducts in maximum practical lengths.

G. Install ducts with fewest possible joints. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

H. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

I. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

J. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

K. Where ducts pass through non-fire-rated interior masonry or drywall partitions and any type of exterior wall(s), cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.

L. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Division 23 Section "Duct Accessories" for fire and smoke dampers. Provide firestopping as specified in Section 233300.

M. Paint interiors of metal ducts that do not have duct liner for 24 inches upstream of registers and grilles. Apply one coat of flat, black, latex finish coat over a compatible galvanized-steel primer.

N. Refer to contract drawings for locations where sprinklers are to be located within various duct systems. Coordinate locations with the sprinkler installer. Refer to contract drawing details for work required for a complete duct installation.

3.2 INSTALLATION OF EXPOSED DUCTWORK

A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.

D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.3 DUCT SEALING

A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

3.4 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports and the requirements of the International Mechanical Code Section 603. Support spacing of all hangers shall be per SMACNA standards but in no case shall hangers be spaced at more than 10’-0” intervals.

B. Supports for Clothes Dryer exhaust ducts shall be at a maximum spacing of 4’-0”.

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," "Rectangular Duct Hangers Minimum Size," and "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.

D. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at maximum intervals of 12 feet.

E. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.
2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
3. Use powder-actuated concrete fasteners for standard-weight aggregate concrete or for slabs more than 4 inches thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concrete or for slabs less than 4 inches thick.

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

G. Cable Support Systems: Where ducts are exposed to view in finished areas provide cable duct support systems installed per the manufacturer’s installation instructions.

3.5 CONNECTIONS

A. Make connections to equipment with flexible connectors complying with 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.

3.6 DUCT CLEANING

A. Where indicated on the contract drawings mechanically clean all ductwork connected to existing systems as described in this specification section.

B. New duct system installations: manually clean ductwork internally, section by section as it is installed, of dust and debris. Clean external surfaces of foreign substances which might cause corrosive deterioration of metal or, where ductwork is to be painted, might interfere with painting or cause paint deterioration.

C. Use service openings for entry and inspection.

1. Create new openings and install access panels appropriate for duct static-pressure class if required for cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner

manufacturers. Comply with Division 23 Section "Air Duct Accessories" for access panels and doors.
2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
3. Remove and reinstall ceiling to gain access during the cleaning process.

D. Particulate Collection and Odor Control:

1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.

E. Clean the following components 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 unit 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. Coils and related components.
5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
6. Supply-air ducts, dampers, actuators, and turning vanes.
7. Dedicated exhaust and ventilation components and makeup air systems.

3.7 MECHANICAL DUCT CLEANING METHODOLOGY

A. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.

B. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.

C. 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.

D. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.

E. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.

F. Provide drainage and cleanup for wash-down procedures.

G. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents according to manufacturer's written instructions after removal of surface deposits and debris.

3.8 DUCT SCHEDULE

A. Fabricate ducts with G90 galvanized sheet steel unless otherwise indicated in the following:

1. Shower area exhaust ducts: Aluminum ducts and fittings with sealed watertight joints.
2. Clothes dryer exhaust ducts: Minimum 28-gauge aluminum. Installation to comply with all requirements indicated in the 2018 International Mechanical Code; Chapter 5, Section 504.

B. Supply Ducts:

1. Ducts Connected to the discharge of Fan Coil Units and Unit Ventilators:

a. Pressure class: positive 1-inch wg.
b. Minimum SMACNA seal class: B.

2. Ducts Connected to the discharge of Modular and Packaged Air-Handling Units:

a. Pressure class: positive 2-inch wg.
b. Minimum SMACNA seal class: B.

C. Return Ducts:

1. Pressure Class: Positive or negative 2-inch wg.

a. Interior ducts: minimum SMACNA seal class B.
b. Exterior ducts: minimum SMACNA seal class B.

D. Exhaust Ducts:

1. Pressure Class: Positive or negative 1-inch wg.

a. Minimum SMACNA seal class: B if negative pressure, and B if positive pressure.

E. Outdoor-Air:

1. Pressure Class: positive or negative 1-inch wg.

a. Minimum SMACNA Seal Class: B.

F. Elbow Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

a. Radius Elbows: type RE-1 with a center line radius of R= (3W)/2

b. Square (mitered) Elbows: type RE-2 with the fitting width (W) equal.

2. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners."
3. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."

a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.

1) Radius-to Diameter Ratio = 1.5.

G. Branch Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-5, "Divided Flow Branches."

a. Type 2 or 3 as indicated on the contract drawings.

2. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."

a. Rectangular Main to Rectangular Branch: 45-degree entry.

3. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Provide fittings as indicated on the contract drawings.

END OF SECTION 233110

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SECTION 233300 - DUCT ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes various duct accessories such as fire dampers, volume dampers and other items that are typically part of a duct system.

1.3 SUBMITTALS

A. Submit Product Data for all accessories provided on the project.

B. Submittals for smoke dampers will require a coordination review by the HVAC Controls manufacturer/installer prior to submission to the Engineer. Refer to Section 230900.

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."

1.5 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. Fusible Links: Furnish quantity equal to 10 percent of amount installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Where indicated in Part 2, provide products manufactured by the listed companies.

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 G60 or G90 coating designation; ducts shall have mill-phosphatized finish for surfaces exposed to view.

C. Stainless Steel: ASTM A 480/A 480M.

D. Aluminum Sheets: ASTM B 209, alloy 3003, temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.

E. Extruded Aluminum: ASTM B 221, alloy 6063, temper T6.

F. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

G. 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. 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.

B. Frame: 0.052-inch thick, galvanized sheet steel, with welded corners and mounting flange.

C. Blades: 0.025-inch thick, roll-formed aluminum.

D. Blade Seals: Vinyl or Neoprene.

E. Blade Axles: Nonferrous.

F. Tie Bars and Brackets: Galvanized steel.

G. Return Spring: Adjustable tension.

2.4 MANUAL BALANCING DAMPERS

A. 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.

B. Standard Balancing Dampers: Multiple or single-blade, with opposed blade design, standard leakage rating, with linkage outside airstream, and suitable for horizontal or

vertical applications. Provide single blade dampers where the duct dimension is 10 inches or less in height. Provide dampers with multiple blade design in larger ducts.

1. Steel Frames: Hat-shaped, galvanized sheet steel channels, minimum of 0.064 inch thick, with mitered and welded corners; provide frames with flanges where required 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: Molded synthetic.
5. Tie Bars and Brackets: Galvanized steel.

C. 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.

D. 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 factory supplied or field installed elevated platform for insulated duct mounting.

2.5 REMOTE DAMPER OPERATORS

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

1. Pottorff.
2. Young Regulator

B. General description: cable system designed for remote control of manual dampers. Provide stainless steel cable and wall box mounting.

2.6 FIRE DAMPERS

A. Manufacturers:

1. Arrow.
2. CESCO Products.
3. Greenheck.
4. Nailor Industries Inc.
5. Pottoroff, Inc.
6. Ruskin Company.

B. Fire dampers shall be listed and bear the label of an approved testing agency indicating compliance with the requirements of the International Mechanical Code 607.3.1. Fire dampers shall be labeled according to UL 555.

C. Fire Rating: 1-1/2 or 3 hours as noted on the drawings.

D. Frame: Curtain type with blades outside airstream; fabricated with roll-formed, minimum 22-gauge galvanized steel; with mitered and interlocking corners.

E. Mounting Sleeve: Factory or field-installed, galvanized sheet steel.

F. Mounting Orientation: Vertical or horizontal as required.

G. Blades: Roll-formed, interlocking, minimum 24-gauge galvanized sheet steel. In place of interlocking blades, use full-length galvanized-steel blade connectors.

H. Horizontal Dampers: Include blade lock and stainless-steel closure spring.

I. Fusible Links: Replaceable, 165 deg F rated.

2.7 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 with the edge of the vanes parallel with the air flow.

B. Manufactured Turning Vanes: Fabricate 1-1/2-inch wide, double vane, curved blades of galvanized sheet steel; support with bars perpendicular to blades set 2 inches 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 and install where noted on the drawings.

2.8 DUCT MOUNTED ACCESS DOORS

A. General Description: Fabricate doors airtight and suitable for duct pressure class.

B. Door: Double wall, duct mounting, and rectangular; fabricated of galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class. Include 1-by-1-inch butt or piano hinge and cam latches.

1. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
2. Provide number of hinges and locks as follows:

    a. Less Than 12 Inches Square: Secure with two sash locks.
    b. Up to 18 Inches Square: Two hinges and two sash locks.
    c. Up to 24 by 48 Inches: Three hinges and two compression latches with outside and inside handles.
    d. Sizes 24 by 48 Inches and Larger: One additional hinge.

C. Seal around frame attachment to duct and door to frame with neoprene or foam rubber.

D. Insulation: 1-inch thick, fibrous-glass or polystyrene-foam board.

2.9 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 5-3/4 inches wide attached to two strips of 0.028-inch thick, galvanized sheet steel or 0.032-inch-thick aluminum sheets. Select metal compatible with ducts.

C. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.

1. Minimum Weight: 26 oz./sq. yd.
2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
3. Service Temperature: Minus 40 to plus 200 deg F.

D. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.

1. Minimum Weight: 24 oz./sq. yd.
2. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.
3. Service Temperature: Minus 50 to plus 250 deg F.

2.10 FLEXIBLE DUCTS AND ACCESSORIES

A. Manufacturers:

1. Thermaflex MK-E or equal.

B. Insulated Flexible Duct: UL 181, Class 1, flexible air duct complying with NFPA Standards 90A and 90B. Flexible duct shall be factory made and composed of a resilient film liner duct liner permanently bonded to a coated spring steel wire helix and supporting a fiberglass insulating blanket. Provide with a low permeability outer vapor barrier of fiberglass reinforced film laminate insulation.

C. Operating temperatures: -20 Deg. F. minimum; 250 deg. F. maximum.

D. Operating pressure: 10” w.g. positive; 1” w.g. negative.

E. Insulation: minimum R 6.0.

F. Rated velocity 5000 fpm.

G. Maximum flame spread = 25. Maximum smoke developed = 50.

H. Flexible Duct Clamps: Nylon strap to suit duct size.

I. Flexible duct elbow supports: Thermaflex FlexFlow or FlexRight.

2.11 DUCT ACCESSORY HARDWARE

A. Instrument Test Ports: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and

of length to suit the specified eternal duct insulation thickness. Provide special gaskets where test holes are to be installed in round or oval ducts. Test Ports to be Duro-Dyne model TH1, IP2 and/or IP4.

B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for metal ducts.

B. Provide duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel ducts, 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 and where indicated.

D. Install manual balancing dampers in ducts with liner utilizing an insulated “hat” section at the damper frame. Avoid damage to and erosion of duct liner. Where balancing dampers are located in ducts with exterior insulation, provide and insulated hat section to house the damper operator.

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 required.

G. Install fire dampers, with fusible links, according to manufacturer's UL-approved written instructions. Provide the required identification for all fire dampers as indicated in the International Mechanical Code, Chapter 6; 607.4

H. Install duct access doors to allow for inspecting, adjusting, and maintaining accessories and terminal units as follows:

1. Adjacent to all fire dampers, providing access to reset or reinstall fusible links.
2. To interior of ducts for cleaning at maximum 100-foot spacing between access doors.

I. Install the following sizes for duct-mounting, rectangular access doors:

1. Minimum size 12 x 12 inches.
2. Ducts with one dimension 24" or larger, install a 20" x 20" access door.

J. Install flexible connectors immediately adjacent to equipment in ducts associated with fans and motorized equipment supported by vibration isolators.

K. For fans developing static pressures of 5-inch wg and higher, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

L. Where indicated on the drawings, connect diffusers to low pressure ducts with maximum 72-inch length of insulated flexible duct. Connect flexible ducts to metal ducts and support flexible ducts in accordance with SMACNA Duct Construction Standards Metal and Flexible, Chapter 3. Install flexible duct elbow supports at all 90-degree flex connections to diffusers.

M. Install duct test holes, where indicated and required for testing and balancing purposes. Coordinate location with testing, adjusting and balancing contractor.

N. Provide turning vanes in all mitered elbows.

3.2 ADJUSTING

A. Adjust duct accessories for proper settings.

END OF SECTION 233300

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SECTION 233400 – HVAC FANS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes various types of fans, exhaust, and supply, as well as fan accessories. Refer to the drawings plans and schedules and provide all required options and accessories.

1.3 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. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Wiring Diagrams: Power, signal, and control wiring. Differentiate between manufacturer-installed and field-installed wiring.

C. Maintenance Data: For power ventilators to include in maintenance manuals specified in Division

D. Submittals for exhaust fans will require a coordination review by the HVAC Controls manufacturer/installer prior to submission to the Engineer. Refer to Section 23 09 00.

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain all similar types of fans from one source and from a single manufacturer, regularly engaged in production of exhaust fans.

B. 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.

C. 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."

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

E. AMCA Compliance: Products shall comply with performance requirements and shall be licensed to use the AMCA-Certified Ratings Seal.

F. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.

G. UL Standard: Power ventilators shall comply with UL 705.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver fans as factory-assembled unit, to the extent allowable by shipping limitations, with protective crating and covering.

B. Disassemble and reassemble units, as required for moving to final location, according to manufacturer's written instructions.

C. Lift and support units with manufacturer's designated lifting or supporting points.

1.6 COORDINATION

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

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

1.7 WARRANTY

A. All equipment, material and labor provided under this specification section shall be warranted for a period of one year from the date of substantial completion.

PART 2 - PRODUCTS

2.1 CEILING MOUNTED FANS

A. Manufacturers: Subject to compliance with requirements, provide ceiling mounted fans manufactured by Loren Cook, model GC. Subject to review, equipment meeting the full requirements of the specifications manufactured by the following will be considered:

1. Carnes Corp.
2. Greenheck.
3. Penn Barry.
4. Solar & Palau, USA.

5. CaptiveAire

B. Description: Fan shall be ceiling, wall, or inline mounted, direct driven, centrifugal exhaust fan.

C. Construction: The fan housing shall be minimum 20-gauge galvanized steel and acoustically insulated. Blower and motor assembly shall be mounted to a minimum 14 gauge reinforcing channel and shall be easily removable from the housing. Motor shall be mounted vibration isolators. Unit shall be supplied with integral wiring box and disconnect receptacle shall be standard. Discharge position shall be convertible from right angle to straight through by moving interchangeable panels. The outlet duct collar shall include a reinforced aluminum damper with continuous aluminum hinge rod and brass bushings. To accommodate different ceiling thickness, an adjustable pre-punched mounting bracket shall be provided. A powder painted white steel grille shall be provided as standard.

D. Fan Wheel: Wheel shall be centrifugal forward curved type, constructed of galvanized steel. Larger fan wheels shall be Wheels shall be twin DWDI centrifugal forward curved type, constructed of galvanized steel. Wheel shall be balanced in accordance with AMCA Standard 204-96, Balance Quality and Vibration Levels for Fans.

E. Motor: Motor shall be open drip proof type with permanently lubricated bearings, built-in thermal overload protection and disconnect plug. Motor shall be furnished at the specified voltage.

F. Accessories: Provide accessories noted on the drawings.

2.2 DESTRATIFICATION FAN

A. Manufacturers: Subject to compliance with requirements, provide fans manufactured by Zoo Fans. Subject to review, equipment meeting the full requirements of the specifications manufactured by the following will be considered:

1. Airius LLC.

B. Fans to be ETL listed and conform to UL standard 507.

C. Motor: Variable speed direct drive, permanent split capacitor type with sealed lifetime bearings and thermal overload protection.

D. Fan Housing: fabricated with UV treated flame resistant plastic. Double wall construction with multifunctional guide aerodynamic vanes.

E. Provide installation hardware including the following:

1. Cable support with Gripple type attachment. Cable to be rated at 200 lb. safe working load with a 5:1 safety factor and UL listed.
2. Stabilization tether with fast-locking Gripple attachment hardware. Cable to be rated at 100 lb. safe working load with a 5:1 safety factor and UL Listed.

F. Controller: Provide manufacture's furnished variable speed controller. Controller shall be an autotransformer-based microprocessor unit with 0-10VDC inputs for connecting to a configurable LED User Interface. Controller shall be capable of operating in BAS, Manual, or Automatic mode. The Automatic mode is configurable for various ceiling heights and utilizes dedicated temperature sensors that enable automatic adjustments to fan speed based on the temperature differential between these sensors. Electrical input is AC single-phase; input may be 115v and output may be 115V.

G. Controls: Provide LED User Interface. Program and configure controller to operate in automatic mode. Provide high and low temperature sensors. Provide a required control wiring between fans, controller(s), temperature sensors, and User Interface, per manufacturer's instructions.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install power ventilators level and plumb.

B. Ceiling Units: Suspend units from structure; use steel wire or metal straps.

C. Install units with clearances for service and maintenance.

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.

B. Install ducts adjacent to power ventilators to allow service and maintenance.

C. Ground equipment.

3.3 FIELD QUALITY CONTROL

A. Equipment Startup Checks: Perform startup per Manufacturer's Instructions on all fans. Verify that unit is secure on mountings and supporting devices and connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.

B. Verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation.

C. Verify lubrication for bearings and other moving parts.

D. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.

E. Starting Procedures: Energize motor and adjust fan to indicated rpm and measure and record motor voltage and amperage.

F. 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.

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

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

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

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

K. The installing contractor shall provide a completed written startup report that records results of all tests and inspections and verifies all fans, associated controls and wiring are installed properly. The start-up report shall be forwarded to the owner's representative.

3.4 ADJUSTING

A. Adjust damper linkages for proper damper operation and adjust belt tension where required.

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.

3.6 DEMONSTRATION

A. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment and schedules. Schedule training with Owner, through Architect, with at least seven days' advance notice.

END OF SECTION 233400

SECTION 233710 - 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, grilles and accessories.

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. Submit manufacturer’s technical product data for all air outlets. 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. Schedule of diffusers, registers, and grilles indicating drawing designation, room location, quantity, model number, size, and accessories furnished. The schedule shall also indicate static-pressure drop, and noise criteria ratings (NC) for each air outlet and inlet. A generic catalog sheet indicating pressure drop and NC ratings is not acceptable.

1.5 QUALITY ASSURANCE

A. Install diffusers, registers, and grilles according to NFPA 90A, "Standard for the Installation of Air-Conditioning and Ventilating Systems.

B. Source Limitations: Obtain diffusers, grilles and registers through one source from a single manufacturer, regularly engaged in production of the equipment.

PART 2 - PRODUCTS

2.1 LOUVERED FACE CEILING AIR DIFFUSERS

A. General: Provide louvered face ceiling air diffusers where shown; of size, shape, capacity and type indicated; constructed of materials and components as indicated, and as required for complete installation. Provide diffusers manufactured by Titus. Subject to review, diffusers meeting the full requirements of the specifications and manufactured by one of the following will be considered:

1. Krueger
2. Price Industries.
3. Nailor.
4. Anemostat.
5. Metalaire.

B. Ceiling diffusers shall have a fixed or adjustable horizontal discharge pattern. The inner louver assembly shall be flush with the outer frame with a 1, 2, 3 or 4-way directional pattern. Individual louvers shall have a horizontal lip to create a ceiling pattern at reduced air flows. The inner core must be easily removable.

C. Ceiling Compatibility: Provide louvered diffusers with border styles that are compatible with adjacent ceiling systems. Refer to general construction drawings and specifications for types of ceiling systems which will contain each type of ceiling air diffuser.

D. Types: The model numbers and manufacturers indicated on the diffuser schedule set the standard for the products to be used. Provide louvered diffusers of type as scheduled and with accessories as required.

E. Provide each diffuser in the manufacturer’s standard white electro-coated finish unless otherwise indicated on the drawings.

F. Diffusers shall be provided with the same style and characteristics as provided with the basis of design product named on the drawings.

2.2 REGISTERS AND GRILLES

A. General: Provide registers and grilles where shown; of size, shape, capacity and type indicated; constructed of materials and components as indicated, and as required for complete installation. Provide opposed blade damper on all registers. Provide registers and grilles manufactured by Titus. Subject to review, registers and grilles meeting the full requirements of the specifications and manufactured by one of the following will be considered:

1. Krueger
2. Price Industries.
3. Nailor.
4. Anemostat.
5. Metalaire.

B. Performance: Provide registers and grilles that have, as minimum, temperature and velocity traverses, throw and drop, and noise criteria ratings for each size device as listed in manufacturer's current data.

C. Structural Integrity: floor registers and grilles are required to meet the structural requirements indicated in the International Mechanical Code Chapter 6: 603.18.1.

D. Compatibility: Provide registers and grilles with border styles indicated and that are compatible with adjacent wall or ceiling systems, and that are specifically manufactured to fit into construction with accurate fit and adequate support. Refer to general construction drawings and specifications for types of construction which will contain each type of register and grille.

E. Types: The model numbers and manufacturers indicated on the drawing schedules set the standard for the product(s) to be provided. Provide registers and grilles of type as scheduled, with accessories as required to match the basis of design product named on the drawing.

F. Provide each register and/or grille in manufacturer’s standard white electro-coated finish. Refer to equipment schedules for grilles/registers that require a custom color. When required, the Architect will select the custom colors.

2.3 DRUM LOUVER REGISTERS

A. General: Except as otherwise indicated, provide drum louvers, where shown of the size, shape, capacity and type indicated and constructed of heavy gauge aluminum. Provide drum louvers manufactured by Titus. Subject to review, drum louvers meeting the full requirements of the specifications and manufactured by one of the following will be considered:

1. Krueger
2. Price Industries.
3. Nailor.
4. Anemostat.
5. Metalaire.

B. Drum louvers to have a single bank of adjustable vanes to provide direction control of the air stream. Vanes to be fabricated of aluminum and shall be adjustable to reduce the maximum throw of the louver. Provide a barrel capable of rotating 30-degrees above and below the center line of the louver.

C. Provide an integral damper fabricated of aluminum blades in a rigid aluminum frame. The damper shall be an opposed blade type and adjustable from the face of the outlet.

D. Provide each drum louver in either a satin anodized or standard white finish as selected by the Architect. Refer to equipment schedules for drum louvers that require custom colors. When required, the Architect will select the custom colors.

E. Drum louvers shall be provided with the same style and characteristics as provided with the basis of design product named on the drawings.

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.

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

3.2 INSTALLATION

A. Install diffusers, registers, and grilles level and plumb.

B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practicable. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

C. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

D. Provide any fasteners (screws, tamper proof screws, etc.) that are required by the manufacturer for installation.

3.3 ADJUSTING

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

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 233710

SECTION 237310 - MODULAR AIR HANDLING 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. This Section includes constant volume and variable volume modular air handling units with coils, filters and other components and accessories, designed for interior and/or exterior installations. Refer to the contract drawings for unit configurations and required components.

1.3 SUBMITTALS

1. Submit product technical data for each unit to include the following information:
2. Certified fan performance curves with system operating conditions indicated.
3. Certified fan sound power ratings.
4. Certified coil performance ratings with system operating conditions indicated.
5. Motor ratings and electrical characteristics plus motor and fan accessories
6. Filters with performance characteristics.

B. Exceptions: Shop drawing submittals are required to include a listing of any and all exceptions to the requirements indicated in this specification and on the drawings. If no exceptions are taken the lead sheet of the submittal shall indicate this. Submittals that do not have this information will be returned without review.

C. Provide manufacturer’s shop drawings detailing dimensions, operating weight, required clearances, all components, and location and size of each field connection.

D. Provide wiring diagrams detailing wiring for power and controls and differentiating between manufacturer-installed wiring and field-installed wiring.

E. Provide Operation and Maintenance data for all units.

F. Provide warranty information.

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain all air handling units through one source from a single manufacturer, regularly engaged in production of air handling units.

B. Air Coils: Certify capacities, pressure drops and selection procedures in accordance with current AHRI Standard 410.

C. Air handling units with fan sections utilizing single fans shall be rated and certified in accordance with AHRI Standard 430.

D. Air handling units with fan sections utilizing multiple fans shall be rated in accordance with AHRI standard 430 for airflow, static pressure, and fan speed performance.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Comply with manufacturer's installation instructions for rigging, unloading, and transporting units.

B. Units shall ship fully assembled up to practical shipping and rigging limitations. Units not shipped fully assembled shall have tags and airflow arrows on each section to indicate location and orientation in direction of airflow. Shipping splits shall be clearly defined on submittal drawings. Each section shall have lifting lugs for field rigging and final placement of AHU sections.

1.6 COORDINATION

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

B. Coordinate sizes and locations of structural-steel support members, if any, with actual equipment provided.

1.7 WARRANTY

A. Provide written warranty indicating all air handling units and components will be warranted for a period of 1 year from the date of substantial completion. The warranty will include all parts, materials and labor for replacement of any of the unit’s components that fail in materials and/or workmanship within the warranty period.

1.8 EXTRA MATERIALS

A. In addition to the equipment and materials furnished with the air handling units, furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing the contents:

1. Filters: Two complete sets of each type filter for each handling unit.
2. Fan Belts: One matched sets for each belt drive fan on each air handling unit.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with requirements, provide air handling units by The Trane Co. Subject to review, equipment meeting the full requirements of the specifications and project installation limitations and manufactured by one of the following will be considered:

1. York \ Johnson Controls.
2. Carrier.
3. Daiken.

2.2 GENERAL

A. Refer to the contract drawings for unit configurations and required components of the air handling units.

2.3 UNIT CASINGS

A. The entire air handler shall be constructed of galvanized steel with insulated double wall construction. Indoor air handling unit casing finish to meet ASTM B117 250-hour salt-spray test. The removal of access panels or access doors shall not affect the structural integrity of the unit. All removable panels shall be gasketed. All doors shall have gasketing around full perimeter to prevent air leakage.

B. Where required the manufacturer shall ship each unit with separate segments so unit can be broken down for ease of installation in tight spaces.

C. Casing air leakage shall not exceed 1% of design airflow at the specified casing pressure. Air leakage shall be determined at 1.00 times maximum casing static pressure up to 8 inches w.g. Specified air leakage shall be accomplished without the use of caulk. Total estimated air leakage shall be reported for each unit in CFM, as a percentage of supply air, and as an ASHRAE 111 Leakage Class.

D. The entire unit casing shall be able to withstand up to 1.5 times design static pressure up to +8” w.g. in all positive pressure sections and -8” w.g. in all negative pressure sections, whichever is less, and shall not exceed 0.0042” per inch of panel span.

E. Floor panels shall be double-wall construction and designed to support a 300-lb load during maintenance activities and shall deflect no more than 0.0042” per inch of panel span.

F. Unit casing panels shall be 2” double-wall construction with solid galvanized construction for all exterior panels and solid galvanized interior for all unit components except for fan sections and discharge plenum sections which shall be provided with an interior perforated liner.

G. Unit casing panels and doors shall be fabricated with insulation to provide a minimum thermal resistance (r value) of 13. All casing panels shall be completely insulated filling the entire panel cavity in all directions so that no voids exist. Panel insulation shall comply with NFPA 90A.

H. Access panels and/or access doors shall be provided on both sides of all sections to allow easy access to drain pan, coil(s), motor, drive components and bearings for cleaning, inspection, and maintenance. Access panels and doors shall be fully removable without the use of specialized tools to allow complete access of interior surfaces.

2.4 ACCESS DOORS

A. Access doors shall be 2” double-wall construction. Interior and exterior shall be of the same construction as the interior and exterior wall panels. All doors downstream of cooling coils shall be provided with a thermal break construction of door panel and door frame. Gasketing shall be provided around the full perimeter of the doors to prevent air leakage.

B. Door hardware shall be surface-mounted to prevent through-cabinet penetrations that could likely weaken the casing leakage and thermal performance.

C. Handle hardware shall be designed to prevent unintended closure. Access doors shall be hinged and removable without the use of specialized tools. Hinges shall be interchangeable with the door handle hardware to allow for alternating door swing in the field to minimize access interference due to unforeseen job site obstructions. Door handle hardware shall be adjustable and visually indicate locking position of door latch external to the section.

D. All doors shall be a minimum of 15” wide and 60” high when sufficient height is available, or the maximum height allowed by the unit height and shall be located on each side of all units. Where access doors are provided in sections with a positive pressure the doors shall be hinged to open in an inward direction.

2.5 DRAIN PANS

A. All cooling coil sections shall be provided with an insulated, double-wall, stainless steel drain pan. The drain pan shall be designed in accordance with ASHRAE 62.1 and be of sufficient size to collect all condensation produced from the coil. The pan shall be sloped in two planes, pitched toward drain connections, promoting positive drainage to eliminate stagnant water conditions when unit is installed level and trapped per manufacturer's requirements. Refer to other specification sections requirements on intermediate drain pans between cooling coils.

B. The drain outlet shall be located at the lowest point of the pan and shall be sufficient diameter to preclude drain pan overflow under any normally expected operating condition. All drain pan threaded connections shall be visible external to the unit. Drain connections shall be of the same material as the primary drain pan and shall extend a minimum 2-1/2” beyond the base to ensure adequate room for field piping of condensate traps.

2.6 FANS

A. Provide supply, return and/or exhaust fans of the types and capacities as scheduled or indicated on the drawings.

B. Fans shall be designed to accommodate a 10 percent future increase in air flow or total static pressure without requiring a fan wheel replacement. The equivalent fan selection shall not increase motor horsepower, fan RPM and tip speed by more than 10 percent and shall not increase inlet or discharge velocity by more than 10 percent from the

specified amount. Include with the shop drawing submittal multiple RPM fan curve with the operating points plotted on the curve.

C. Fan shafts shall be solid steel, coated with a rust-inhibiting coating, and properly designed so that fan shaft does not pass through first critical speed as unit comes up to rated RPM. All fans shall be statically and dynamically tested by the manufacturer for vibration and alignment as an assembly at the operating RPM to meet design specifications. Fans controlled by variable frequency drives shall be statically and dynamically tested for vibration and alignment at speeds between 25% and 100% of design RPM. Fan wheels shall be keyed to fan shafts to prevent slipping.

D. Belt-driven fans shall be provided with grease lubricated, self-aligning, anti-friction bearings selected for L-50 200,000-hour average life per ANSI/AFBMA Standard 9. Lubrication lines for both bearings shall be extended to the drive side of the AHU and rigidly attached to support bracket with zerk fittings. Lubrication lines shall be a clear, high-pressure, polymer to aid in visual inspection. If extended lubrication lines are not provided, manufacturer shall provide permanently lubricated bearing with engineering calculations for proof of bearing life.

E. All fans shall be mounted on spring isolation bases. Internally-mounted motors shall be on the same isolation base. Isolator bases and springs shall be designed and provided to eliminate vibration. Isolation bases shall have factory installed tie-down bolts provided to secure the isolation base to the unit. A flexible connection (e.g. canvas duct) shall be installed between fan and unit casing to ensure complete isolation. Flexible connection shall comply with NFPA 90A and UL 181 requirements.

F. Fan sections containing multiple fans shall be provided as indicated on the schedule and drawings. Each fan shall operate in parallel to the other fan in the array. The fans shall be SWSI plenum type with high-efficient AF blades. Fan wheels shall be aluminum. The Hp characteristic of the fans shall be non-overloading. Fan sections containing multiple fans shall be controlled using a common control signal, such as the duct static control signal, to modulate the fan speed. The manufacturer shall supply a blank-off plate, for field installation, to prevent air circulation in the event one of the fans is disabled.

G. For belt drive fans provide belt guards as required by OSHA standard 29 CFR 1910 to protect worker from accidental contact with the belts and sheaves.

H. Fan sections shall have an access door located on each side of the unit to allow inspection and maintenance of the fan, motor, and drive components.

2.7 MOTORS AND DRIVES

A. All motors and drives shall be factory-installed and run tested. All motors shall be installed on a slide base to permit adjustment of belt tension. Slide base shall be designed to accept all motor sizes offered by the air-handler manufacturer for that fan size to allow a motor change in the future, should airflow requirements change.

B. Motors shall meet or exceed all NEMA Standards Publication MG 1 – 2006 requirements and comply with NEMA premium efficiency levels when applicable. Motors shall comply with applicable requirements of NEC and shall be UL Listed.

C. Belt-driven fan sections with single fans shall use 4-pole (1800 rpm) motors, NEMA Design B, with Class B insulation to operate continuously at 104°F (40°C) ambient without tripping of overloads.

D. Direct-driven fan sections shall use 2-pole (3600 rpm), 4-pole (1800 rpm), or 6-pole (1200 rpm) motors, NEMA Design B, with Class B insulation to operate continuously at 104°F (40°C) ambient without tripping of overloads. Multiple fan selections utilizing 8-pole (900 rpm) motors are unacceptable due to motor inefficiency, cost, and replacement lead times.

E. Motors shall have a +/- 10 percent voltage utilization range to protect against voltage variation.

F. V-Belt Drive shall be variable pitch rated at 1.5 times the motor nameplate. Drives 20 hp and larger or any drives on units equipped with VFDs shall be fixed pitch.

G. All fans with fixed-pitch drives and motors 15 hp and larger shall be equipped with multiple belt drives.

H. Manufacturer shall provide for each fan a nameplate with the following information to assist air balance contractor in startup and service personnel in maintenance:

1. Fan and motor sheave part number
2. Fan and motor bushing part number
3. Number of belts and belt part numbers
4. Number of belts and belt part numbers
5. Belt tension and deflection

2.8 COILS

A. Coils section side panel shall be removable to allow for removal and replacement of coils without impacting the structural integrity of the unit.

B. Install coils such that headers and return bends are enclosed by unit casing to ensure that if condensate forms on the header or return bends, it is captured by the drain pan under the coil.

C. Coils shall be manufactured with plate fins to minimize water carryover and maximize airside thermal efficiency. Fin tube holes shall have drawn and belled collars to maintain consistent fin spacing to ensure performance and air pressure drop across the coil as scheduled. Tubes shall be mechanically expanded and bonded to fin collars for maximum thermal conductivity.

D. Construct coil casings of galvanized steel. End supports and tube sheets shall have belled tube holes to minimize wear of the tube wall during thermal expansion and contraction of the tube.

E. All coils shall be completely cleaned prior to installation into the air handling unit. Complete fin bundle shall be degreased and cleaned to remove any lubricants used in the manufacturing of the fins, or dirt that may have accumulated, in order to minimize the chance for water carryover.

F. When two or more cooling coils are stacked in the unit, an intermediate drain pan shall be installed between each coil. The intermediate drain pan shall be designed being of sufficient size to collect all condensation produced from the coil and sloped to promote positive drainage to eliminate stagnant water conditions. The intermediate drain pan shall be constructed of the same material as the primary drain pan.

G. The intermediate drain pan shall begin at the leading face of the water-producing device and be of sufficient length extending downstream to prevent condensate from passing through the air stream of the lower coil.

H. Intermediate drain pan shall include downspouts to direct condensate to the primary drain pan. The intermediate drain pan outlet shall be located at the lowest point of the pan and shall be sufficient diameter to preclude drain pan overflow under any normally expected operating condition.

I. Hydronic Coils:

1. Supply and return header connections shall be clearly labeled on unit exterior such that direction of coil water-flow is counter to direction of unit air-flow.
2. Coils shall be proof-tested to 300 psig and leak-tested to 200 psig air pressure under water.
3. Headers shall be constructed of round copper pipe or cast iron.
4. Tubes shall be minimum 5/8-inch O.D. and minimum 0.024-inch-thick copper. Fins shall be aluminum with a maximum of 12 fins per inch.
5. Hydronic coils shall be supplied with factory installed drain and vent piping to the unit exterior.

2.9 FILTERS

A. Filter MERV rating and arrangement shall be provided as defined on the project drawings.

B. Provide factory-fabricated filter section of the same construction and finish as unit casings. Filter section shall be provided with filter frames. Filter holding frames shall be continuously welded for heavy-duty construction, long-term reliability, minimal maintenance, and minimal air bypass such that filtration efficiency is that of the scheduled filters. Frames shall be equipped with filter fasteners of the same material as the filter frame. Filter holding frames shall be of the universal type to accommodate standard filters as well as appropriate fasteners. Hinged access door(s) shall be provided on each side of the section to facilitate filter removal.

C. Pre-Filters: Provide 2” pleated media filters made with 100 percent synthetic fibers capable of operating at face velocities of up to 625 fpm without loss of efficiency. The filters shall have MERV 8 rating in accordance with ANSI/ASHRAE Standard 52.2.

D. High Efficiency Filters: The filters shall be constructed with a continuous sheet of fine-fiber media made into closely spaced pleats. The filters shall be capable of operating up to 625 fpm face velocity without loss of filter efficiency and holding capacity. The filters shall be sealed into a metal frame assembled in a rigid manner. A gasket material shall be installed on the metal header of the filter to prevent filter bypass where the metal

headers meet on the side-access racks. The manufacturer shall supply a side-access filter rack capable of holding high efficiency filters and pre-filters. High Efficiency filters shall have a MERV 13 rating when tested in accordance with the ANSI/ASHRAE Standard 52.2.

2.10 DAMPERS

A. All dampers, with the exception of external bypass, shall be internally mounted. Dampers shall be premium ultra-low leak and located as indicated on the schedule and plans. Blade arrangement shall be opposed. Dampers shall be Ruskin CD60 double-skin airfoil design or equivalent for minimal air leakage and pressure drop. Leakage rate shall not exceed 3 CFM/square foot at one inch water gauge complying with ASHRAE 90.1 maximum damper leakage and shall be AMCA licensed for Class 1A. All leakage testing and pressure ratings shall be based on AMCA Standard 500-D.

2.11 ACCESS SECTIONS

A. Access sections shall be provided where indicated in the schedule and plans. Access sections to be of the same construction and finish as the unit casings. Provide access doors on each side of the access section. Refer to preceding paragraphs for access door requirements.

2.12 DISCHARGE PLENUM SECTIONS

A. Plenums shall be provided where indicated on the drawings. Discharge plenum opening types and sizes shall be scaled to meet pressure drop requirements scheduled and align with duct takeoffs. Discharge plenum panels shall include an acoustical liner. The liner shall be fabricated from stainless steel perforated material to prevent corrosion and designed to completely encapsulate fiberglass insulation. The perforation spacing and hole size shall be such as to prevent insulation breakaway, flake off, or de-lamination when tested at 9000 fpm, in accordance with UL 181 or ASTM C1071. Insulation material must be resistant to fungi in accordance with ASTM C1338.

2.13 VARIABLE FREQUENCY DRIVES (VFD)

A. Where indicated on the drawings variable frequency drives shall be provided by the unit manufacturer. Variable frequency drives shall NOT be supplied with bypass capabilities on air handling units that serve systems with variable air volume terminal units.

B. Unless otherwise indicated on the drawings variable frequency drives shall be mounted and wired by the AHU manufacturer. All standard and optional features shall be included within the VFD enclosure, unless otherwise specified. The VFDs shall be UL listed. The listing shall allow mounting in plenum or other air handling compartments.

C. The VFD shall convert incoming fixed frequency three-phase AC power into a variable frequency and voltage for controlling the speed of three-phase AC motors. The motor current shall closely approximate a sine wave. Motor voltage shall be varied with

frequency to maintain desired motor magnetization current suitable for centrifugal pump and fan control and to eliminate the need for motor de-rating.

D. With the motor's rated voltage applied to the VFD input, the VFD shall allow the motor to produce full rated power at rated amps, RMS fundamental volts, and speed without using the motor's service factor. VFDs utilizing sine weighted/coded modulation (with or without 3rd harmonic injection) must provide data verifying that the motors will not draw more than full load current during full load and full speed operation.

E. The VFD shall include an input full-wave bridge rectifier and maintain a fundamental power factor near unity regardless of speed or load.

F. The VFD and options shall be tested to ANSI/UL Standard 508. The complete VFD, including all specified options, shall be assembled by the manufacturer, which shall be UL 508 certified for the building and assembly of option panels. Assembly of separate panels with options by a third-party is not acceptable. The appropriate UL stickers shall be applied to both the VFD and option panel, in the case where these are not contained in one panel.

G. The VFD shall have DC link reactors on both the positive and negative rails of the DC bus to minimize power line harmonics. VFDs without DC link reactors shall provide a minimum 3% impedance line reactor.

H. The VFDs full load amp rating shall meet or exceed NEC Table 430-150. The VFD shall be able to provide full rated output current continuously, 110% of rated current for 60 seconds and 160% of rated current for up to 0.5 second while starting.

I. The VFD shall be able to provide full torque at any selected frequency from 28 Hz to base speed to allow driving direct drive fans without de-rating.

J. An automatic energy optimization selection feature shall be provided standard in the VFD. This feature shall automatically and continually monitor the motor's speed and load and adjust the applied voltage to maximize energy savings and provide up to an additional 3% to 10% energy savings.

K. Input and output power circuit switching shall be able to be accomplished without interlocks or damage to the VFD. Switching rate may be up to 1 time per minute on the input and unlimited on the output.

L. An automatic motor adaptation test algorithm shall measure motor stator resistance and reactance to optimize performance and efficiency. It shall not be necessary to run the motor or de-couple the motor from the load to run the test.

M. Galvanic and/or optical isolation shall be provided between the VFDs power circuitry and control circuitry to ensure operator safety and to protect connected electronic control equipment from damage caused by voltage spikes, current surges, and ground loop currents. VFDs not including either galvanic or optical isolation on both analog I/O and discrete I/O shall include additional isolation modules.

N. The VFD shall minimize the audible motor noise through the use of an adjustable carrier frequency. The carrier frequency shall be automatically adjusted to optimize motor and VFD efficiencies while reducing motor noise.

O. Protective Features

1. Protection shall be provided against input transients, loss of AC line phase, output short circuit, output ground fault, overvoltage, undervoltage, VFD overtemperature and motor overtemperature. The VFD shall display all faults as words. Codes are not acceptable.
2. The VFD shall be protected from sustained power or phase loss. The VFD shall provide full rated output with an input voltage as low as 90% of the nominal. The VFD shall continue to operate with reduced output with an input voltage as low as 164 V AC for 208/230-volt units, 313 V AC for 460-volt units, and 394-volts for 600-volts units.
3. The VFD shall incorporate a motor preheat circuit to keep the motor warm and prevent condensation build up in the stator.
4. The VFD package shall include semi-conductor rated input fuses to protect power components.
5. To prevent breakdown of the motor winding insulation, the VFD shall be designed to comply with IEC Part 34-17. Otherwise, the AHU manufacturer shall ensure that inverter rated motors are supplied.
6. The VFD shall include a “signal loss detection” circuit to sense the loss of an analog input signal such as 4 to 20 mA or 2 to 10 V DC, and shall be programmable to react as desired in such an instance.
7. The VFD shall function normally when the keypad is removed while the VFD is running and continue to follow remote commands. No warnings or alarms shall be issued as a result of removing the keypad.
8. The VFD shall catch a rotating motor operating forward or reverse up to full speed.
9. The VFD shall be rated for 65,000 amp interrupting capacity (AIC).
10. The VFD shall include current sensors on all three output phases to detect and report phase loss to the motor. The VFD shall identify which of the output phases is low or lost.
11. The VFD shall continue to operate without faulting until input voltage reaches 300-volt AC on 208/230-volt units, 539 V AC on 460-volt units, and 690 volts on 600-volt units.

PART 3 - EXECUTION

3.1 SHIPPING

A. Protect equipment during shipment and delivery, all indoor units shall be completely stretch or shrink wrapped. Wrap shall be a minimum of 7 mil plastic. Pipe ends and pipe connection holes in the casing shall be capped or plugged prior to shipment.

3.2 ON-SITE STORAGE

A. If equipment is to be stored for a period of time prior to installation, the installing contractor shall remove all stretch or shrink wrap from units upon receipt to prevent unit corrosion and shall either place the units in a controlled indoor environment or shall cover the units with canvas tarps and place them in an area not subject to rain and/or snow.

3.3 EXAMINATION

A. The contractor shall verify that the mechanical room and/or roof are ready to receive work and the opening dimensions are as indicated on the shop drawings and contract documents. The contractor shall verify that the proper power supply is available prior to starting of the fans.

B. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

C. Examine casing insulation materials and filter media before air-handling unit installation. Reject insulation materials and filter media that are wet, moisture damaged, or mold damaged.

D. Examine roughing-in for piping, ducts and electrical services to verify actual locations of connections before installation.

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

3.4 INSTALLATION

A. Install modular air-handling units level and plumb, in accordance with manufacturer's written instructions. Arrange installation of units to provide the required access space around air-handling units for service and maintenance.

B. Provide watertight coverings over all unit openings until the final duct connections are completed.

C. Install floor mounted air-handling units on concrete bases, where indicated on the drawings. Secure units to anchor bolts installed in concrete bases. Comply with requirements for concrete bases specified.

D. Where air handling units are to be installed in existing areas with limited access the contractor shall require the unit manufacturer to ship the units in segments that allow installation through existing construction. Provide shipping segments dimensions to the manufacture.

E. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing, with new, clean filters.

F. Install filter-gage, static-pressure taps upstream and downstream of filters. Mount filter gages on outside of filter housing or filter plenum in accessible position. Provide filter

gages on filter banks, installed with separate static-pressure taps upstream and downstream of filters.

G. At the direction of the Owner's Representative the contractor shall remove and dispose of filters from the respective units and install a new filter obtained from the Extra Materials required in Part 1 of this specification. If additional filter installation is not required, forward filters to the owner as extra stock, at the completion of the project.

3.5 CONNECTIONS

A. Comply with requirements for piping specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to air-handling unit to allow service and maintenance.

C. Connect piping to air-handling units mounted on vibration isolators with flexible connectors.

D. Connect condensate piping to drain pans and extend to nearest equipment or floor drain. Construct trap at connection to drain pan per the manufacturer's requirements and install cleanouts at changes in direction.

E. Hot and Chilled-Water Piping: Install control valve, shutoff valve and union or flange at each coil supply connection. Install balancing valve and union or flange at each coil return connection.

F. Connect duct to air-handling units with flexible connections.

3.6 FIELD QUALITY CONTROL

A. Engage a factory service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections and to provide start-up service.

B. Air-handling unit or components will be considered defective if unit or components do not pass tests and inspections.

C. Prepare test and inspection reports.

3.7 CLEANING

A. After completing system installation and testing, adjusting, and balancing air-handling unit and air-distribution systems and after completing startup service, clean air-handling units internally to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings, and install new, clean filters.

3.8 DEMONSTRATION

A. Engage a factory service representative to train Owner's maintenance personnel to adjust, operate, and maintain air-handling units.

END OF SECTION 237310

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SECTION 238235 – HYDRONIC FINNED TUBE

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. This Section includes Hydronic baseboard heating units.

1.3 SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for each type of product indicated.

B. Color Charts for Selection.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with requirements provide convectors manufactured by Zehnder Rittling.

B. Finned Tube meeting the full requirements of the specifications including aesthetic properties, and manufactured by the following will be considered:

1. Slant/Fin.
2. Sterling.
3. Sigma.

2.2 HYDRONIC FINNED TUBE

A. Performance Ratings: Rate baseboard radiators according to Hydronics Institute's "I=B=R Testing and Rating Standard for Baseboard Radiation."

B. Heating Elements: Copper and / or steel tubing mechanically expanded into flanged collars of evenly spaced aluminum and/or steel fins.

C. Enclosures: Provide enclosures to match the style indicated by model number on the drawings.

D. Cover Finish: Refer to drawing schedules for finishes required for each baseboard / finned tube. Provide units with finishes, as noted on the drawings per the following:

1. If the drawings indicate a “Primer” finish, provide a factory applied baked enamel primer.
2. If the drawings indicate a “Standard” color, provide a factory applied baked enamel color, selected by the Architect from the manufacturer’s standard color chart.
3. If the drawings indicate a “Custom Color” provide, a factory applied baked enamel in a custom color as selected by the Architect.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive convection heating units for compliance with requirements for installation tolerances and other conditions affecting performance. Examine roughing-in for hydronic-piping connections to verify actual locations before convection heating unit installation. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 BASEBOARD INSTALLATION

A. Install all units level and plumb.

B. Where indicated install enclosure continuously around corners, using outside and inside corner fittings or install continuously from wall to wall. Join sections with splice plates and filler pieces to provide continuous enclosure. Install access doors for access to valves.

C. Terminate enclosures with manufacturer's end caps except where enclosures are indicated to extend to adjoining walls.

D. Install valves within reach of access door provided in enclosure.

E. Install piping within pedestals for freestanding units.

F. Provide all required hangers and brackets.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Section. Drawings indicate general arrangement of piping, fittings, and specialties. Provide all specialties indicated.

B. Unless otherwise indicated, install union, control valve, strainer and ball valve on supply-water connection and union, calibrated balancing valve and ball valve on return-water connection of unit heater.

C. Install piping adjacent to units to allow service and maintenance.

3.4 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Test and adjust controls. Replace damaged and malfunctioning controls and equipment.

B. Remove and replace units that do not pass tests and inspections and retest as specified above.

END OF SECTION 238235

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SECTION 260010 - BASIC ELECTRICAL REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes general administrative and procedural requirements for electrical installations. The following administrative and procedural requirements are included in this Section to expand the requirements specified in Division 1:

1. Submittals.
2. Coordination Drawings.
3. Record documents.
4. Maintenance manuals.
5. Rough-ins.
6. Electrical installations.
7. Cutting and patching.

1.2 SUBMITTALS

A. Follow the procedures specified in Division 1.

B. Submit, in electronic format, as a PDF, electrical related Shop Drawings and Product Data. Provide requested Samples of sufficient quantity, to allow for required distribution to Owner, Owner's Representative, Architect and Engineer.

C. Submittals must be provided with all catalog information clearly identified indicating all options to be provided as part of the product. Any submittal not containing this information will be rejected.

D. Provide the following shop drawings in booklet form:

1. Light fixtures cuts shall be submitted all at one (1) time in a single packet.
2. Electrical switchgear, including, but not limited to panelboards, transformers, disconnect switches, manual motor starters, combination motor starters / disconnect switches, and contactors shall be submitted all at one (1) time in a single packet. All equipment shall be of one manufacturer.
3. Wire devices shall be submitted all at one (1) time in a single packet and be from one (1) manufacturer.
4. Occupancy sensors shall be submitted all at one (1) time in a single packet and be from one (1) manufacturer whether connected to a lighting control system or provided with power packs, unless noted otherwise. Layout drawings may be submitted after the devices are approved.
5. **All required layout drawings shall be shown on architectural backgrounds and not the electrical drawings to ensure that the manufacturer locates all devices. It is the contractor's responsibility to acquire the CAD drawings per Division 1 requirements.**

1.3 PRODUCT REVIEWS AND SUBSTITUTIONS

A. Refer to Division 1 for substitutions requirements under this contract. Division 1 requirements supersede requirements listed elsewhere.

1.4 SHOP DRAWINGS

A. Refer to the Conditions of the Contract (General and Supplementary) and Division-1 for submittal definitions, requirements, and procedures.

B. Where submittals include multiple items, a bill of material (not including quantity) shall be provided at the front of the shop drawing. The bill of material shall include product identification, manufacturer and model number.

C. Submittal of Shop Drawings, Product Data, and Samples will be reviewed only when submitted by the Prime Contractor. Submittals from sub-Contractors and material suppliers directly to the Architect/Engineer will not be reviewed. No equipment/materials shall be installed until the Shop Drawings have been stamped with "No Exceptions Taken" or "Make Corrections Noted" by the Architect/Engineer.

D. Submit Shop Drawings as listed in each specification section. Following is a list of shop drawings to assist the contractor; however, the contractor shall supply all shop drawings as listed in each individual section whether listed below or not.

1. Coordination Drawings.
2. Electrical Systems Commissioning.
3. Aluminum/Copper Compression Lugs.
4. Power Panelboards.
5. Disconnect Switches.
6. Fuses.
7. Thermal Overload Switches.
8. Wiring Devices and Wall Plates.
9. Dimmer Switches.
10. All Lighting Fixtures (submit in booklet form and with detail drawings where required).
11. Occupancy Sensors and associated layout drawings.
12. Fire Alarm Equipment and associated wiring diagrams, and layout drawings.
13. Fire Stopping Material.
14. Access Panels.

E. When preparing submittals and any required final programming, use a room number schedule generated by the architect and/or the owner, which indicates the actual room numbers that will be used when the building is occupied. If the schedule is not available, revise the initial submittal, when a schedule is available, to reflect the proper room numbers.

F. Submittal Plans: Submittal plans **MUST** be provided with only the system being presented. Plans not submitted that have not been cleaned of extraneous systems (i.e. a low voltage system being installed on the power drawing, showing all the power and other low voltage systems), will be grounds for immediate rejection without review.

1.5 COORDINATION SUBMITTALS

A. The Contractor shall coordinate with other trades, and provide building coordination drawings for all major components. Following is a MINIMUM list of components that must be included on the coordination drawings; however, the Contractor must also include all other components and systems of substantial size to ensure proper coordination.

1. Conduit pathways, denoting pathways for larger conduits (3” and larger) as well as bundles of MC cable.
2. Panelboards, transformers.
3. Lighting.

1.6 PRODUCT OBSOLESCENCE

A. In all cases, the most current iteration of the specified product shall be submitted. Where the specified product is no longer manufactured, the contractor shall submit an equivalent product with the same or better specifications. Where specific manufacturers are specified, the contractor shall supply from the same manufacturer the recommended replacement; however, under no circumstances shall the replacement product be deficient in any aspect to the specified product.

B. In the submittal for the product, the Contractor shall provide a signed letter clearly indicating the reason for the replacement product, and confirmation that the replacement product meets or exceeds all of the specified product's specifications to the best of the Contractor's knowledge.

C. The replacement product shall be provided at no additional cost to the owner, and shall not constitute any extension to the project schedule.

D. These requirements shall be inclusive to requirements listed elsewhere in the specifications, and shall not void any other requirements.

1.7 INSPECTIONS

A. The Contractor shall provide certificates of approval, in triplicate, for service equipment, building rough wiring, and building finished wiring.

B. Inspection certificates shall be submitted to the Engineer within 30 days after the inspections are made. Contractor shall use an independent NEC Certified Inspection Agency as the approved agency. Contractor must verify that the Certified Inspection Agency is approved by the local municipality and the Owner to inspect electrical installations in the project locality. All inspection certificates must be received before final payment can be made.

C. Refer to General Conditions for additional information.

1.8 INDEPENDENT COMMISSIONING

A. Independent Commissioning of electrical systems meeting local and state codes, and owner requirements shall be provided as part of this project. The independent commissioning authority may be hired by this Contractor, another project Contractor or the Owner, as indicated in the documents. However, this does not absolve the installing Contractor and manufacturer from ensuring full functionality of the systems, and manufacturer commissioning as outlined in the individual sections.

B. The Contractor shall schedule and coordinate shop drawing submissions, systems installation and systems start-up with the commissioning authority as required to allow the commissioning authority to perform their work.

C. Commissioning of the lighting control system shall take place on every project, and shall meet the local currently adopted version of the International Energy Conservation Code. This Contractor shall ensure this takes place, and contract with the applicable party as required.

1.9 MANUFACTURER'S REQUIREMENTS

A. All material shall be new, of the best respective kinds, manufactured by the company or companies mentioned and shall be of domestic manufacture unless specified otherwise.

B. All equipment, material or apparatus of any one system must be the product of one Manufacturer, or system tested products.

C. Manufacturers not listed in the Contract Documents must submit to the Engineer, via a Bidding Contractor, all product information per Division 1 requirements.

1.10 NAMEPLATE DATA

A. Each item of power operated equipment shall be provided with a permanent operational data nameplate on indicating Manufacturer, product name, model number, serial number, capacity, operating and power characteristics, labels of tested compliance, and similar essential data. Nameplates shall be located in an accessible location.

1.11 FAMILIARITY WITH PROPOSED WORK

A. All Contracts are with the understanding that the Contractor, prior to submission of his bid, acquainted himself with the requirements of the Drawings and Specifications, including "Conditions of the Contract," conditions of the site, its terrain, soil conditions, all other requirements of the Contract, and that he obtained all information necessary for completion of the work on or before the date specified for receiving of bids.

B. In all cases where a device or part of the equipment is herein referred to in the singular, such reference shall apply to as many such items as are required to complete the installation.

C. "Existing" information does not necessarily represent "as-built" conditions. The Contractor shall verify all existing conditions. If discrepancies are found the Contractor shall notify the Architect/Engineer for a resolution before proceeding.

1.12 DEFINITIONS

A. The terms "The Contractor" or "This Contractor" mentioned in these Specifications refers to the Electrical Contractor responsible for the work and equipment included in these Specifications.

B. The term Sub-Contractor refers to any reference to, or letting of work contained in these Specifications to any Sub-Contractor or Manufacturer by the Prime Contractor. This does not relieve the Prime Contractor of his responsibility for all work, material and equipment in this Specification.

C. The term "Provide," when used separately, shall mean to "Furnish and Install."

D. The term "Furnish," when used separately, shall mean to obtain and deliver on the job for installation by other trades.

E. The term "Install," when used separately, shall mean to mount in place, connect and make operable.

1.13 INTENT OF THE DRAWINGS AND SPECIFICATIONS

A. The Drawings which accompany the Specifications are for the purposes of illustrating the character and extent of the work, and are subject to such modifications by Architect/Engineer as may be found either necessary or advisable before ordering the prosecution of the work. The Contractor shall conform to and abide by whatever Supplementary Drawings and explanations which may be furnished by the Architect/Engineer for the purpose of illustrating the work. The Architect/Engineer shall decide as to the meaning or intention of any portion of the Specifications and Drawings.

B. Where the work is shown in complete detail on only half or a portion of a Drawing, or there is an indication of continuation, the remainder being shown in outline, the work drawn out in detail shall be understood to apply to other like portions of the structure. All work that may be called for in the Specifications and not shown on the Drawings, or shown on the Drawings and not called for in the Specifications, shall be executed and furnished by the Contractor as described in both.

C. Should any incidental work or materials be required, but not set forth in the Specifications or Drawings, either directly or indirectly, but which is necessary to fulfill the intent thereof, the Contractor is to understand same to be implied and required, and he shall perform all such work and furnish all such materials as fully as if they were particularly delineated or described, without additional cost to Owner. This shall include all materials, devices, methods peculiar to the machinery, equipment, apparatus, or systems as described herein.

1.14 EQUIPMENT ENCLOSURE RATINGS

A. Electrical equipment installed within the building shall carry a NEMA rating 1 or higher if indicated in the specifications or on the drawings.

B. Electrical equipment installed outside the building, or in environmentally wet locations shall carry a NEMA rating 3R or higher if indicated in the specifications or on the drawings.

C. Electrical equipment installed in harsh environments (i.e. natatoriums, greenhouses, etc.) shall carry a NEMA rating 4X, and be manufactured from stainless steel.

D. Where specifications and drawings conflict (i.e. drawings indicated NEMA 3R, but specifications indicate NEMA 1), the higher rating shall be provided at no additional cost to the project.

1.15 WIRING LAYOUTS

A. Should it become necessary to rearrange any of the circuit or feeder wiring, approval to do so shall first be obtained from the Engineer. The Contractor will be supplied with a spare set of Drawings on which all such approved changes shall be noted. Upon completion of all work under this Contract, these Drawings shall be returned to the Architect/Engineer, who will issue a receipt for same.

1.16 FIELD MEASUREMENTS

A. Before ordering any materials or doing any work, Contractor shall verify all measurements at the building site, and shall be responsible for correctness of same. At no time shall the Contractor scale Drawings for the purpose of installation.

B. No extra compensation will be allowed on account of differences between actual dimensions and those indicated on the Drawings. Any difference which may be found shall be submitted to the Architect/Engineer for consideration before proceeding with the work.

1.17 COORDINATION

A. The Contractor shall cooperate with the other Contractors and shall arrange to eliminate conflicts with the equipment and work of the Contractors.

B. The Contractor shall be responsible for coordinating all electrical devices/equipment with the casework before rough-in. Any conflicts with casework and electrical devices/equipment shall be brought to the attention of the Architect/Engineer before rough-in. Any electrical device/equipment installed in conflict with casework shall be removed and reinstalled at the Contractor's expense.

C. The Contractor shall be responsible to coordinate all electrical conduits which are installed for rooftop equipment. Where the equipment can be fed from within the equipment curb, the contractor shall utilize this space. Where the equipment must be

fed from the exterior, the contractor shall furnish and install a roof curb designed for conduit penetrations.

1.18 CHASES AND OPENINGS

A. The Contractor shall determine, in advance, the locations and sizes of all chases and openings necessary for the proper installation of his work and have same provided during construction. Any chase or opening not made during construction, due to the Contractor's failure to determine same in advance, shall be done by the Contractor at his own expense. Any unnecessary cutting shall be repaired to match the original conditions of the area disturbed at the Contractor's expense.

1.19 AIR PLENUMS

A. The Contractor shall use a conduit system or approved plenum rated wiring for all wiring located above ceilings.

1.20 RECORD DOCUMENTS

A. Refer to Division 1 for Record Document requirements. The following requirements supplement the requirements of Division 1.

B. Mark Drawings to indicate revisions to conduit size and location both exterior and interior; actual equipment locations, dimensioned from column lines; concealed equipment, dimensioned from column lines; distribution and branch electrical circuitry; fuse and circuit breaker size and arrangements; support and hanger details; work performed via Change Orders; concealed control system devices.

C. Mark Specifications to indicate changes by addendum or Change Orders; actual equipment and materials used.

D. All new underground utilities shall be marked and dimensioned on site plan as-built drawings.

1.21 OPERATION AND MAINTENANCE DATA

A. Refer to Division 1 for Operation and Maintenance Manual requirements.

B. Contractor shall provide Operation and Maintenance data listed in individual section in addition to requirements listed in Division 1.

C. Included with operation and maintenance data, under a separate tab or volume, complied into a single place, shall be manufacturer recommended preventative maintenance measures for each piece of equipment installed as part of this project.

1.22 WARRANTIES

A. Division 1 warranties shall be considered minimum warranties. Any warranties listed in the individual sections that are longer than Division 1 warranties shall be honored.

B. Refer to individual sections for warranty requirements beyond those as specified in Division 1.

1.23 TEST AND ADJUST

A. All systems installed under this Contract shall be tested and adjusted to ensure that all equipment and systems meet or exceed the specified requirements.

1.24 PHASE LOAD BALANCE

A. A reasonable balance shall be secured on the phases of all main distribution feeders and bus bars.

B. Following installation and with the system in operation, the Electrical Contractor shall check the balance and rearrange connections so that the ampacity on any of the two single-phase phases of the main bus shall not vary more than 10% of each other.

1.25 PAINTING

A. Refer to the Division 1 for general painting requirements.

B. The Contractor shall be responsible for all touch up painting on this project for electrical work.

C. The Contractor shall be responsible for painting of all conduits that is installed after general painting has been completed. In areas where the General Trades Contractor is not painting, this Contractor shall be responsible for painting conduits and boxes to match adjacent surfaces.

1.26 CLEANING

A. Refer to Division 1 Section, "Project Closeout" or "Final Cleaning" for general requirements for final cleaning.

B. The Contractor shall keep the building free of rubbish and material during the course of construction insofar as the work under this Contract is concerned.

C. Upon completion of the project, the Contractor shall remove all rubbish, surplus equipment and shipping labels and have all areas broom clean. The Contractor shall thoroughly clean all fixtures, and other electrical equipment, leaving same in first-class working condition.

1.27 INSTRUCTION OF OWNER'S PERSONNEL

A. The Contractor shall provide instruction of the owner's personnel as outlined in Division 1. The following requirements shall be included in addition to Division 1 requirements.

B. The Contractor shall provide the services of competent personnel and/or Manufacturer trained personnel to instruct employees designated by the Owner in the proper operation, care and maintenance of the equipment and system installed under the Contract.

C. A letter of certification itemizing the equipment, system, instructor, and bearing signatures of the employees instructed shall be delivered to the Engineer and the Owner upon completion of the project. The letter of certification shall note the number of hours spent in explanation and actual operation of system with maintenance personnel. If the Contractor cannot turn over this letter of certification with employee signatures, the Contractor shall be prepared to provide additional owner training, meeting the specification requirements, at no additional cost to the owner.

1. The Contractor shall keep notes of all of the training sessions, list discussion topics, questions and answers. The contractor shall provide these typed meeting minutes of the training sessions to all of the attendees and owner's representative. A final copy of these minutes shall also be provided with the O and M manuals for the applicable product.

D. The Contractor shall be responsible to video record each trained presentation session with the owner and the manufacturer and turn over the recordings to owner after completion of training session. The recordings may be turned over on DVD or Thumb drive. The Contractor shall obtain a signed receipt for the recordings proving the owner received them. If a copy of the receipt cannot be turned over and validated when requested, the contractor shall be responsible to provide additional training sessions as requested. A generic training video shall be acceptable in lieu of recording the owner's training session; however, this does not absolve the contractor of providing a private training session with the owner.

1.28 DELIVERY AND STORAGE OF MATERIALS

A. Refer to the Division 1 for delivery and storage of materials requirements.

B. The Contractor shall provide for, or secure use of, suitable-dry storage space for the safe delivery and storage of his materials. The Contractor shall be responsible for providing their own storage trailers on site. <u>The use of Owner's inside-building storage will not be permitted, unless specifically noted otherwise.</u>

1.29 PROTECTION OF EQUIPMENT AND MATERIALS

A. Responsibility for care and protection of electrical work rests with the Contractor until it has been tested and accepted by the Owner. After delivery, before and after installation, protect equipment and materials against theft, injury, or damage in all cases.

B. Protect equipment outlets, and pipe openings with temporary plugs, caps, or burlap. Electrical conduit openings shall be covered with capped bushing or fiber disks and bushings.

C. The contractor shall be responsible to protect all existing electrical or communications equipment to remain from construction dirt and debris, whether created from this contractor or another contractor. The contractor shall determine the method needed to protect each piece of equipment to remain. Should existing equipment be damaged during demolition it will be the responsibility of the contractor to provide necessary repairs or replacement of the damaged equipment.

1.30 PROTECTION OF SENSITIVE ELECTRONICS

A. During construction activities, the Contractor shall protect all newly installed and existing sensitive electronics, including, but not limited to Data equipment (network electronics, servers, etc.), intercommunications equipment, telephone equipment, security equipment and CCTV equipment with a method that will keep all construction dirt and debris from the equipment filters, whether generated by this contractor or other contractors.

B. At a minimum, the Contractor shall build wood frames around all equipment housed in freestanding and wall mounted racks when construction occurs within the vicinity of the equipment. Cover housing with minimum 6mil thick reinforced clear plastic sheeting. The enclosure shall include removable access panels to work on equipment and shall be sized to provide sufficient air flow around equipment to avoid excessive heat buildup. The contractor shall provide an exhaust fan at one end and a similar sized framed inlet opening at the other end with a removable MERV 8 filter. Filters shall be replaced within sufficient intervals to avoid excessive heat buildup.

C. The Contractor may propose an alternate protection method prior to construction; however, the Contractor shall be prepared to provide the enclosure if their method is rejected.

D. Should the equipment be damaged during construction, the contractor shall replace the equipment with the same piece at no additional cost to the owner.

1.31 SCAFFOLDING AND HOISTING

A. The Contractor shall provide all lumber and other material required for the erection of all staging, scaffolding, shoring, protective platforms, railings and ladders. Scaffolding shall be removed at the completion of the work.

B. The Contractor shall protect any flooring that is to remain. The Contractor shall inspect the flooring before the scaffolding is installed and report any damage that exists before the start of construction. The Contractor shall be responsible to repair any damage to the flooring after the scaffolding is removed to the acceptance of the owner at no additional cost to the owner.

1.32 PERMITS AND FEES

A. Refer to the Division 1 for Permits and Fee requirements.

B. Unless noted otherwise, all electrical work permits, certificates, tests, and inspection fees required for the electrical work provided under this contract shall be paid by the Contractor, including any electrical licenses required to work on the project.

PART 2 - PRODUCTS

Not Applicable.

PART 3 - EXECUTION

3.1 ROUGH-IN

A. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.

B. Refer to equipment Specifications in Divisions-2 through -25 for rough-in requirements.

3.2 CUTTING AND PATCHING

A. Perform cutting and patching in accordance with Division 1. In addition to the requirements specified in Division 1, the following requirements apply. The Contractor shall be responsible for providing all cutting and patching required to perform his work unless noted otherwise.

B. Perform cutting, fitting, and patching of electrical equipment and materials required to:

1. Uncover work to provide for installation of ill-timed work.
2. Remove and replace defective work.
3. Remove and replace work not conforming to requirements of the Contract Documents.
4. Remove samples of installed work as specified for testing.
5. Install equipment and materials in existing structures.
6. Upon written instructions from the Architect, uncover and restore work to provide for Architect observation of concealed work.

C. Cut, remove, and legally dispose of selected electrical equipment, components, and materials as indicated, including but not limited to removal of electrical items indicated to be removed and items made obsolete by the new work.

D. Protect the structure, furnishings, finishes, and adjacent materials not indicated or scheduled to be removed.

E. Provide and maintain temporary partitions or dust barriers adequate to prevent the spread of dust and dirt to adjacent areas.

F. Unless noted otherwise, where equipment is being provided on existing roofing systems, the contractor shall provide all roof patching where he penetrates the roof. The roof patching must be performed by an authorized vendor of the roofing system, maintaining all existing roofing warranties. The Contractor must contract with the owner's existing roofing vendor all roofing work.

3.3 PROTECTION OF INSTALLED WORK

A. During construction activities, including cutting and patching operations, protect adjacent installations.

B. Patch existing finished surfaces and building components using new materials matching existing materials and experienced installers. For installers' qualifications refer to the materials and methods required for the surface and building components being patched.

3.4 ELECTRICAL INSTALLATION

A. Coordinate electrical equipment and material installation with other building components. Verify all dimensions by field measurements. If no dimensions are given, Contractor shall verify with Architect or Engineer before starting work. At no time shall the Contractor scale Drawings for the purpose of locating items.

B. Provide for chases, slots, and openings in other building components to allow for electrical installations. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components, as they are constructed.

C. Sequence, coordinate, and integrate installations of electrical materials and equipment for efficient flow of the work. Give particular attention to large equipment requiring positioning prior to closing-in the building.

D. Where mounting heights are not detailed or dimensioned, install systems, materials, and equipment to provide the maximum headroom possible, or to meet current local, national and ADA codes.

E. Coordinate connection of electrical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.

F. Install systems, materials, and equipment to conform with submittal data, including Coordination Drawings, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the work are shown only in diagrammatic form. Where coordination requirements conflict with individual system requirements, refer conflict to the Architect/Engineer.

G. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components, where installed exposed in finished spaces.

H. Install electrical equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations.

1. Contractor shall also take care to leave access to other systems located behind electrical components being installed as part of this project. Should it be found that access has been blocked to other equipment requiring access (i.e. filters, valves, etc.), the offending system will be required to be removed and reinstalled at no additional cost to the owner.

I. Install access panel or doors where units are concealed behind finished surfaces. Access panels and doors are specified in Division 26 “Common Requirements – Electrical.”

J. Install systems, materials, and equipment giving right-of-way priority to systems required to be installed at a specified slope.

K. Electrical component installation in spaces where abuse may occur (i.e. gymnasiums, locker areas, exterior areas) shall be provided with vandal covers. Covers shall be provided with a means to be locked. System components include, but are not limited to light switches/dimmers, occupancy sensors, sound system controls, fire alarm devices, clocks, wireless access points, etc.

3.5 LOW VOLTAGE WIRING INSTALLATION

A. All low voltage wiring, installed above ceilings, must be plenum rated, unless noted otherwise. Wiring shall be installed perpendicular to steel, located in j-hooks and/or cable tray as available and allowed. Refer to individual specification and drawings for allowance if cable installation in cable trays.

B. All low voltage wiring, installed in spaces without ceilings, must be installed within conduit or other approved raceway. This requirement shall apply to finished spaces (i.e. gymnasium, etc.) and unfinished spaces (i.e. mechanical rooms, electrical rooms, etc.) Under no circumstances is exposed wiring acceptable.

C. The contractor shall be responsible to provide surge protection for all low voltage systems where copper lines leave and/or enter a building. System shall include, but not be limited to, voice, fire alarm, CCTV, television and security. All surge protection for low voltage systems shall be solid state, unless otherwise noted.

3.6 EXISTING INSTALLED EQUIPMENT

A. Where existing installed equipment (including, but not limited to gymnasium equipment (batting cage, divider nets, etc.), free hanging projection screens, theatrical equipment, etc.) is in the way of construction, the Contractor shall move equipment as required to accommodate their work.

B. During relocation, and work, the Contractor shall take care to no damage the equipment. Should the equipment be damaged prior to work commencing, they shall take

photographic evidence, and report, in writing to the Owner, Architect and Engineer, the existing observed damage.

C. Should the existing equipment be damaged during construction activities, the contractor shall repair at no additional cost to the Owner.

3.7 ELECTRICAL REQUIREMENTS FOR EQUIPMENT INSTALLATION

A. Conduit and power wiring of required size and voltage, from a panelboard or similar source, shall be furnished and installed by this Contractor, to the equipment furnished by another Contractor. A junction box or means of disconnect (as required) shall be furnished and installed at the equipment by this Contractor meeting the National Electric Code.

B. Unless noted otherwise, a full complement of electrical control components, required for the intended use and/or operation of specified equipment, including variable frequency controllers, speed controllers and/or other control devices required, whether integral or remote, shall be furnished by the Contractor furnishing the equipment. These control devices as well as power wiring (where required) through these devices shall be installed by this Contractor.

3.8 CONTROL WIRING FOR EQUIPMENT INSTALLED BY ANOTHER CONTRACTOR

A. This Contractor shall be responsible for providing all required control wiring, (except HVAC system control wiring) for any equipment provided by another Contractor which shall include, but not be limited to, motorized backboards, screens, partitions, curtains, motor operated doors, etc, unless noted otherwise.

B. The Contractor shall provide all boxes and conduit required for any equipment provided by another Contractor. Control wiring shall also include any wiring of motion or occupancy sensors for doors, curtains, etc.

C. Coordinate all required work for a complete and functional system with the Contractor supplying the equipment. Make all required connections.

D. Prior to installing any control wiring to any equipment, acquire control wiring diagrams and direction from the installing contractor.

3.9 TEMPORARY ELECTRIC/TELEPHONE

A. Refer to Division 1 "General Conditions."

B. Lighting: Provide temporary lighting in accordance with OSHA, (5-footcandles) with local switching to fulfill security requirements and provide illumination for construction operations and traffic conditions.

1. Lamps and Light Fixtures: Provide general service lamps. Provide guard cages or tempered glass enclosures, where exposed to breakage. Provide exterior fixtures where exposed to moisture.

3.10 ELECTRICAL DEMOLITION

A. The Electrical Contractor shall be responsible for all electrical demolition.

B. The Contractor shall be responsible for disconnecting and removing from the site all conduit, wiring, light fixtures, devices, panelboards, disconnect switches, etc. The Owner shall tag or notify the Contractor as to any devices, equipment or systems which they wish to salvage before start of each phase of construction. See paragraph, "Salvage" for additional information.

C. The Electrical Contractor shall review all demolition drawings, including from other trades, and remove from the site all power wiring and associated electrical equipment, including, but not limited to wire, conduit, boxes, disconnecting means, supports, etc. feeding equipment that is being removed by other trades. This includes within the building, on the roof.

D. Where fastened equipment is removed, the contractor shall be responsible to remove the associated lags or bolts that fastened the equipment down. Grind lags or bolts to below exiting surface and patch surface to match existing condition.

3.11 ELECTRICAL EQUIPMENT IN AND ABOVE CEILINGS

A. Where ceilings are being removed to accommodate phasing, the contractor shall tie up all low and line voltage wiring that is resting on the ceiling grid scheduled to remain or feeding a later phase until that wire can be removed.

B. Any wire that is scheduled to remain shall be independently supported from the structure or walls per the applicable specification sections. Low voltage wire shall be installed in cable tray or j-hooks and line voltage wire shall be installed in conduit and supported per NEC.

C. Where ceilings are being removed to accommodate phasing, the contractor shall tie up all, fire alarm equipment (smoke detectors, annunciation devices, etc.), intercom speakers, and other electrical equipment until the new ceiling is installed. Electrical devices shall be removed or reinstalled as scheduled on the documents.

D. All existing MC cable encountered above the ceiling, not supported per the NEC, shall be tied up and supported per NEC requirements when encountered.

E. All wire, conduit, electrical systems or electrical devices, including, but not limited to lighting, power wiring, receptacles, data, fire alarm, security, CCTV, access control, intercom, phone, etc. above or in the ceiling that is abandoned prior to construction or being abandoned as part of the construction shall be removed at no additional cost to the owner. At the completion of the project, there shall be no abandoned wire, conduit, electrical systems or electrical devices in or above the ceiling.

3.12 CONTINUATION OF SYSTEMS DURING PHASED PROJECT

A. The contractor shall include all wiring, accessories, programming, etc. as required to accommodate the following. The contractor shall be responsible to contact the owner's

vendor of each system for the necessary programming, and subsequent decommissioning of the existing systems being removed.

B. During the construction process, it is the contractor's responsibility to ensure that the building fire alarm system remain active.

C. During the construction process, it is the contractor's responsibility to ensure that the building intercommunications system remain active. The contractor shall provide temporary wiring and programming as required to ensure that there is no interruption to either system outside the construction zone during each phase.

D. In all cases, systems that require programming, including, but not limited to lighting control system(s), occupancy sensors, intercommunications system and fire alarm system, shall be reprogrammed after each phase of construction to ensure that each system is functional. Final programming and training shall occur at substantial completion of the final phase. The warranty period for each system shall commence only after final programming and training.

E. All required night, weekend and holiday time required to ensure that the above requirements are met shall be provided at no additional cost to the owner.

3.13 SALVAGE

A. The Owner reserves the right to salvage any electrical equipment prior to the start of each phase of construction.

3.14 ELECTRICAL ROOM LAYOUTS

A. The contractor shall be responsible for submitting electrical room layouts to the engineer prior to any panel or equipment rough ins. Layouts shall show that all equipment will be installed to meet the N.E.C. Code clearance requirements. The Contractor shall bare all costs associated with any changes required if electrical rough-ins are done prior to layout approval.

B. It shall be the contractor's responsibility to verify all N.E.C. clearance requirements prior to installation, including, but not limited to ductwork, piping, or other equipment above electrical equipment, as well as all horizontal requirements.

END OF SECTION 260010

SECTION 260500 – COMMON REQUIREMENTS – ELECTRICAL CONSTRUCTION

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes materials and methods that are common to various Electrical Systems.

1.2 SUBMITTALS

A. Product Data: For the following:

1. Fireproofing
2. Access Doors

1.3 COORDINATION

A. Arrange for conduit spaces, chases and openings in building structure during progress of construction to allow for electrical installations.

B. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are construction as applicable.

C. Coordinate requirements for access panels and doors for electrical items requiring access that are concealed behind finished surfaces.

PART 2 - PRODUCTS

2.1 FIRESTOPPING

A. The Contractor shall be responsible for providing permanent, UL approved firestopping systems for all penetrations through fire rated floor or fire rated wall assemblies. For areas that will require future access for the installation of additional cables, repair, or retrofit, the firestopping system shall consist of re-usable intumescent pillows or putty. All firestopping shall meet the requirements of ASTM E-814 and UL 1479.

1. Subject to compliance with project requirements, firestopping materials may be provided by one of the following Manufacturers.

a. Specified Technologies Inc. (STI) Somerville, NJ (800) 992-1180
b. Tremco, Beechwood, OH (800) 321-7906
c. 3M, St. Paul, MN (800) 328-1687

2. Submit for review the following product data.

a. Product data sheets.

b. UL System Drawings for each firestopping application.
c. Manufacturer's Certificates of Conformance for their products.

2.2 ACCESS DOORS

A. Refer to Division 8, "Access Doors and Frames" for additional requirements. Access doors furnished and installed under this contractor shall comply with Division 8 requirements in addition to the following.

B. Manufacturers: Subject to review, provide access doors manufactured by Milcor, Inc or equal.

C. Description: Steel access doors and frames for installation in masonry and/or drywall/gypsum board assemblies. Provide fire rated access doors when doors are installed in a fire rated assembly.

D. Frames: minimum 16 gage steel with exposed nominal 1" flange around the perimeter of the unit. Where doors are to be installed in drywall/gypsum board assemblies provide frames with a drywall bead. Doors to be installed in masonry shall be furnished with adjustable metal masonry anchors.

E. Flush Panel Doors: minimum 14 gage steel with concealed spring or piano hinge(s) with a minimum swing of 175 degrees. Finish to be a factory-applied primer, suitable for field painting. Provide flush cylinder lock with key. Key all locks alike. Verify keying with owner prior to ordering.

PART 3 - EXECUTION

3.1 ROUGH-IN

A. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.

B. Refer to equipment Specifications in Divisions-2 through -25 for rough-in requirements.

3.2 EQUIPMENT INSTALLATION – COMMON REQUIREMENTS

A. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components, where installed exposed in finished spaces.

B. Install electrical equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations.

3.3 FIRESTOPPING

A. Comply with manufacturer's written instructions for install fire stopping. When mechanical system is used, set securely in place in accessible locations.

B. Environmental Limitations: Do not install penetration firestopping system when ambient or substrate temperatures are outside limits permitted by penetration firestopping system manufacturers or when substrates are wet because of rain, frost, condensation, or other causes.

C. Firestopping shall be installed in all fire rated walls. Review all drawings, including architectural, and site conditions to determine where fire rated walls are located.

D. Preparation

1. Surface Cleaning: Before installing penetration firestopping systems, clean out openings immediately to comply with manufacturer's written instructions and with the following requirements:

    a. Remove from surfaces of opening substrates and from penetrating items foreign materials that could interfere with adhesion of penetration firestopping materials.
    b. Clean opening substrates and penetrating items to produce clean, sound surfaces capable of developing optimum bond with penetration firestopping materials. Remove loose particles remaining from cleaning operation.
    c. Remove laitance and form-release agents from concrete.

E. Installation

1. General: Install penetration firestopping systems to comply with manufacturer's written installation instructions and published drawings for products and applications.
2. Install forming materials and other accessories of types required to support fill materials during their application and in the position needed to produce cross-sectional shapes and depths required to achieve fire ratings.

    a. After installing fill materials and allowing them to fully cure, remove combustible forming materials and other accessories not forming permanent components of firestopping.

3. Install fill materials by proven techniques to produce the following results:

    a. Fill voids and cavities formed by openings, forming materials, accessories and penetrating items to achieve required fire-resistance ratings.
    b. Apply materials so they contact and adhere to substrates formed by openings and penetrating items.
    c. For fill materials that will remain exposed after completing the Work, finish to produce smooth, uniform surfaces that are flush with adjoining finishes.

F. Identification

1. Wall Identification: Permanently label walls containing penetration firestopping systems with the words "FIRE AND/OR SMOKE BARRIER - PROTECT ALL OPENINGS," using lettering not less than 3 inches (76 mm) high and with minimum 0.375-inch (9.5-mm) strokes.

2. Locate in accessible concealed floor, floor-ceiling, or attic space at 15 feet (4.57 m) from end of wall and at intervals not exceeding 30 feet (9.14 m).

G. Cleaning and Protection

1. Clean off excess fill materials adjacent to openings as the Work progresses by methods and with cleaning materials that are approved in writing by penetration firestopping system manufacturers and that do not damage materials in which openings occur.
2. Provide final protection and maintain conditions during and after installation that ensure that penetration firestopping systems are without damage or deterioration at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, immediately cut out and remove damaged or deteriorated penetration firestopping material and install new materials to produce systems complying with specified requirements.

3.4 ACCESS DOORS

A. Comply with manufacturer's written instructions for installing access doors and frames. Set frames accurately in position and attach securely to supports with plane of face panels aligned with adjacent finish surfaces. Install doors flush with adjacent finished surfaces or recessed to receive finish material.

B. Adjust doors and hardware after installation for proper operation. Remove and replace doors and frames that are warped, bowed or otherwise damaged.

END OF SECTION 260500

SECTION 260519 – WIRES AND CABLES – 600V AND BELOW

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

A. The extent of the wire and cable work is indicated by Drawings and by requirements or other sections of the Specifications for cables used for power, lighting, signal, control and related system rated 600 volts or less. See below article “CABLES” for permitted use of Type MC Cables on this project.

1.2 CODES AND STANDARDS

A. NEC Compliance: Comply with applicable requirements of NEC for construction and installation of wires/cables and connectors.

B. UL Compliance: Comply with UL Stds 44, 83 and 486A, B and C. Provide wiring/cabling and connector products which are UL-listed and labeled consistent with their uses.

C. ICEA Compliance: Insulated Cable Engineers Association Inc., Standard WC-5-86.

D. IEEE Compliance: Institute of Electrical and Electronic Engineers, Standard 82-83.

E. ANSI Compliance: American National Standard Institute, Standard C119.4

1.3 SUBMITTALS

A. Provide submittals for compression lugs only; wire does not require submittal.

B. Comply with Division 1 requirements.

C. Compression Lug Product Data:

1. Submit manufacturer’s descriptive literature and produce specifications for each product.
2. Manufacturer’s product drawings.

PART 2 - PRODUCTS

2.1 GENERAL

A. Provide all wires and cables of sizes indicated on the Drawings and suitable for the temperature, conditions and location where installed. Install all wire in raceway.

2.2 CONDUCTOR MATERIAL

A. Use copper conductors of 98% conductivity and rated at 600V for all wires and cables, unless otherwise noted.

B. Provide aluminum switchboard, transformer and panelboard feeders for 50amps and larger where permitted in these specifications and/or as indicated on the drawings. Where aluminum switchboard, transformer and panelboard feeders are used, they shall be sized according to NEC Article 310. Feeder sizes on the drawings are for copper conductors, unless otherwise noted.

1. All device and equipment feeds shall be copper unless specifically noted otherwise.

2.3 INSULATION

A. No conductors smaller than No. 12 AWG shall be used unless noted elsewhere. All wires No. 8 AWG or larger shall be stranded. Wire sizes No. 12 and No. 10 AWG. shall be solid (stranded wire used for No. 12 AND 10 will not be permitted unless otherwise noted).

B. Where permitted, aluminum wire shall be provided with compact strands.

C. All conductors shall be provided with type THHN/THWN insulation, unless noted otherwise.

D. All switchboard, transformer and panelboard feeder insulation shall be type XHHW-2.

E. Each circuit shall be provided with a dedicated neutral wire. Sharing of neutral wire for multiple circuits shall not be permitted, unless otherwise noted.

2.4 CABLES

A. Provide the following in NEC approved locations and project applications where indicated.

B. Type MC Cable: Provide Metal Clad Cable wiring using two No. 12 or 10 AWG with separate insulated copper ground wire (unless noted otherwise). Where AC (armored cable without separate neutral) is installed, Contractor will be required to remove cable and reinstall with approved cable type at no additional cost to the owner. Metal Clad cable may be used on this project only as follows:

1. For lighting and receptacle branch circuits from panel to device(s) or light fixture(s).
2. Connection to motors (2 feet maximum).
3. Fishing existing walls.
4. Branch circuits in stud walls.
5. Mechanical equipment/miscellaneous branch circuits inside of the building (less than 50amps) where condition warrants.

C. Where MC cables are run in parallel (i.e., down corridors), the Contractor shall bundle the cables and zip tie them together.

D. The Contractor shall bear all costs related for removing MC cable not pre-approved. Support and secure type MC cable at intervals not exceeding 6'-0". In addition, type MC cable must be supported within 12" of every fitting, junction box or outlet box that the cable enters.

E. All other wiring shall be installed in conduit as specified in Division 26 “Raceways,” unless approved otherwise by the Engineer prior to installation.

F. All switchboard, transformer and panelboard feeder wiring shall be run in conduit.

2.5 CONNECTORS FOR CONDUCTORS

A. Provide UL-listed factory-fabricated, solderless metal connectors of sizes, ampacity ratings, materials, types and classes for applications and for services indicated. Use connectors with temperature ratings equal to or greater than those of the wires upon which used.

2.6 ALUMINUM AND COPPER COMPRESSION LUGS

A. All aluminum cables shall have compression lugs at both ends of the cable. Under no circumstances shall the contractor attach aluminum cables directly to mechanical lugs.

B. Contractor may use copper compression lugs with copper cables at their discretion.

C. Manufacturer: Compression Lugs shall be Blackburn as manufactured by Thomas & Betts, or equal.

D. Aluminum NEMA Lugs

1. Lugs, splices and tees shall meet or exceed ANSI C119.4 requirements for Aluminum lugs and splices.
2. Lugs, splices and tees shall be dual-rated for use with both aluminum and copper conductors.
3. Lugs, splices and tees shall be made from high strength, high conductive aluminum alloy.
4. Lugs, splices and tees shall be prefilled with oxide inhibitor to prevent oxidation and keep out moisture.
5. Splices and tees shall have solid center stops to insure proper cable insertion depth.
6. Lugs, splices and tees shall be marked with conductor sizes and die references for easy identification.
7. Lugs shall be provided for all aluminum wire connections. Where aluminum wire is to terminate at mechanical lugs, provide bi-metal pin terminal compression lug to allow the mechanical lug to clamp on a copper pin.

PART 3 - EXECUTION

3.1 WIRES AND CABLES

A. General: Install electrical cables, wires, and connectors in compliance with NEC. Coordinate cable installation with other work. Pull conductors simultaneously where more than one is being installed in same raceway. Use UL listed pulling compound or lubricant, where necessary.

B. Use pulling means including, fish tape, cable, rope, and basket weave wire/cable grips which will not damage cables or raceways. Do not use rope hitches for pulling attachment to wire or cable.

C. While installing cables, care shall be taken to protect outer coating. If outer coating is damaged, contractor shall remove and reinstall cables.

D. Conceal all cable in finished spaces. Install exposed cable parallel and perpendicular to surfaces or exposed structural members, and follow surface contours, where possible. Keep conductor splices to minimum.

E. Install splice and tap connectors which possess equivalent or better mechanical strength and insulation rating than conductors being spliced. Use splice and tap connectors which are compatible with conductor material.

F. Provide adequate length of conductors within electrical enclosures and train the conductors to terminal points with no excess. Make terminations so there is no bare conductor at the terminal. Provide wire ties and neatly train and rack wires in all boxes, panels, and other areas as required.

G. Tighten electrical connectors and terminals, including screws and bolts, in accordance with Manufacturer's published torque tightening values. Where Manufacturer's torque requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL 486A and UL 486B.

H. Each branch circuit shall be provided with a dedicated neutral wire, unless noted otherwise.

I. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies.

3.2 FIELD QUALITY CONTROL

A. Prior to energizing, provide the following tests to all cables, 600 Volt or less and size no. 3 AWG or larger:

1. Inspect exposed sections of Inspect exposed sections of conductor and cable for physical damage and correct connection according to the single-line diagram.
2. Test bolted connections for high resistance using one of the following:

a. A low-resistance ohmmeter.
b. Calibrated torque wrench.

c. Thermographic survey.

3. Inspect compression-applied connectors for correct cable match and indentation.
4. Inspect for correct identification.
5. Inspect cable jacket and condition.
6. Insulation-resistance test on each conductor for ground and adjacent conductors. Apply a potential of 500 V(dc) for 300 V rated cable and 1000 V(dc) for 600 V rated cable for a one-minute duration. Use an industry approved meter for all tests.
7. Continuity test on each conductor and cable.
8. Uniform resistance of parallel conductors.
9. All inspection, cleaning and testing procedures shall be in compliance with the recommendations and standards outlined in the "maintenance testing specifications for electrical power distribution equipment and systems", latest edition, published by International Electrical Testing Association (NETA).

B. Prepare test and inspection reports and locate in the O&M manuals at the completion of the project. Test and inspection reports shall be provided to record the following:

1. Procedures used.
2. Results of above tests that comply with requirements.
3. Results that do not apply, corrective action taken, and retesting showing that they comply with the above requirements.

C. Subsequent to wire and cable hook-ups, energize circuits and demonstrate proper functioning. Correct malfunctioning units, and retest to demonstrate compliance.

D. Color-Coding for Phase Identification:

1. Color-code secondary service, feeder, and branch circuit conductors with factory-applied color as follows:

Phase	120/208 Volts	120/240 Volts	277/480 Volts
A	Black	Black	Brown
B	Red	Orange (High-Leg)	Orange
C	Blue	Blue	Yellow
Traveler	Yellow	Yellow	Yellow w/ “T” tag
Neutral	White	White	Gray
Ground	Green	Green	Green w/ Yellow stripe

2. Switch legs shall include an additional “S” tag.
3. Provide visible colored taped as listed above at all termination points for No. 8 and larger wires.

END OF SECTION 260519

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SECTION 260526 – GROUNDING

PART 1 - GENERAL

1.1 SUMMARY

A. Extent of electrical grounding and bonding work is indicated by Drawings and Schedules and as specified herein. Grounding and bonding work is defined to encompass systems, circuits, and equipment.

B. Type of electrical grounding and bonding work specified in this section includes the following:

1. Solidly grounded.

1.2 CODES AND STANDARDS

A. Electrical Code Compliance: Comply with applicable local electrical code requirements of the authority having jurisdiction, and NEC as applicable to electrical grounding and bonding, pertaining to systems, circuits and equipment.

B. UL Compliance: Comply with applicable requirements of UL 467, 486A, and 869, pertaining to grounding and bonding of systems, circuits and equipment. Provide grounding and bonding products which are UL-listed and labeled for their intended usage.

C. NRTL: Connectors shall be 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.

PART 2 - PRODUCTS

2.1 MATERIALS AND COMPONENTS

A. General: Except as otherwise indicated, provide electrical grounding and bonding system assembly of materials, including, but not limited to, cables/wires, connectors, solderless lug terminals, grounding electrodes and plate electrodes, bonding jumper braid, surge arresters, and additional accessories needed for a complete installation. Where more than one type component product meets indicated requirements, selection is Installer's option. Where materials or components are not indicated, provide products which comply with NEC, UL, and IEEE requirements and with established industry standards for those applications indicated.

B. Conductors: Unless otherwise indicated, provide electrical grounding conductors for grounding system connections that match power supply wiring materials and are sizes according to NEC.

C. Bonding Plates, connectors, Terminals, and Clamps: Provide electrical bonding plates, connectors, terminals, lugs and clamps as recommended by bonding plate, connector, terminal and clamp Manufacturers for indicated applications.

D. Ground Electrodes and Plates:

1. Grounding Electrodes: Solid copper, 5/8" diameter by 10 feet.
2. Grounding Electrodes: Steel with copper welded exterior, 3/4" diameter by 10 feet.

E. Electrical Grounding connection Accessories: Provide electrical insulating tape, heat shrinkable insulating tubing, welding materials, bonding straps, as recommended by accessories Manufacturers for type service indicated.

F. Direct Burial Compression Grounding System similar to Panduit's Structural Ground "Direct Burial Compression Grounding System" shall also be acceptable where exothermic connections are specified. Direct Burial System shall meet IEEE Standard 837-2002. System shall also meet UL 467. Contractor shall be responsible for providing all Grounding plates, connectors, cables, hydraulic crimping tool, etc. for a complete system. All other Direct Burial Grounding system manufacturers shall be submitted for approval prior to bidding.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions under which electrical grounding and bonding connections are to be made and notify Architect/Engineer in writing of conditions detrimental to proper completion of work. Do not proceed with work until unsatisfactory conditions have been corrected in a manner acceptable to Installer.

3.2 INSTALLATION OF ELECTRICAL GROUNDING AND BONDING SYSTEM

A. General: Install electrical grounding and bonding system as indicated, in accordance with Manufacturer's instructions and applicable portions of NEC, NECA's "Standard of Installation", and in accordance with recognized industry practices to ensure that products comply with requirements.

B. Coordinate with other electrical work as necessary to interface installation of electrical grounding and bonding system work with other work.

C. Branch Circuits: Install a minimum 12 AWG ground wire in each 20A circuit and conduit run and to connect to each device. Size larger circuit ground wires as per NEC Table 250-122.

D. Exothermically weld grounding conductors to underground grounding electrodes.

E. Ground electrical service system neutral at service entrance equipment to grounding electrodes per NEC Article 250. Grounding conductor shall be 4/0 copper, unless otherwise noted.

F. Direct burial compression grounding system similar to T&B and Panduit shall also be acceptable. System shall meet IEEE Standard 837-2002. System shall meet UL.

G. Ground each separately-derived system neutral to separate grounding electrode.

H. Connect together system neutral, service equipment enclosures, exposed noncurrent carrying metal parts of electrical equipment, metal raceway systems, grounding conductor in raceways and cables, receptacle ground connectors, and plumbing systems.

I. Terminate feeder and branch circuit insulated equipment grounding conductors with grounding lug, bus, or bushing.

J. Connect grounding electrode conductors to copper electrodes as per N.E.C., building steel and 1" diameter, or greater, metallic cold-water pipe using a suitably sized ground clamp. Provide grounding electrode connection to concrete slab rebar to meet NEC. Provide 4/0 copper conductor for all connections.

K. Tighten grounding and bonding connectors and terminals, including screws and bolts, in accordance with Manufacturer's published torque tightening values for connectors and bolts. Where Manufacturer's torquing requirements are not indicated, tighten connections to comply with tightening torque values specified in UL 486A to assure permanent and effective grounding.

L. Route grounding connections and conductors to ground and protective devices in shortest and straightest paths as possible to minimize transient voltage rises.

M. Apply corrosion-resistant finish to field-connections, buried metallic grounding and bonding products, and places where factory-applied protective coatings have been destroyed, which are subjected to corrosive action.

N. Install clamp-on connectors on clean metal contact surfaces, to ensure electrical conductivity and circuit integrity.

O. Provide ground wire connection to all electrical boxes and wiring devices.

P. Provide #6 AWG copper ground conductor connection to all cable trays. Cable tray grounding shall be continuous.

Q. Provide minimum #6 AWG ground connection from transformer to building steel. Provide larger conductor as required per NEC and drawings.

R. Bond service ground conduit to grounding conductor if conduit is metallic.

S. The contractor shall be responsible to provide grounding connection on gas piping where an appliance or mechanical piece of equipment has gas and electric circuit run to it. The ground conductor size shall be the same size as the electrical branch circuit run to the appliance or equipment to meet the NEC. article 250.

T. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit

and to air duct and connected metallic piping. Connect with same size ground as ground feeding circuit.

U. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components. Connect with same size ground as ground feeding circuit.

V. Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

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

1. Install 4/0 AWG, unless noted otherwise, tinned-copper conductor for ground ring and for taps to building steel.
2. Bury ground ring not less than 24 inches from building's foundation.

X. Connections: Make connections so possibility of galvanic action or electrolysis is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact are galvanically compatible.

1. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer in order of galvanic series.
2. Make connections with clean, bare metal at points of contact.
3. Make aluminum-to-steel connections with stainless steel separators and mechanical clamps.
4. Make aluminum-to-galvanized-steel connections with tin-plated copper jumpers and mechanical clamps.
5. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

3.3 FIELD QUALITY CONTROL

A. Upon completion of installation of electrical grounding and bonding systems, test ground resistance of each separately derived system with ground resistance tester. Where tests show resistance-to-ground is over 25 ohms, take appropriate action to reduce resistance to 25 ohms, or less, by driving additional ground rods; then retest to demonstrate compliance.

1. Provide type-written report in O&M manual documenting test results.

B. Contractor shall coordinate with local inspector to provide tests as required, and provide additional tests as required.

END OF SECTION 260526

SECTION 260529 – SUPPORTING DEVICES

PART 1 - GENERAL

1.1 CODES AND STANDARDS

A. NEC Compliance: Comply with NEC as applicable to construction and installation of electrical supporting devices.

B. NECA Compliance: Comply with National Electrical Contractors Association's "Standard of Installation" pertaining to anchors, fasteners, hangers, supports, and equipment mounting.

C. UL Compliance: Provide electrical components and devices which are UL-listed and labeled.

PART 2 - PRODUCTS

2.1 GENERAL

A. Provide supporting devices which comply with manufacturer's standard materials, design and construction in accordance with published product information, and as required for complete installation; and as herein specified. Where more than one (1) type of device fulfills indicated requirements, selection is Installer's option.

2.2 SUPPORTS

A. Provide supporting devices of types, sizes and materials indicated; and having the following construction features:

1. Clevis Hangers: For supporting up to 2" rigid metal conduit; galvanized steel; with 2" diameter hole for round steel rod; approximately 54 pounds per 100 units.
2. Riser Clamps: For supporting up to 5" rigid metal conduit; black steel; with 2 bolts and nuts, and 4" ears; approximately 510 pounds per 100 units.
3. Reducing Couplings: Steel rod reducing coupling, 2" x 5/8", black steel; approximately 16 pounds per 100 units.
4. C-Clamps: Black malleable iron; 2" rod size; approximately 70 pounds per 100 units.
5. I-Beam Clamps: Black steel, 1-1/4" x 3/16" stock; 3/8" cross bolt; flanges width 2"; approximately 52 pounds per 100 units.
6. One-Hole Conduit Straps: For supporting 3/4" rigid metal conduit; galvanized steel; approximately 7 pounds per 100 units.
7. Two-Hole Conduit Straps: For supporting 3/4" rigid metal conduit; galvanized steel; 3/4" strap width; and 2-1/8" between center of screw holes.
8. Hexagon Nuts: For 2" rod size; galvanized steel; approximately 4 pounds per 100 units.
9. Round Steel Rod: Black steel; 2" diameter; approximately 67 pounds per 100 feet.

10. Offset conduit clamps: For supporting 2” rigid metal conduit; black steel; approximately 200 pounds per 100 units.

2.3 ANCHORS

A. Provide anchors of types, sizes and materials indicated; and having the following construction features:

1. Lead Expansion Anchors: 2”; approximately 38 pounds per 100 units.
2. Toggle Bolts: Spring head; 3/16" x 4"; approximately 5 pounds per 100 units.
3. Manufacturers: Provide anchors of one of the following (for each type of anchor):

a. Ackerman Johnson Fastening Systems, Inc.
b. Ideal Industries, Inc.
c. Joslyn Manufacturing and Supply Co.
d. McGraw Edison Co.

2.4 SLEEVES AND SEALS

A. Provide sleeves and seals, including armored cable seals, of types, sizes, and materials indicated, with the following construction features:

1. Sleeve Seals: Provide sleeves for piping which penetrated foundation walls below grade, or exterior walls. Caulk between sleeve and pipe with non-toxic, UL-classified caulking material to ensure watertight seal.
2. Wall and Floor Seals: Provide watertight wall and floor seals, or types and sizes indicated; suitable for sealing around conduit, pipe, of tubing passing through concrete floors and walls. Construct seals with steel sleeves, malleable iron body, neoprene sealing grommets and rings, metal pressure rings, pressure clamps, and cap screws.

B. Fire-Rated Walls and Floors: At all locations where conduits, cables, or ducts penetrate a fire-rated wall or floor, a special fire-retardant caulking compound or other approved device as specified in Division 26 “Common Requirements - Electrical” shall be used.

2.5 CONDUIT CABLE SUPPORTS

A. Provide cable supports with insulating wedging plug for non-armored type electrical cables in risers; construct for 2” rigid metal conduit; 3-wires, type wire as indicated; construct body of malleable-iron casting with hot-dip galvanized finish.

2.6 U-CHANNEL STRUT SYSTEMS

A. Provide U-channel strut system for supporting equipment supplied under this contract, 12-ga hot-dip galvanized steel, or types and sizes indicated; construct with 9/16” diameter holes, 8” on center on top surface, with standard green finish, and with the fittings which mate and match with U-channel. The Contractor is responsible to size and install strut to meet properly support its intended load.

B. Auxiliary Steel Supports: Provide all required auxiliary steel to install any equipment supplied under this contract. The design and gauge of steel used shall be as required by the manufacturer's specifications. The Contractor is responsible to size and install auxiliary steel to properly support its intended load.

C. Manufacturers: Provide U-channel strut systems of one of the following (for each type system):

1. Allied Tube and Conduit Corp.
2. Midland-Ross Corp.
3. OZ/Gedney Div; General Signal Corp.
4. Power-Strut Div; Van Huffel Tube Corp.
5. Unistrut Div; GTE Products Corp.

PART 3 - EXECUTION

3.1 GENERAL

A. Install hangers, anchors, sleeves and seals as indicated, in accordance with manufacturer's written instructions and with recognized industry practices. Comply with installation requirements of NECA and NEC pertaining to supporting devices.

B. Coordinate with other mechanical and electrical work, including raceway and wiring work, as necessary to interface installation of supporting devices with other work.

C. Where supports or anchors are installed after the spray on insulation and/or firestopping is installed, patch the spray on insulation and/or firestopping to match surrounding area.

END OF SECTION 260529

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SECTION 260533 – RACEWAYS

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

A. The extent of the raceway and work required by this section is indicated by Drawings and requirements of other sections of this Specification.

B. Provide metal and nonmetallic conduit, tubing and fittings of types, grades, sizes and weights (wall thicknesses) for each service indicated on plans. Where types and grades are not indicated, provide proper selection determined by installer to fulfill wiring requirements and comply with applicable portions of NEC for raceways.

C. It is the intent of these Specifications and Drawings that all feeder wiring be run in a continuous conduit system. Type MC cables are permitted for lighting and power, branch circuits above ceilings and in stud walls, fishing existing walls, and connection to equipment/motors (2 feet max). In areas of exposed structure all wiring shall be run in conduit. At all locations where MC cable cannot be fished in an existing wall, surface (nonmetallic or metallic as specified) raceway shall be used. Finish of raceway shall be verified with the Architect before ordering. Surface raceway shall be screwed into the surface being installed at both ends and every 24” minimum along raceway. All surface raceway shall be run parallel and perpendicular to wall surfaces and run to blend in with surrounding equipment.

D. Refer to Division 26, “Wires and Cables – 600V and Below” for acceptable uses of MC cables.

1.2 CODES AND STANDARDS

A. NEMA Compliance: Comply with applicable requirements of NEMA standards pertaining to raceways.

B. UL Compliance and Labeling: Comply with provisions of UL safety standards pertaining to electrical raceway systems; provide products and components which have been UL-listed and labeled.

C. NEC Compliance: Comply with NEC requirements as applicable to construction and installation of raceway systems.

PART 2 - PRODUCTS

2.1 CONDUITS

A. Rigid Steel Conduit: Provide rigid steel, zinc-coated, threaded type conforming to FS WW-C-581, ANSI C80.1 and UL 6. Provide zinc-coating fused to inside and outside walls.

B. Rigid Aluminum Conduit: Provide rigid aluminum, threaded type conforming to ANSI and UL standards.

C. Intermediate Steel Conduit: Provide rigid intermediate grade (IMC) hot-dip galvanized threaded conforming to FS WW-C-581 and UL 1242.

D. Electrical Metallic Tubing (EMT): FSW-C-563, ANSI C80.3, and UL 797.

E. Liquid-Tight Flexible Metal Conduit: Provide liquid-tight flexible metal conduit; construct of single strip, flexible, continuous, interlocked, and double-wrapped steel; galvanized inside and outside; coat with liquid-tight jacket of flexible polyvinyl chloride (PVC).

F. Flexible Metal Conduit: FS WW-C-566 and UL 1. Formed from continuous length of spirally wound, interlocked zinc-coated strip steel.

G. PVC Light Wall Conduit shall not be acceptable under any circumstances. PVC Heavy Wall conduit shall be used when encased in concrete.

H. No other type of conduit shall be used, unless otherwise noted, or prior approval granted by the engineer.

2.2 CONDUIT FITTINGS

A. Flexible Metal Conduit Fittings: Provide conduit fittings for use with flexible steel conduit of threadless hinged clamp type.

B. Straight Terminal Connectors: Contractor shall provide one-piece body, with female end with clamp and deep slotted machine screw for securing conduit, and male threaded end provided with locknut.

C. 45-Deg or 90-Deg Terminal Angle Connectors: Two-piece body construction with removable upper section, female end with clamp and deep slotted machine screw for securing conduit, and male threaded end provided with locknut.

D. Rigid Metal Conduit Fittings: Cast-malleable-iron, galvanized or cadmium plated, conforming to FS W-F-408. Use Type 1 fittings for raintight connections, Type 2 fittings for concrete tight connections, and Type 3 fittings for other miscellaneous connections.

E. Rigid Aluminum Conduit Fittings: Provide cast-aluminum conduit fittings and mounting hardware conforming to ANSI and UL standards of types required for the application.

F. Liquid-Tight Flexible Metal Conduit Fittings: FS W-F-406, Type 1, Class 3, Style G. Provide cadmium-plated, malleable-iron fittings with compression type steel ferrule and neoprene gasket sealing rings, with insulated, or non-insulated throat.

G. EMT Fittings: All couplings and connectors shall be of the compression type.

H. PVC Heavy Wall Conduit and Tubing Fittings: Mate and match to conduit or tubing type and material.

I. Conduit and Tubing Accessories: Provide conduit, tubing and duct accessories of types, sizes, and materials, complying with Manufacturers' published product information, which mate and match conduit and tubing.

J. Conduit Bodies: Provide galvanized cast-metal conduit bodies of types, shapes, and sizes as required to fulfill job requirements and NEC requirements. Construct conduit bodies with threaded-conduit entrance ends, removable covers, either cast or galvanized steel, and corrosion-resistant screws.

K. All raceway conduit and fittings above a ceiling shall be plenum rated.

L. Press type fittings may not be used unless specifically specified to be acceptable elsewhere in the specifications or on the drawings.

2.3 WIREWAYS

A. General: Provide electrical wireways of types, grades, sizes, and number of channels for each type of service as indicated. Provide complete assembly of raceway including, but not limited to, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other components and accessories as required for complete system.

B. Lay-In Wireways: Provide lay-in wireways with hinged covers, in accordance with UL 870 and with components UL-listed, including lengths, connectors and fittings. Design units to allow fastening hinged cover closed without use of parts other than standard lengths, fittings and connectors. Construct units to be capable of sealing cover in closed position with sealing wire. Provide wireways with knockouts.

C. Connectors: Provide wireway connectors suitable for "lay-in" conductors, with connector covers permanently attached that removal is not necessary to utilize the lay-in feature.

D. Finish: Protect sheet metal parts with rust inhibiting coating and baked enamel finish. Plate finish hardware to prevent corrosion. Protect screws installed toward inside of wireway with spring nuts to prevent wire insulation damage.

E. Raintight Troughs: Construct in accordance with UL 870, with components UL listed.

F. Construction: 16-ga galvanized sheet metal parts for 4" x 4" to 6" x 6" sections, and 14-ga parts for 8" x 8" and larger sections. Provide knockouts only in bottom of troughs, with suitable adapters to facilitate or tear during installation, or would compromise raintight capability of the trough. Do not use cover screws that will protrude into the trough area and damage wire insulation.

G. Finish: Provide 14-ga and 16-ga galvanized sheet metal parts with corrosion-resistant phosphate primer and baked enamel finish. Plate hardware to prevent corrosion.

2.4 SURFACE RACEWAY

A. Provide single or dual channel surface raceway as specified on the drawings. Unless noted otherwise, raceway finish shall be selected at shop drawings from full list of standard and premium finishes.

B. Device plates matching the raceway system shall be utilized. Standard wall mounted device plates shall not be acceptable.

PART 3 - EXECUTION

3.1 GENERAL

A. Low voltage wiring in walls must be run in conduit system rated for 600V, as specified above. the use of flexible innerduct material in walls shall not be acceptable, unless specifically specified elsewhere. In new construction, conduits shall be rigid of appropriate type for the installation. In existing construction, flexible metallic conduit shall be used.

B. Unless noted otherwise, all conduit shall be installed concealed in walls, under slabs, or above ceilings.

C. Type MC cables shall be permitted only as noted.

D. Unless noted otherwise, raceways and cables shall be installed near the structure and be supported independently from the structure. Support systems for other building systems (i.e. ductwork, HVAC equipment, system piping, ceiling supports, etc.) shall not be used to support conduits and cables. When routed from light fixtures and other system connections, raceways and cables shall be routed directly vertical to structure and across. Drop wire supports shall not be used on any ceiling support wires under any circumstances.

E. Use PVC Schedule 40 conduit where circuits, feeders and service conductors are embedded in concrete, masonry, or earth, and use rigid galvanized steel elbows with large sweep elbows wherever turns are needed **(do not use PVC elbows)**. Where PVC conduit is installed below finished floor level within the building pad, contractor shall transition to IMC or rigid galvanized steel at the elbow and rise to above floor slab. Where PVC conduit is used exterior to the building under finished grade, contractor shall transition to galvanized rigid steel conduit at the elbow up, and continue using galvanized rigid steel along the riser to above finished grade.

F. PVC Schedule 40 conduit may be run in CMU wall cavities when originating from below finished grade and terminating at a recessed box no higher than 48” above finished floor or grade. For all other installations within wall cavities, PVC conduit shall not be used.

G. Use rigid aluminum conduit where installed exposed outdoors.

H. Use EMT conduit in mechanical equipment rooms, electrical equipment rooms, penthouses, crawl spaces, walls, and areas above ceiling.

I. Use flexible metal conduit in moveable partitions and from outlet boxes to recessed lighting fixtures, and final 24" of connection to motors, or control items subject to movement or vibration, and in cells of precast concrete panels. Conduit size shall be increased as required to fit wiring per NEC.

J. Use liquid-tight flexible metal conduit in mechanical spaces. Conduit size shall be increased as required to fit wiring per NEC.

K. Cut conduits straight, properly ream, and cut threads for heavy wall conduit deep and clean.

L. Field-bend conduit with benders designed for purpose so as not to distort nor vary internal diameters.

M. Size conduits to meet NEC, except no conduit shall be smaller than 3/4" on this project.

N. Fasten conduit terminations in sheet metal enclosures by two locknuts, and terminate with bushing. Install locknuts inside and outside enclosure. **Metallic insulating conduit bushings shall be used on all power conduits.** Split bushings shall **not** be acceptable.

O. Conduits are not to cross pipe shafts or ventilating duct openings.

P. Keep conduits a minimum distance of 6" from parallel runs of hot water pipes or other sources of heat. Wherever possible, install horizontal raceway runs above water and steam piping.

Q. Support riser conduit at each floor level with clamp hangers.

R. Use of running threads at conduit joints and terminations is prohibited.

S. Where required, use 3-piece union or split coupling.

T. Complete installation of electrical raceways before starting installation of cables/wires within raceways.

U. For concrete floors-on-grade, install PVC Schedule 40 conduits under concrete slabs.

V. Install underground conduits minimum of 24" below finished grade.

W. Install conduits so as not to damage or run through structural members. Avoid horizontal or cross runs in building partitions or side walls.

X. Above requirements for exposed conduits also apply to conduits installed in space above hung ceilings, and in crawl spaces.

Y. EMT conduits shall not be installed against roof deck. Allow minimum 3" space between top conduit and roof deck for the possible penetration of roof nails to protrude without damaging conduit.

1. Where conduits are indicated to be installed against roof deck, or where required by construction, IMC or GRS conduits may be used. Unless specifically stated on the documents, prior written approval shall be requested of the Architect/Engineer prior to installation.
2. Where boxes and conduit bodies are installed to accommodate conduits against the roof deck, they shall be cast type.

Z. In finished spaces without ceilings (i.e. gymnasiums, natatoriums, etc.), conduits shall be installed as high as possible, while meeting other requirements within these specifications. Conduits along bottom cord of open joists shall not be acceptable. Where conduits need to be installed along bottom of joists or beams, they shall be installed against walls.

AA. Provide fish wire or pull string in all spare conduits.

BB. Cap all spare conduits installed for future use.

CC. Install surface metal raceways in corners or walls or conceal as much as possible.

DD. There shall be no more than three (3) 20A branch circuits installed in a single 3/4" conduit. Each circuit shall be provided with a dedicated neutral wire. Sharing of neutral wire for multiple circuits will not be permitted.

EE. At locations where conduits are installed after painting is done, the contractor shall be responsible to go back and paint conduit and boxes same color to match. At locations where there is no General Trades painting, this Contractor shall be responsible to paint conduit and boxes to match adjacent surfaces.

FF. Metallic and non-metallic raceway shall be mechanically fastened to surfaces at intervals as recommended by the manufacturer. Under no circumstances shall glue, two-sided tape, or other type of adhesive be the only means of attachment.

GG. For exterior wall or foundation penetrations, seal around conduits/sleeves and annular space between sleeve and conduits to limit water migration.

1. Select seal material to fit the installation location, and ensures no degradation of the sealing material over time due to environmental conditions including, but not limited to continuous ground or rain water, solar impact, temperature changes, freezing, etc. Where exposed, sealing compound shall match adjacent surfaces in texture and color.

HH. Installation through walls:

1. Where conduits are installed to pass through existing walls, the wall shall be cored to allow the conduit to be installed through the wall, and fire calk installed around the conduit.

2. Where MC cable is installed through a wall, an EMT sleeve of sufficient size to fit all of the MC cables shall be installed through a core in the wall, fire calk installed around the sleeve, and fire putty installed around the MC cables.
3. Should the contractor break out blocks, or cut an opening in the wall, not using a properly sized hole saw, he shall provide an appropriately sized lintel to maintain structural integrity of the wall, patch the wall by toothing in new block, new drywall sheet, or other means matching the wall material, and provide fire calk around the conduit or sleeve in the opening.

3.2 CONDUITS IN CONCRETE SLABS

A. Conduits installed in concrete slabs will not be permitted. PVC conduits shall be installed under concrete slabs in stone base minimum 4” below to top of conduit.

B. Conduits installed in elevated slabs will not be permitted. Conduits shall be installed in ceiling plenum spaces below elevated slabs.

3.3 EXPOSED CONDUITS

A. Unless noted otherwise on the documents, or expressly permitted by the Architect/Engineer in writing, Exposed conduits may only be run in open structure, and surface to walls in unfinished spaces (i.e. crawl spaces, mechanical equipment rooms, electrical equipment rooms, etc.) All conduits in finished spaces (i.e. offices, conference rooms, corridors, classrooms, gymnasium, storage, etc.) shall be recessed in the walls, and concealed.

B. Install exposed conduits and extensions from concealed conduit systems neatly, parallel with, or at right angles to walls of building.

C. Install exposed conduit work as not to interfere with ceiling inserts, lights, or ventilation ducts or outlets.

D. Support exposed conduits by use of hangers, clamps, or clips. Support conduits on each side of bends and on spacing not to exceed following: Up to 1": 6'-0"; 1-1/4" and over: 8'-0".

E. Run conduits for outlets on waterproof walls exposed. Set anchors for supporting conduit on waterproof wall in waterproof cement.

F. Cap all spare and active conduits stubbed up from the floor with secure PVC caps. Caps used for active conduits shall be notched to accommodate the quantity and size of cables installed in each conduit.

G. Where possible, exposed conduits shall be run along walls and at 3” from roof deck. Care shall be given to avoid creating a ledge of conduits along bottom of steel.

H. Where exposed conduits are installed outside of spaces labeled as electrical or mechanical, they shall be prepped and painted with appropriate products to match adjacent surfaces, unless specifically stated, in writing, by the architect/engineer/owner that they may remain unfinished.

3.4 NON-METALLIC CONDUITS

A. Make solvent cemented joints in accordance with recommendations of Manufacturer.

B. Install PVC conduits in accordance with NEC and in compliance with local utility practices. Provide expansion joints as required by Manufacturer and NEC.

3.5 CONDUIT FITTINGS

A. Construct locknuts for securing conduit to metal enclosure with sharp edges for digging into metal, and ridged outside circumference for proper fastening.

B. Bushings for terminating conduits smaller than 1-1/4" are to have flared bottom and ribbed sides, with smooth upper edges to prevent injury to cable insulation.

C. Install insulated type bushings for terminating conduits 1-1/4" and larger.

D. Bushings are to have flared bottom and ribbed sides. Upper edge to have phenolic insulating ring molded into bushing.

E. Bushing of standard or insulated type to have screw type grounding terminal.

F. Miscellaneous fittings such as reducers, chase nipples, 3-piece unions, split couplings, and plugs to be specifically designed for their particular application.

3.6 RACEWAYS AND WIREWAYS

A. Avoid use of dissimilar metals through system to eliminate possibility of electrolysis. Where dissimilar metals are in contact, coat all surfaces with corrosion inhibiting compound before assembling.

B. Install expansion fittings in all raceways/wireways wherever structural expansion joints are crossed.

C. Make changes in direction to raceway/wireway run with proper fittings, supplied by raceway Manufacturer. No field bends of raceway/wireway sections will be permitted.

D. Properly support and anchor raceways/wireways for their entire length by structural materials. Raceways are not to span any space unsupported.

E. Use boxes as supplied by Manufacturer wherever junction, pull or device boxes are required. Standard electrical "handy" boxes, etc., shall not be permitted for use with surface installations.

END OF SECTION 260533

SECTION 260535 – ELECTRICAL BOXES AND FITTINGS

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

A. The extent of electrical box and associated fittings work is indicated by Drawings and Schedules.

1.2 CODES AND STANDARDS

A. NEC Compliance: Comply with NEC as applicable to construction and installation of electrical wiring boxes and fittings.

B. UL Compliance: Comply with UL Std No.'s 50, 514-series and 886. Provide electrical boxes and fittings which are UL-listed and labeled.

C. NEMA Compliance: Comply with applicable requirements of NEMA Stds/Pub No.'s OS1, OS2 and Pub 250.

PART 2 - PRODUCTS

2.1 FABRICATED MATERIALS

A. Outlet Boxes: Provide galvanized coated flat-rolled sheet-steel outlet wiring boxes, of shapes, cubic inch capacities, and sizes, including box depths as indicated (or as required), suitable for installation at respective locations. Construct outlet boxes with mounting holes, and with cable and conduit-size knockout openings in bottom and sides. Provide boxes with threaded screw holes, with corrosion-resistant cover and grounding screws for fastening surface and device type box covers, and for equipment type grounding. Flush boxes must be mounted flush with finished wall surface.

B. Outlet Box Accessories: Provide outlet box accessories as required for each installation, including box supports, mounting ears and brackets, wallboard hangers, box extension rings, fixture studs, cable clamps and metal straps for supporting outlet boxes, which are compatible with outlet boxes being used to fulfill installation requirements for individual wiring situations. Choice of accessories is Installer's code-compliant option.

C. Device Boxes: Provide galvanized coated flat-rolled sheet-steel non-gangable device boxes, of shapes, cubic inch capacities, and sizes, including box depths as indicated (or as required), suitable for installation at respective locations. Construct device boxes for flush mounting with mounting holes, and with cable-size knockout openings in bottom and ends, and with threaded screw holes in end plates for fastening devices. Provide cables clamps and corrosion-resistant screws for fastening cable clamps, and for equipment type grounding. Flush boxes must be mounted flush with finished wall plate.

D. Device Box Accessories: Provide device box accessories as required for each installation, including mounting brackets, device box extensions, switch box supports, plaster ears, and plaster board expandable grip fasteners, which are compatible with device boxes being utilized to fulfill installation requirements for individual wiring situations. Choice of accessories is Installer's codes-compliant option.

E. Surface-Mounted Device and Outlet Boxes: Provide a minimum depth galvanized-coated steel box where indicated on the Drawings, without pre-punched knockouts.

F. Raintight Outlet Boxes: Provide corrosion-resistant cast-metal raintight outlet wiring boxes, of types, shapes and sizes, including depth of boxes, with threaded conduit holes for fastening electrical conduit, including face plate gaskets and corrosion-resistant plugs and fasteners. Provide raintight outlet boxes where installed outside, and within moisture rich environments (showers, locker areas, natatoriums, etc.)

G. Junction and Pull Boxes: Provide galvanized code-gauge sheet steel junction and pull boxes, with screw-on covers; of types, shapes and sizes, to suit each respective location and installation; with welded seams and equipped with stainless steel nuts, bolts, screws and washers. Provide handles on covers over 4 square feet.

H. Where surface or recessed boxes are indicated to be blank or with wire leads for future use, they shall be provided with blank covers per Division 26 “Wiring Devices”.

I. All boxes shall be metallic, unless noted otherwise.

J. Under no circumstances shall low voltage rings be used on the project. All outlet boxes used for low voltage system including, but not limited to tele/data, controls, A/V wiring, etc. shall be fully enclosed device boxes, rated for 600V wiring as specified above.

PART 3 - INSTALLATION

3.1 GENERAL

A. Install electrical boxes and fittings as indicated, in accordance with Manufacturer's written instructions, applicable requirements of NEC and NECA's "Standard of Installation", and in accordance with recognized industry practices to fulfill project requirements.

B. When installed in stud walls (wood or steel), electrical boxes shall be installed in walls, supported from both sides, bridged between studs, the use of cantilevered supports shall be unacceptable.

C. Coordinate installation of electrical boxes and fittings with wire/cable, wiring devices, and raceway installation work.

D. Provide weathertight outlets for interior and exterior locations exposed to weather or moisture.

E. Provide knockout closures to cap unused knockout holes where blanks have been removed.

F. Install electrical boxes in those locations which ensure ready accessibility to enclosed electrical wiring.

G. Position recessed outlet boxes accurately to allow for surface finish thickness.

H. Where devises are shown at casework, contractor shall coordinate exact location and height with casework to ensure usability of devices.

I. Avoid using round boxes where conduit must enter box through side of box, which would result in difficult and insecure connections when fastened with locknut or bushing on rounded surfaces.

J. Fasten electrical boxes firmly and rigidly to substrates, or structural surfaces to which attached, or solidly embed electrical boxes in concrete or masonry.

K. Provide electrical connections for installed boxes.

L. Subsequent to installation of boxes, protect boxes from construction debris and damage.

M. Ground electrical boxes properly upon completion of installation work and demonstrate compliance with requirements. Ground electrical box and wiring device.

N. Where boxes and conduit bodies are installed against roof deck, they shall be cast type.

3.2 INSTALLATION TO MEET ACOUSTICAL PERFORMANCE

A. In order to reduce sound transmission through walls, when back boxes are installed to serve both sides of the wall, they shall be installed in different stud cavities. Where boxes are found to be installed in the same stud cavity, feeding two different sides of the wall, they will be required to be removed and reinstalled at the contractor's expense.

END OF SECTION 260535

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SECTION 260553 – ELECTRICAL IDENTIFICATION

PART 1 - GENERAL

1.1 CODES AND STANDARDS

A. UL Compliance: Comply with UL Std 969.

B. NEC and NEMA Compliances: Comply with NEC and NEMA WC-1 and WC-2.

C. ANSI Compliance: Comply with ANSI Std A13.1.

PART 2 - PRODUCTS

2.1 GENERAL

A. Except as otherwise indicated, provide Manufacturer's standard products of categories and types required for each application. Where more than single type is specified for an application, selection is installer's option, but provide single selection for each application.

B. The Electrical Identification, as outlined in this specification, shall be provided in addition to the labeling requirements listed in other specification sections.

2.2 CABLE/CONDUCTOR IDENTIFICATION BANDS

A. Provide Manufacturer's standard vinyl-cloth self-adhesive cable/conductor markers of wrap-around type; either pre-numbered plastic-coated type, or write-on type with clear plastic self-adhesive cover flap; numbered to show circuit identification.

2.3 SELF-ADHESIVE PLASTIC SIGNS

A. Provide Manufacturer's standard, self-adhesive or pressure-sensitive, pre-printed, flexible vinyl signs for operational instructions or warnings; of sizes suitable for application areas and adequate for visibility, with proper wording for each application areas and adequate for visibility, with proper wording for each application (e.g., “EXHAUST FAN FED FROM PANEL PD1”).

B. Colors: Unless otherwise indicated, or required by governing regulations, provide white signs with black lettering.

2.4 ENGRAVED PLASTIC-LAMINATE SIGNS

A. Provide engraving stock melamine plastic laminate with black face and white core plies (letter color), complying with FS L-P-387, in sizes and thicknesses indicated. Engrave laminate with engraver's standard letter style of sizes and wording indicated, and punch

for mechanical fastening except where adhesive mounting is necessary because of substrates.

B. Thickness: 1/16", for units up to 20 sq. in. or 8" length; 1/8" for larger units.

C. Fasteners: Self-tapping stainless-steel screws, except contact-type permanent adhesive where screws cannot or should not penetrate substrate.

2.5 LETTERING AND GRAPHICS

A. Coordinate names, abbreviations and other designations used in electrical identification work, with corresponding designations shown, specified or scheduled. Provide numbers, lettering and wording as indicated or, if not otherwise indicated, as recommended by Manufacturers or as required for proper identification and operation/maintenance of electrical systems and equipment systems and equipment. Comply with ANSI A13.1 pertaining to minimum sizes for letters and numbers.

2.6 MANUFACTURER

A. Provide electrical identification products of one of the following (for each type marker):

1. Ideal Industries, Inc.
2. LEM Products, Inc.
3. Markal Company
4. National Band and Tag Co.

PART 3 - EXECUTION

3.1 GENERAL

A. Install electrical identification products as indicated, in accordance with Manufacturer's written instructions, and requirements of NEC.

3.2 COORDINATION

A. Where identification is to be applied to surfaces which require finish, install identification after completion of painting.

3.3 REGULATIONS

A. Comply with governing regulations and requests of governing authorities for identification of electrical work.

3.4 CABLE/CONDUCTOR IDENTIFICATION

A. Apply cable-conductor identification where wires of communication/signal system are present, except where another form of identification (such as color-coded conductors) is

provided. Match identification with marking system used in panelboards, shop drawings, Contract Documents, and similar previously established identification for project's electrical work.

B. Install engraved plastic-laminate tags on new power cables in all manholes and in pullboxes to identify over current device number. Use tie wraps to attach tag to cables. The nameplate shall bear the following information: Building served; voltage, cable size, class of insulation, phase designation.

3.5 CONDUIT IDENTIFICATION

A. Where spare conduits are installed, labels shall be provided at each end clearly identifying destination. Where one end is located in a handhole or manhole, provide label directly above spare conduit.

B. Where spare conduit path includes intermediate pull boxes, conduit bodies, wireways, etc., provide label at each location indicating the next termination point. The label at each end shall identify quantity of intermediate pull boxes, conduit bodies, wireways, etc. as well as location.

C. Where spare conduits are provided above ceilings on either side of an inaccessible area, provide small label on T-bar to indicate location of spare conduit.

D. Where low voltage and conduit sleeves enter floor or below grade, provide label identifying termination point.

3.6 DANGER SIGNS

A. In addition to installation of danger signs required by governing regulations and authorities, install appropriate danger signs at locations indicated and at locations subsequently identified by Installer of electrical work as constituting similar dangers for persons in or about project.

B. High Voltage: Install danger signs wherever it is possible, under any circumstances, for persons to come into contact with electrical power of voltages higher than 110-120 volts.

C. Critical Switches/Controls: Install danger signs on switches and similar controls, regardless of whether concealed or locked up, where untimely or inadvertent operation (by anyone) could result in significant danger to persons, or damage to or loss of property.

3.7 ARC FLASH LABELS

A. Provide arc flash labels on equipment per NEC and NFPA. Labels shall be placed in a prominent position that is clearly visible before access to a dangerous area is reached. This includes the front of devices similar to disconnect switches, motor starters, switchboards, etc. and just inside the front cover of panelboards. The labels shall be of sufficient durability to withstand the environment involved.

B. Provide signs for each unit of the following categories of electrical work.

1. Panelboards, electrical cabinets and enclosures.
2. Combination starter / disconnect switches.
3. Disconnect switches.

3.8 EQUIPMENT/SYSTEM IDENTIFICATION

A. Install engraved plastic-laminate sign on each major unit of electrical equipment in building; including central or master unit of each electrical system including communication/control/signal systems, unless unit is specified with its own self-explanatory identification or signal system. Except as otherwise indicated, provide single line of text, 1/2" high lettering on 1-1/2" high sign (2" high where 2 lines are required), White lettering in Black field. Provide text matching terminology and numbering of the Contract Documents and shop drawings. Each listed piece of equipment below shall have a sign that has the following: 1. Equipment Name, 2. Where the equipment is fed from. Example: PANEL “PD1" (FED FROM PANEL DPD).

B. Provide signs for each unit of the following categories of electrical work.

1. Panelboards, electrical cabinets and enclosures.
2. Access panel/doors to electrical facilities.
3. Combination starter / disconnect switches.
4. Disconnect switches.

C. Install signs at locations indicated or, where not otherwise indicated, at location for best convenience of viewing without interference with operation and maintenance of equipment. Secure to substrate with fasteners, except use adhesive where fasteners should not or cannot penetrate substrate.

3.9 DIRECTORIES

A. Provide typed circuit directory cards in all panelboards (both breaker and fuse type) and low voltage lighting control panels indicating the room number or area, and the item or items controlled by each circuit. Provide typed circuit directory cards for all “Existing” panelboards and low voltage lighting control panels where the Contractor has added, deleted or moved circuits with in an “Existing” panelboard.

1. Contractor shall trace existing circuits within existing panelbaords and low voltage lighting control panels to properly identify all circuits within the panelboards and low voltage lighting control panels.

B. Switchboards, unit substations, motor control centers and switchgear shall be provided with plastic-laminate tags similar to those specified in under “Equipment/System Identification”. The tags shall indicate what the circuit feeds and the location of the device.

C. Directories shall use actual room numbers to indicate locations of all devices, including, but not limited to receptacles, lighting, mechanical equipment, etc. When preparing schedule, use a room number schedule generated by the architect and/or the owner,

which indicates the actual room numbers that will be used when the building is occupied. If the schedule is not available, request, in writing, a schedule to reflect the proper room numbers.

D. Provide sufficient information to meet requirements of Article 408 of the National Electric Code. Specifically, location of device fed shall be added to directory cards.

3.10 ADDITIONAL FUSE LABELING

A. At the exterior enclosure of all fused switches, provide additional labeling designating fuse sizes, types and quantity.

3.11 EMERGENCY POWER SOURCE NOTIFICATION

A. Provide a sign at the main service location indicating type and location of emergency power source in accordance with the requirements of Section 700-8 of the National Electrical Code.

3.12 RECEPTACLE CIRCUIT IDENTIFICATION

A. At each receptacle, identify panelboard and circuit number from which receptacle is served. Use machine printed, pressure sensitive, abrasion resistant label tape on **backs and fronts** of the wall plate and durable wire markers or tags within outlet boxes.

3.13 ADDITIONAL EQUIPMENT LABELS

A. Refer to individual Division 27 and 28 sections for labeling requirements of low voltage systems.

END OF SECTION 260553

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SECTION 260810 – ELECTRICAL SYSTEMS COMMISSIONING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Requirements for commissioning of electrical systems including lighting systems, time-switch controls and daylight responsive controls. Time-switch controls shall include time-clocks, relay panels, lighting system programs, and other time-based lighting controls.

B. The contractor, and manufacturer of the applicable systems must work with the commissioning agent to perform all required tests of the system.

1.2 PROJECTION CONDITIONS

A. Partial Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during the Commissioning process to minimize conflicts with Owner's operations.

B. Project Phasing: Refer to the non-technical specifications which indicate the various phases of construction. Provide Commissioning services so that all mechanical systems located within or serving a particular area of the building are complete when the respective area is scheduled for occupancy.

1.3 SUBMITTALS

A. Qualification data for the full-time staff member overseeing the testing, including professional engineering license in the state of the project, or authorization of the local authority having jurisdiction.

B. Construction Checklists for the systems being commissioned.

C. At the completion of the tests, turn over all documentation to the local authority having jurisdiction and the owner. All test forms must be dated. All documentation must be turned over to the owner no later than 90 days from the date of the receipt of the certificate of occupancy.

1.4 QUALITY ASSURANCE

A. The commissioning company shall be independent from the installing contractor, vendor and manufacturer.

B. The commissioning company shall have provided commissioning services for a minimum continuous duration of five (5) years.

C. The full-time staff member overseeing the testing shall have a valid professional engineering license in the state of the project.

D. All testing and documentation must conform with the locally adopted version of the International Energy Conservation Code (IECC) 2015. At the completion of the tests, turn over all documentation to the local authority having jurisdiction and the owner.

E. Wherever any test fails, that particular devices, system, program, etc. shall be rectified and retested. Both the failed and passing report must be turned over to the owner at completion.

PART 2 - PRODUCTS

Not Applicable.

PART 3 - INSTALLATION

3.1 GENERAL TESTING REQUIREMENTS

A. All testing must be performed prior to final inspection. All documentation must be signed off by the full-time staff member, and their engineering license information provided on the paperwork affirming that all information in the document is accurate.

B. All tests shall be performed, as required, to ensure that control hardware and software are correctly calibrated, adjusted, programmed and in proper working condition, in accordance with the construction documents and manufacturer's recommendations.

C. All tests shall be performed in conjunction with, and in addition to start-up and commissioning requirements as identified in the individual product specifications, outlined on the drawings and required by the manufacturers of the tested systems.

D. All tests shall be performed to ensure compliance with the currently locally adopted version if the International Energy Conservation Code (IECC), section C405 and C408.

3.2 OCCUPANT SENSOR CONTROLS

A. Tests shall be performed and documented to meet the following requirements:

1. Certify that occupancy sensors have been located and aimed in accordance with manufacturer recommendations to cover the space.
2. If there are greater than seven (7) occupancy sensors, the following tests shall be performed where there is a unique combination of sensor type and space geometry, not less than 10%, but in no case less than one (1) of each unique combination of sensor type and space geometry, unless required by the code official. Where 30% or more of the tested devices fail, all occupancy sensors must be tested to verify compliance. Where there are seven (7) or fewer occupancy sensors, all sensors must be tested.

    a. Where there are status indicators, verify correct operation.

b. Verify controlled lights turn off or reduce to the programmed minimum level within the required time.
c. For auto-on sensors, verify the lights turn on to the programmed level.
d. For vacancy (manual-on) sensors, verify the lights only turn on when manually activated.
e. Verify lights are not incorrectly turned on by movement in adjacent areas or by HVAC operation.

3.3 TIME-SWITCH CONTROLS

A. Tests shall be performed and documented to meet the following requirements:

1. Confirm that the time-switch control is programmed with accurate weekday, weekend and holiday schedules. Document and verify schedules with the owner.

    a. Provide a final document of the schedules to the owner, including set-up instructions and preference program settings.

2. Verify the correct time and date in the time switch.
3. Verify that any battery back-up is installed and functioning.
4. Verify that override limits are set as identified in the construction documents, or if not listed, that no override time limit is set beyond two (2) hours.
5. Simulate occupied condition. Verify and document the following:

    a. All lights can be turned on and off by their respective area control station.
    b. The station only operates lighting in the enclosed space in which the switch is located.

6. Simulate unoccupied condition. Verify and document the following:

    a. All nonexempt lighting, as identified in the locally adopted version of the International Energy Conservation Code (IECC), turns off.
    b. Manual override controls allow only the lights in the enclosed space where the override station is located to turn on or remain on until the next scheduled shutoff occurs.

END OF SECTION 260810

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SECTION 262213 – LOW-VOLTAGE DRY-TYPE TRANSFORMERS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following types of dry-type transformers rated 600 V and less, with capacities up to 1000 kVA:

1. Distribution transformers.

1.2 SUBMITTALS

A. Product Data: Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, and performance for each type and size of transformer indicated.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Wiring Diagrams: Power, signal, and control wiring.

C. Vibration Isolators: Provide product data on vibration isolators to be provided at each transformer. Refer to Paragraph “Installation,” below.

1.3 QUALITY ASSURANCE

A. Source Limitations: Obtain each transformer type through one source from a single manufacturer.

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

C. Comply with IEEE C57.12.91, "Test Code for Dry-Type Distribution and Power Transformers."

1.4 DELIVERY, STORAGE, AND HANDLING

A. Temporary Heating: Apply temporary heat according to manufacturer's written instructions within the enclosure of each ventilated-type unit, throughout periods during which equipment is not energized and when transformer is not in a space that is continuously under normal control of temperature and humidity.

1.5 COORDINATION

A. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

B. Coordinate installation of wall-mounting and structure-hanging supports with actual transformer provided.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Square D Company.

B. Siemens equivalent.

C. GE by ABB equivalent.

D. Eaton (Cutler Hammer) equivalent.

E. No Other Manufacturers Will Be Considered.

2.2 GENERAL TRANSFORMER REQUIREMENTS

A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.

B. Cores: Grain-oriented, non-aging silicon steel.

C. Coils: Continuous windings without splices except for taps.

1. Internal Coil Connections: Brazed or pressure type.
2. Coil Material: Aluminum.

2.3 DISTRIBUTION TRANSFORMERS

A. Comply with NEMA ST 20, and list and label as complying with UL 1561.

B. Cores: One leg per phase.

C. Enclosure: Ventilated, NEMA 250.

1. Provide NEMA Type 2 for interior applications and NEMA Type 3R for exterior applications unless otherwise noted on the drawings.
2. Core and coil shall be encapsulated within resin compound, sealing out moisture and air.

D. Insulation Class: 220 deg C, UL-component-recognized insulation system with a maximum of 115 deg C rise above 40 deg C ambient temperature.

E. Energy Efficiency for Transformers Rated 15 kVA and Larger:

1. Marked as compliant with currently adopted DOE and Energy Code efficiency levels by qualified electrical testing laboratory recognized by authorities having jurisdiction.
2. Tested according to NEMA TP 2.

F. Wall Brackets: Manufacturer's standard brackets.

G. Low-Sound-Level Requirements: Maximum sound levels shall meet NEMA ST 20 standard sound levels when factory tested according to IEEE C57.12.91.

2.4 SOURCE QUALITY CONTROL

A. Test and inspect transformers according to IEEE C57.12.91.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.

B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions.

C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.

D. Verify that ground connections are in place.

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

3.2 INSTALLATION

A. Install wall-mounting transformers level and plumb with wall brackets fabricated by transformer manufacturer.

B. Construct concrete bases and anchor floor-mounting transformers according to manufacturer's written instructions. Provide 4” concrete housekeeping pad under transformer.

C. Provide vibration isolation pads at transformers providing a minimum static deflection of 0.3 inches similar to Kinetics 2” KIP.

D. Verify all dimensions in the field.

E. Adjust transformer secondary voltages to provide the required voltage at the loads.

3.3 IDENTIFICATION

A. The requirements listed below are in addition to the requirements listed in Division 26 “Electrical Identification.”

B. Nameplates: Engraved, laminated-plastic or metal nameplate for each transformer, mounted with corrosion-resistant screws.

3.4 CONNECTIONS

A. Connect ground equipment.

B. Connect wiring.

C. Tighten electrical connectors and terminals in accordance with manufacturer’s published torque-tightening values. If manufacturer’s torque values are not indicated, use those specified in UL 486A-486B.

D. Upon completion of the installation, an infrared scan shall be provided for all bolted connections. Correct any deficiencies.

E. Conduit connections to transformers shall employ sufficient length of flexible conduit to create a U-shaped bend.

3.5 ADJUSTING

A. Record transformer secondary voltage at unit for at least 48 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 5 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.

B. Output Settings Report: Prepare written report recording output voltages and tap settings.

3.6 CLEANING

A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION 262213

SECTION 262416 – PANELBOARDS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes panelboards, overcurrent protective devices, and associated auxiliary equipment rated 600 V and less for the following types:

1. Lighting and appliance branch circuit panelboards.
2. Distribution panelboards.
3. TVSS Devices.

1.2 DEFINITIONS

A. GFCI: Ground fault circuit interrupter.

1.3 SUBMITTALS

A. Product Data: For each type of panelboard, overcurrent protective device, accessory, and component indicated. Include dimensions and Manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each panelboard and related equipment.

1. Dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings. Include the following:

a. Enclosure types and details for types other than NEMA 250, Type 1.
b. Bus configuration, current, and voltage ratings.
c. Short circuit current rating of panelboards and overcurrent protective devices.
d. UL listing for series rating of installed devices.
e. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

2. Wiring Diagrams: Diagram power, signal, and control wiring and differentiate between Manufacturer installed and field installed wiring.

C. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing.

D. Maintenance Data: For panelboards and components to include in maintenance manuals specified in Division 1. In addition to requirements specified in Division 1 Section "Contract Closeout," include the following:

1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.

2. Time current curves, including selectable ranges for each type of overcurrent protective device.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For switchboards and components to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Division 01 "Operation and Maintenance Data," include the following:

a. Routine maintenance requirements for switchboards and all installed components.
b. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
c. Time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.

1.5 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. Comply with NEMA PB 1.

C. Comply with NFPA 70.

1.6 COORDINATION

A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, and encumbrances to workspace clearance requirements.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Square D Company.

B. Siemens.

C. GE by ABB.

D. Eaton (Cutler Hammer).

E. No Other Manufacturers Will Be Considered.

2.2 FABRICATION AND FEATURES

A. Enclosures: Flush and surface mounted cabinets. Refer to panel Schedules on Drawings to determine flush or surface. NEMA PB 1, Type 1 for interior locations and Type 3R for exterior locations, unless noted otherwise in the documents.

B. Front: See panelboard, Hinged Trim Covers.

C. Finish: Manufacturer's standard enamel finish over corrosion resistant treatment or primer coat.

D. Directory Card: With transparent protective cover, mounted inside metal frame, inside panelboard door.

E. Bus Material (Main, Neutral & Ground): aluminum.

F. Main and Neutral Lugs: Mechanical type suitable for use with conductor material.

G. Equipment Ground Bus: Adequate for feeder and branch circuit equipment ground conductors; bonded to box.

H. Service Equipment Label: UL labeled for use as service equipment for panelboards with main service disconnect switches. Provide when indicated on the panel Schedules.

I. Skirt for Surface Mounted Panelboards: Provide skirts with same gage and finish as panelboard front with flanges for attachment to panelboard, wall, and ceiling or floor. Skirts shall be provided for all surface mounted panels in all rooms with exception of rooms labeled on plans “Electric or Mechanical.”

J. Feed through Lugs: Mechanical type suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.

2.3 PANELBOARD SHORT CIRCUIT RATING

A. Panelboards shall be fully rated to interrupt symmetrical short circuit current as indicated on the schedules. All breakers within panelboards shall be fully rated to the panel AIC rating. Series ratings of branch breakers or bus shall not be acceptable.

2.4 ARC ENERGY REDUCTION

A. For any circuit breaker rated for 1200A, or can be adjusted to 1200A or higher, an electronic circuit breaker must be used, and the following shall be provided:

1. Documentation shall be made available, at the switchboard, regarding the Arc Energy Reduction methodology.
2. The applicable breaker shall be provided with an energy-reducing maintenance switch setting with local status indicator.

2.5 LIGHTING AND APPLIANCE BRANCH CIRCUIT PANELBOARDS

A. Branch Overcurrent Protective Devices: Bolt on circuit breakers, replaceable without disturbing adjacent units.

B. Doors: See Panelboard Hinged Trim Covers.

2.6 DISTRIBUTION PANELBOARDS

A. Doors: Front mounted secured with latch and lock; keyed alike.

B. Main Overcurrent Protective Devices: Circuit breaker or Main Lugs Only. Refer to panel Schedule.

C. Branch Overcurrent Protective Devices: Bolt on circuit breakers.

2.7 OVERCURRENT PROTECTIVE DEVICES

A. Lighting and Appliance Branch Circuit Panelboards:

1. Molded Case Circuit Breaker: NEMA AB 1, with interrupting capacity to meet available fault currents.

    a. Thermal Magnetic Circuit Breakers: Inverse time current element for low level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit breaker frame sizes 250 A and larger.
    b. GFCI Circuit Breakers: Single pole configurations with 5mA trip sensitivity.

2. Molded Case Circuit Breaker Features and Accessories. Standard frame sizes, trip ratings, and number of poles.

    a. Lugs: Mechanical style, suitable for number, size, trip ratings, and material of conductors.
    b. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HACR for heating, air conditioning, and refrigerating equipment.
    c. Ground Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time delay settings, push to test feature, and ground fault indicator.
    d. Shunt Trip: 120 V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage.

B. Distribution Panelboards, 600A main lug and larger

1. 100A and larger, provide electronic trip units with LSI (Long time, Short time and Instantaneous) protection, size as specified on the drawings. Interrupting rating

shall be available up to 200 kAIR RMS without fuses. Under 100A, provide thermal magnetic trip units, size as specified on the drawings.

a. Circuit Breakers

1) Circuit breakers shall have voltage and interrupting ratings that meet the application requirements.
2) Circuit breakers shall be constructed using glass reinforced insulating material.
3) Current carrying components shall be completely isolated from the handle, and the accessory mounting area.
4) Circuit breakers shall have an over center, trip-free, toggle-operating mechanism which shall provide quick-make, quick-break contact action. The circuit breaker shall have common tripping of all poles.
5) Up to 600 A rating frame, MCCBs breaking unit shall be made with a double rotary contact to limit let-through energy on the installation.
6) MCCBs shall be designed to trip the circuit breaker in the event of high-level short-circuit currents. This design shall be independent of the trip unit.
7) The circuit breaker handle shall 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.
8) The maximum ampere rating and UL, IEC, or other certification standards with applicable voltage systems and corresponding interrupting ratings shall be clearly marked on the face of the circuit breaker.
9) Each circuit breaker shall be equipped 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.
10) Circuit breakers shall be factory-sealed with a hologram quality mark or a tamper evident label and shall have a date code.
11) MCCB's shall be able to receive a device for locking in the isolated position.
12) Electronic components shall withstand temperatures up to 221 °F (105 °C).
13) Circuit breakers shall be UL-listed to accept field installable/removable mechanical type lugs. Lugs shall be UL-listed to accept solid and/or stranded copper and aluminum conductors. Lugs shall be suitable for 194 °F (90 °C) rated wire, sized according to the 167 °F (75 °C) temperature rating in the NEC.
14) Circuit breakers shall be capable of accepting bus connections.
15) For frame ratings, higher than 250 amperes, MCCBs shall be fitted with metallic filters to reduce effects perceptible from the outside during current interruption.
16) For a given MCCB rated frame, MCCBs dimensions shall be the same whatever the AIR.

17) 1200 amperes frame shall be provided in electrically operated version. The operation shall use stored-energy type only and will be equipped with anti-pumping function.
18) Circuit breakers, 600A and larger, shall be equipped with a safety interlock which keeps the circuit breaker open if the trip unit is not installed.

b. Trip Units

1) MCCB's, 100A and larger shall be equipped with electronic trip units. MCCB's less than 100A shall be equipped with thermal magnetic trip units.
2) Circuit breakers with permanent trip units shall be UL-listed for reverse connection without restrictive line and load markings and be suitable for mounting in any position.
3) MCCBs with field interchangeable trip units (600A and larger) shall have trip units that are easily interchangeable and easily secured to the MCCB.
4) The trip units shall not augment overall circuit breaker volume.
5) Thermal Magnetic (less than 100A):

a) Thermal trip elements shall be factory preset and sealed. Circuit breakers shall be true RMS sensing and thermally responsive to protect circuit conductor(s) in a 104 °F (40 °C) ambient temperature.
b) Where indicated on drawings, circuit breakers shall be equipped with a ground fault module (GFM) with 20 to 200 amperes sensitivity level or earth leakage module (ELM) with sensitivity ranges between 30 mA and 3 amperes, or approved equivalent.

6) Electronic Trip Circuit Breakers (100A and larger):

a) Trip unit shall be true RMS sensing.
b) Air core current transformers shall be used to ensure accurate measurements from low currents up to high currents.
c) Electronic trip unit shall be fitted with thermal imaging to protect intermittent short circuits or ground-faults.
d) The following monitoring functions shall be integral parts of electronic trip units:

i) A test connector shall be installed for checks on electronic and tripping mechanism operation using an external device.
ii) LED for load indication at 105 percent.
iii) LED for load indication at 90 percent of load for applications 600 amperes and smaller.
iv) LED for visual verification of protection circuit functionality for applications 600 amperes or smaller.
v) LED for trip indication for applications above 600 amperes.

vi) Trip unit functions shall consist of adjustable protection settings with the capability to be set and read locally by rotating a switch.
vii) Long-time pickup shall allow for adjustment to nine long-time pickup settings. This adjustment must be at least from 0.4 to 1 times the sensor plug (In), with finer adjustments available for more precise settings to match the application.
viii) Adjustable long-time delay shall be in nine bands. At six times Ir, from 0.5 to 24 seconds above 600 amperes, and 0.5 to 16 seconds for 600 amperes and below.
ix) Short-time pickup shall allow for nine settings from 1.5 to 10 times Ir.
x) Short-time delay shall be in nine bands from 0.1-0.4 I^2t ON and 0-0.4 I^2t OFF.
xi) Instantaneous settings on the trip units with LSI protection shall be available in nine bands.

1. 250 amperes and below, from 1.5 to 15 times In

xii) Four-pole devices shall be equipped for neutral protection with a three-position setting; neutral not protected, neutral tripping threshold equal to half the phase value, and neutral threshold equal to the phase value.
xiii) Ground fault settings for circuit breaker sensor sizes 1200 amperes or below shall be in nine bands from 0.2 to 1.0 times In. The ground fault settings for circuit breakers above 1200 amperes shall be nine bands from 500 to 1200 amperes.

e) It shall be possible to fit the trip unit with a seal to prevent unauthorized access to the settings in accordance with NEC Section 240-6(b).
f) Trip unit shall provide local trip indication and capability to locally and remotely indicate reason for trip, i.e., overload, short circuit, or ground fault.
g) Measurement chain shall be independent from the protection chain.
h) The measurements shall be displayed on the breaker itself.

2.8 ACCESSORY COMPONENTS AND FEATURES

A. Accessory Set: Tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

B. Portable Test Set: To test functions of solid-state trip devices without removal from panelboard.

C. Provide top and bottom panel skirts for all surface mounted lighting and power panels.

2.9 HINGED TRIM COVERS

A. Provide Hinged Trim Panelboard covers for lighting and power panelboards. Entire Trim Hinged to one side of the box with a piano type hinge to access panel gutter space. Front door of panel shall be keyed to lock.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install panelboards and accessories according to NEMA PB 1.1.

B. Mounting Heights: Top of trim 74 inches above finished floor, unless otherwise indicated.

C. Mounting: Plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish.

D. Circuit Directory: Create a directory to indicate installed circuit loads after balancing panelboard loads. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable. Refer to Section 260553 for more information.

E. Install filler plates in unused spaces.

F. Provision for Future Circuits at Flush Panelboards: Stub four 1-inch empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub two 1-inch empty conduits below slab not on grade into suspended ceiling cavity.

G. Wiring in Panelboard Gutters: Arrange conductors into groups and bundle and wrap with wire ties after completing load balancing.

3.2 IDENTIFICATION

A. Provide panel and circuit identification as outlined in Division 26 “Electrical Identification”.

3.3 CONNECTIONS

A. Install equipment grounding connections for panelboards with ground continuity to main electrical ground bus.

B. Tighten electrical connectors and terminals according to Manufacturers’ 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. Test continuity of each circuit.

B. Testing: After installing panelboards and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.

1. Procedures: Perform each visual and mechanical inspection and electrical test indicated in NETA ATS, Section 7.5 for switches and Section 7.6 for molded case 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.

C. Balancing Loads: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes as follows:

1. Measure as directed during period of normal system loading.
2. Perform load balancing circuit changes outside normal occupancy/working Schedule of the facility and at time directed. Avoid disrupting critical 24 hour services such as on line data processing, computing, transmitting, and receiving equipment.
3. After circuit changes, recheck loads during normal load period. Record all load readings before and after changes and submit test records.
4. Tolerance: Difference exceeding 10 percent between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.

3.5 PROTECTIVE SHIELDS

A. Provide metal protective shield(s) under all piping located within 3’-0” of the panelboard to defect a pipe leak away from the electrical equipment. Shield(s) shall be sized as required to cover the required pipe to prevent water from reaching the panelboard.

3.6 ADJUSTING

A. Set field adjustable switches and circuit breaker trip ranges.

3.7 CLEANING

A. On completion of installation, inspect interior and exterior of panelboards. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

3.8 DEMONSTRATION AND START-UP

A. Adjust all adjustable settings. When a coordination study is performed, adjust breakers and ground fault circuit interrupters as required per the study.

END OF SECTION 262416

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SECTION 262726 – WIRING DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes receptacles, connectors, switches, dimmers, finish plates and cord reels.

1.2 DEFINITIONS

A. GFCI: Ground fault circuit interrupter.

1.3 SUBMITTALS

A. Product Data: For each product specified.

B. Shop Drawings:

1. Legends for receptacles and switch plates, where indicated on the drawings.
2. Provide Lighting Control catalog literature including performance specifications indicating compliance to the specifications.
3. Provide a lighting plan clearly marked by manufacturer showing proper occupancy sensor locations for each space utilizing occupancy sensors.

C. Samples: For devices and device plates for color selection and evaluation of technical features, when requested by the Architect-Engineer and/or Owner.

D. Maintenance Data: For materials and products to include in maintenance manuals specified in Division 1.

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.

B. Comply with NEMA WD 1.

C. Comply with NFPA 70.

D. Compliance with Federal Specifications – identified by the federal specifications mark (capital letters ‘F’ and ‘S’ each in a wing on either side of the UL Listing mark):

1. Receptacles and GFCI’s: Federal Specification number WC596.
2. Switches: Federal Specification number WS896.

1.5 COORDINATION

A. Receptacles for Owner Furnished Equipment, or Equipment furnished by other trades: Match plug configurations.

1. Cord and Plug Sets: Match equipment requirements.

1.6 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. Deliver extra materials to Owner.

1. Extra Keys: Provide minimum ten (10) keys for each type of key.
2. Lighting Controls:

a. Occupancy Sensors: One (1) of each type used.
b. Room Zone Controllers: One (1) 1-zone.
c. Low Voltage Controls: One (1) of each type used.
d. One (1) programmer.

PART 2 - PRODUCTS

2.1 WALL SWITCHES

A. Manufacturers

1. Hubbell HBL1221 Series.
2. Leviton 1221-2 Series.
3. Pass & Seymour PS20AC1 Series.

B. Description: NEMA WD 1, heavy duty industrial grade, binding screw type for back and side wiring, AC only snap switch with grounded mounting strap, and grounding terminal with green screw.

C. Toggle Color: As selected by Architect.

D. Types: Switch shall be single pole, double pole, three-way, or 4-way, as required by the drawings.

E. Voltage Rating: 120/277 volts, AC.

F. Current Rating: 20 amperes.

G. Prewired and plug-in devices shall be acceptable provided device matches specifications and plug-in devices are crimped and welded.

2.2 LIGHTING CONTROLS

A. Manufacturers

1. Hubbell Building Automation.
2. No other manufacturer shall be acceptable.

B. SYSTEM OPERATION

1. Contractor must properly set sensitivity and time delay in the occupancy sensors. Simply changing sensitivity to maximum, unless space requires, shall not be acceptable. The sensitivity shall be set appropriately for the space, to detect half step into room, and detecting people working at a desk at the four (4) corners of the room. See below for time delay settings.

    a. Automatic sensitivity or time delay settings shall NOT be used. All sensitivity and time delay settings shall be actively set.

2. Provide the appropriate occupancy sensor for each room. Simply selecting dual technology sensors for every space shall not be acceptable.

    a. Where dual technology sensors are used, initial occupancy shall require both technologies (PIR and ultrasonic), while either technology will maintain and re-trigger occupancy.

3. Occupancy Sensors shall be set as vacancy (lights turn on by button, maintain by sensing individuals, and turn off when an individual is no longer sensed). Lights shall not operate automatically, unless noted otherwise.

    a. Provide compatible low voltage dimmers and wire with sensor. Use digital addressable dimmers to achieve specified operation.

4. Daylight sensors shall be provided as indicated, and control the lighting nearest the daylighting independently from the rest of the room. Lighting control shall be set to dim the lighting based on the amount of light entering the space. The system shall NOT turn off the lights based on daylight, and shall only dim to a minimum level, unless the locally adopted codes dictate otherwise.

C. Occupancy Sensors

1. Listed products by application shall be Watt Stopper product numbers. Should the contractor choose to use an alternate listed manufacturer, they shall provide the sensor that meets the requirements of the specified sensors. Should an alternate manufacturer require additional sensors due to coverage patterns, they shall be provided at no additional cost to the owner.

    a. Instructional and lecture Spaces: Provide, low (24) voltage ceiling mounted dual technology occupancy sensor. Provide coverage pattern to accommodate entire room.

        1) Where spaces do not have ceilings, provide surface or wall mount version as required.

b. Open Offices, Restrooms, Storage Rooms and Corridors: Provide, low (24) voltage ceiling mounted ultrasonic occupancy sensor. Provide coverage pattern to accommodate entire room.

1) Where spaces do not have ceilings, provide surface or wall mount version as required.

c. Private Offices, Cafeteria and Conference Rooms: Provide, low (24) voltage ceiling mounted passive infrared occupancy sensor. Provide coverage pattern to accommodate entire room.

1) Where spaces do not have ceilings, provide surface or wall mount version as required.

d. High Ceiling/Structure Spaces (Gymnasiums, Atriums, etc.): Provide, low (24) voltage high ceiling mounted passive infrared occupancy sensor. provide coverage pattern to accommodate entire space.
e. Wet/damp, Refrigerated, Exterior and Unconditioned Spaces: Provide, low (24) voltage low temperature / wet listed passive infrared occupancy sensor Provide coverage patter to accommodate entire area.
f. Provide, where indicated, dual (120/277) voltage passive infrared wall switch occupancy sensor.
g. Provide, where indicated, dual (120/277) voltage passive infrared 0-10V dimming wall switch occupancy sensor. Set as vacancy so that manual operation is required to turn lights on.
h. Provide low voltage controls (switches and dimmers), where indicated, compatible with the room zone controller, from the same manufacturer as the occupancy sensor.

1) Dimming stations shall comprise of a minimum three (3) buttons (raise, lower and on/off). Four (4) button stations may also be used (raise, lower, on, off). Buttons must be factory engraved for ease of use.

i. Where no time delay setting is indicated, provide 10-minute time delay.
j. Manufacturer shall be responsible to provide a shop drawing which indicates correct sensor type and location of sensor within each space.

2. Wall switch sensors shall be capable of detection of occupancy at desktop level up to 300 square feet, and gross motion up to 1000 square feet.
3. Wall switch sensors shall accommodate loads from 0 to 800 watts at 120 volts; 0 to 1200 watts at 277 volts and shall have 180˚ coverage capability.
4. Wall switch products shall utilize Zero Crossing Circuitry which increases relay life, protects from the effects of inrush current, and increases sensor's longevity.
5. Wall switch sensors shall have no leakage current to load, in manual or in Auto/Off mode for safety purposes and shall have voltage drop protection.
6. Where specified, wall switch sensors shall provide a field selectable option to convert sensor operation from automatic-ON to manual-ON.
7. Vandal resistant wall switch sensors shall utilize a hard lens with a minimum 1.0mm thickness. Products utilizing a soft lens will not be considered.
8. Passive infrared sensors shall utilize Pulse Count Processing and Digital Signature Analysis to respond only to those signals caused by human motion.

9. Passive infrared sensors shall provide high immunity to false triggering from RFI (hand-held radios) and EMI (electrical noise on the line).
10. Passive infrared sensors shall have a multiple segmented Fresnel lens, in a multiple-tier configuration, with grooves-in to eliminate dust and residue build-up.
11. Dual technology sensors shall be either corner mounted or ceiling mounted in such a way as to minimize coverage in unwanted areas.
12. Dual technology sensors shall consist of passive infrared and ultrasonic technologies for occupancy detection. Products that react to noise or ambient sound shall not be considered.
13. Ultrasonic sensors shall utilize Advanced Signal Processing to adjust the detection threshold dynamically to compensate for constantly changing levels of activity and air flow throughout controlled space.
14. Ultrasonic operating frequency shall be crystal controlled at 25 kHz within ± 0.005% tolerance, 32 kHz within ± 0.002% tolerance, or 40 kHz ± 0.002% tolerance to assure reliable performance and eliminate sensor cross-talk. Sensors using multiple frequencies are not acceptable.
15. All sensors shall be capable of operating normally with electronic ballasts, PL lamp systems and rated motor loads.
16. Coverage of sensors shall remain constant after sensitivity control has been set. No automatic reduction shall occur in coverage due to the cycling of air conditioner or heating fans.
17. All sensors shall have readily accessible, user adjustable settings for time delay and sensitivity. Settings shall be located on the sensor (not the control unit) and shall be recessed to limit tampering.
18. In the event of failure, a bypass manual override shall be provided on each sensor. When bypass is utilized, lighting shall remain on constantly or control shall divert to a wall switch until sensor is replaced. This control shall be recessed to prevent tampering.
19. All sensors shall provide an LED as a visual means of indication at all times to verify that motion is being detected during both testing and normal operation.
20. Where specified, sensor shall have an internal additional isolated relay with Normally Open, Normally Closed and Common outputs for use with HVAC control, Data Logging and other control options. Sensors utilizing separate components or specially modified units to achieve this function are not acceptable.
21. All sensors shall have UL rated, 94V-0 plastic enclosures.

D. Room Zone Controller

1. Provide room controllers as required to control the loads indicated.

    a. Room Controllers shall provide one (1) through four (4) zones of independent control. Provide sufficient quantity of room controllers to control all zones of lighting indicated on the documents.

2. General Requirements:

    a. Delivered and installed in plenum rated enclosure as individual panel, or to attach to an electrical box.
    b. Passively cooled via free-convection, unaided by fans or other means.
    c. Mounting: Surface.

d. Connection to wired:

1) Occupancy sensors.
2) Daylight sensors.
3) IR receivers for personal control, where required.
4) Occupant controls.

e. Contact Closure Input (Where required/specified):

1) Communicate with input from a dry contact closure or solid-state output. Interface may be performed without or with interface to:

a) Activate scenes.

i) Scene activation from momentary or maintained closure.

b) Enable or disable after hours.

i) Automatic sweep to user-specified level after user-specified time has elapsed.
ii) System will provide occupants a visual warning prior to sweeping lights to user-specified level.
iii) Occupant can reset timeout by interacting with the lighting system.

f. Emergency Contact Closure Input (where applicable):

1) Turn all zones to full output during emergency state via direct contact closure input from UL 924 listed emergency lighting interface, security system or fire alarm system.
2) Allow configurable zone response during emergency state.
3) Disable control operation until emergency signal is cleared.

g. Supplies power for control link for keypads and control interfaces.
h. Distributes sensor data among multiple lighting control modules.

3. Provide switching and/or continuous dimming to drivers or load per zone. The room controller shall provide 0-10 Volt, PWM, forward-phase, reverse-phase or 3-wire dimming as required for the application. Provide interface modules as required to accommodate the type of dimming as required.
4. Device Specifications:

a. Provide devices rated for the zone wattage (up to 16 Amp continuous per zone). Less than 16 Amp continuous per zone may be used where the connected zone wattage is less
b. Devices shall be universal voltage rated to operate 120 Volt through 277 Volt lighting. 347 Volt devices shall be available as needed.
c. Memory: Retains all system settings in non-volatile memory.

5. Room controllers shall be located as follows:

    a. Where room controllers control fixtures in general public areas (hallways, corridors, etc.), they shall be installed in panelboard closets, dedicated electric rooms or data closets.
    b. Where room controllers control fixtures in multiple rooms, they shall be located above accessible ceiling in hallways, directly outside the rooms they control.
    c. Where room controllers control fixtures in a single room, they shall be located above accessible ceiling in that room, near the entrance door, directly above the wall station.
    d. The final location for all room controllers shall be coordinated with the Owner prior to rough-in.

6. ADDITIONAL EQUIPMENT/REQUIREMENTS

    a. All room controllers shall be interwired, and connected to the Owner's network.
    b. Provide components, wiring and programming to interface all room controllers installed as part of this project into the school's existing Hubbell Building Automation Lighting Management System.

2.3 RECEPTACLES

A. Duplex Convenience Receptacle

1. Manufacturers

    a. Hubbell HBL5362 Series.
    b. Leviton 5362 Series.
    c. Pass & Seymour PS5362 Series.

2. Description: Heavy-Duty Federal Industrial Spec Grade with nylon face (smooth), brass strap, brass contacts for side and back wiring, and nylon base.
3. Provide with WR (weather resistant) label when installed in exterior applications per code.
4. Where indicated on the drawings, or per current version of NEC, provide the tamper resistant version with internal shutter system.
5. Color of receptacles shall be as selected by the Architect.
6. Prewired and plug-in devices shall be acceptable provided device matches specifications and plug-in devices are crimped and welded. Provide similar to Pass & Seymour "Plug Tail" type receptacles.

B. Tamper Resistant Ground Fault Circuit Interrupter (GFCI) Receptacle

1. Manufacturers

    a. Hubbell GFTR20 Series.
    b. Leviton X7899 Series.
    c. Pass & Seymour 2097TR Series.

2. Description: Federal Specification Grade tamper resistant with high-impact-resistant thermoplastic construction, brass contacts for side and back wiring and LED trip indicator light.
3. GFCI receptacles shall not be connected to protect downstream devices, unless noted otherwise on the drawings. Provide unit designed for installation in a 2-3/4" deep outlet box without adapter, grounding type, Class A, Group 1, per UL 943.
4. Device shall comply with Federal Specification WC596. Devices shall have protection so that if critical components are damaged and ground fault protection is lost, power to receptacle shall be disconnected.
5. Provide with WR (weather resistant) label when installed in exterior applications per code.
6. Provide tamper resistant with internal shutter system.
7. Prewired and plug-in devices shall be acceptable provided device matches specifications and plug-in devices are crimped and welded.

C. Weatherproof Receptacle

1. Consisting of a GFCI receptacle as specified above in an outlet enclosure that is UL listed for wet locations, and meet NEC and OSHA requirements while in use.
2. Exterior-mounted receptacles installed in existing walls and on mechanical units shall have a self-closing weatherproof (in use) cover **with locking hasp** similar to Pass & Seymour WIUCAST series. Exterior-mounted receptacles installed in new walls shall have a self-closing weatherproof (in use) and be mounted over a recessed box similar to Arlington Industries DSBVR1W series. Paint cover to match adjacent surface with appropriate type of paint. Coordinate color with Architect prior to ordering.

2.4 SPECIAL PURPOSE RECEPTACLES

A. Manufacturers

1. Hubbell.
2. Leviton.
3. Pass & Seymour.

B. Description: Polarized, grounding type

C. Device Body: Black nylon

D. Configuration: As required by the amperage and voltage of the equipment to be connected on the drawings.

E. Provide equipment cord and caps as required for equipment.

2.5 WIRING DEVICE ACCESSORIES

A. Wall Plates: Provide wall plates for single and combination wiring devices, of types, sizes, and with ganging and cutouts as indicated. Provide plates which mate and match with wiring devices to which attached. Provide metal screws for securing plates to devices with screw heads colored to match finish of plates.

B. Wall Plates: Provide 302 satin finished stainless steel wall plates throughout the building.

C. Provide galvanized steel wall plates in unfinished spaces.

D. Floor Service Outlets: Provide duplex receptacles as required and specified under receptacles.

2.6 CORD AND PLUG SETS

A. Description: Match voltage and current ratings and number of conductors to requirements of equipment being connected.

1. Cord: Rubber insulated, stranded copper conductors, with type SOW A jacket. Green insulated grounding conductor, and equipment rating ampacity plus a minimum of 30 percent.
2. Plug: Nylon body and integral cable clamping jaws. Match cord and receptacle type for connection.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Coordinate with other work, including painting, electrical boxes and wiring work, as necessary to interface installation of wiring devices with other work.

B. Verify all receptacle mounting heights before roughing in unless noted. If an outlet is installed in such a location as to be out of proper relation to beams, walls, or finish details of the building, its location shall be corrected by and at the expense of the Contractor under direction of the Architect/Engineer.

C. Install devices and assemblies plumb and secure only in electrical boxes which have been cleaned of excess building materials, dirt, and debris. Device to be secure tight against wall box and flush with wall plate.

D. Install switches on latch side of doorways.

E. Install wall plates when painting is complete.

F. Install wall dimmers to achieve indicated rating after derating for ganging as instructed by manufacturer.

G. Do not share neutral conductor on load side of dimmers.

H. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical, and grounding terminal of receptacles on top. Group adjacent switches under single, multi-gang wall plates.

I. Protect devices and assemblies during painting.

J. Adjust locations at which floor service outlets and telephone/power service poles are installed to suit arrangement of partitions and furnishings.

K. Analog Dimmers: Provide the required low and/or line voltage wiring shall be provided to control the fixture. Any and all additional accessories required, including power packs, shall be provided in their entirety.

L. Install Occupancy Sensors to meet the following requirements. Locations indicated on the plans are diagrammatical, and do not necessary represent the optimal placement of sensors.

1. Sensor is activated within half step into room.
2. If person walks past open door, but not into room, sensor does not activate.
3. Sensor sensitivity shall be set to achieve the above, while allowing operation throughout the entire room with minimal activity.
4. Sensors shall be placed to avoid interference from HVAC equipment, including diffusers, and other architectural ceiling mounted items. Refer to manufacturer installation manual for additional information to ensure proper coverage of the space.
5. Contractor shall be responsible to reposition any sensor where the above is not accurate.
6. Occupancy Sensors shall be provided with minimum 10’ additional wiring to allow repositioning of the sensor after the fact for poorly positioned sensors. Extra wire shall be coiled and supported adjacent to the sensor.
7. Provide label on ceiling grid for location of occupancy sensor room zone controller above ceiling.

M. Install room controllers as outlined in part 2.

3.2 LIGHTING CONTROLS FACTORY COMMISSIONING

A. 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 occupancy-based lighting control system. The factory authorized technician shall enter every space containing an occupancy sensor to verify the locations, sensitivity and delay. Any issues that have been noted previous to this visit shall also be addressed. This meeting shall include, at a minimum, the installing contractor, lighting control manufacturer (when installed) and occupancy manufacturer.

B. Upon completion of the system fine tuning the factory authorized technician shall provide the proper training to the owner's personnel in the adjustment and maintenance of the sensors. This training shall be during an additional visit around substantial completion and last a minimum four (4) hours.

1. Approximately six (6) months after substantial completion, the manufacturer/vendor shall contact the Owner, and schedule a follow-up visit to provide additional sensor adjustments, programming, and training. The manufacturer shall assume a full eight (8) hours for this visit to address all concerns and ensure full system functionality. It shall be the manufacturer/vendor’s responsibility to initiate this visit. Should they fail to initiate, and the Owner request

additional support in the next six months (12 months after substantial completion), the support shall be provided at no additional cost.

C. All commissioning visits shall be scheduled a minimum two (2) weeks in advance, and the Architect, Engineer, Owner and Construction Manager/Clerk of the Work shall be informed of all meetings in addition to parties that are to be present. A factory authorized technician shall be present at all required commissioning meetings. Any additional meetings required for a fully functioning system shall be included at no additional cost to the owner.

3.3 INSTALLATION TO MEET ACOUSTICAL PERFORMANCE

A. In order to reduce sound transmission through walls, when devices boxes are installed to serve both sides of the wall, they shall be installed in different stud cavities. Where boxes are found to be installed in the same stud cavity, feeding two different sides of the wall, they will be required to be removed and reinstalled at the contractor's expense.

3.4 IDENTIFICATION

A. The requirements listed below are in addition to the requirements listed in Division 26 “Electrical Identification”.

B. Switches: Where three or more switches are ganged, and elsewhere as indicated, identify each switch with approved legend engraved on wall plate.

C. Receptacles: Identify panelboard and circuit number from which served. Use machine printed, pressure sensitive, abrasion resistant label tape on backside of the wall faceplate and durable wire markers or tags within outlet boxes.

3.5 CONNECTIONS

A. Connect wiring device grounding terminal to outlet box with bonding jumper.

B. Connect wiring device grounding terminal to branch circuit equipment grounding conductor.

C. Tighten electrical connectors and terminals according to manufacturers published torque tightening values. If manufacturers torque values are not indicated, use those specified in UL 486A and UL 486B.

3.6 FIELD QUALITY CONTROL

A. Test wiring devices for proper polarity and ground continuity. Operate each device at least six times.

B. Test GFCI operation with both local and remote fault simulations according to manufacturer's written instructions.

C. Replace damaged or defective components.

3.7 CLEANING

A. Internally clean devices, device outlet boxes, and enclosures. Replace stained or improperly painted wall plates or devices.

END OF SECTION 262726

SECTION 262813 – FUSES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes cartridge fuses, rated 600 V and less, for use in switches, panelboards, switchboards, controllers, and motor control centers; and spare fuse cabinets.

1.2 SUBMITTALS

A. Product Data: Include dimensions and Manufacturer's technical data on features, performance, electrical characteristics, and ratings for each fuse type indicated.

1.3 QUALITY ASSURANCE

A. Source Limitations: Provide fuses from a single Manufacturer.

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

C. Comply with NEMA FU 1.

D. Comply with NFPA 70.

1.4 PROJECT 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.

1.5 COORDINATION

A. Coordinate fuse ratings with HVAC and refrigeration equipment nameplate limitations of maximum fuse size.

1.6 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged in original cartons or containers and identified with labels describing contents.

1. Fuses: Quantity equal to one (1) set for every five (5) installed sets, but not fewer than one set of three of each kind.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Eaton Bussmann Series
2. Mersen (Ferraz Shawmut) by Powerfuse.
3. Littelfuse, Inc.

2.2 CARTRIDGE FUSES

A. Characteristics: NEMA FU 1, nonrenewable cartridge fuse; class and current rating indicated; voltage rating consistent with circuit voltage.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.

B. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.

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

3.2 FUSE APPLICATIONS

A. Main Service: Class L, time delay (601 to 6000A) or Class J, time delay (0 to 600A).

B. Main Feeders: Class L, time delay (601 to 6000A) or Class J, time delay (0 to 600A).

C. Combination Starter/Disconnect Switches: Class RK1, time delay.

D. Disconnect Switches: Class RK1, time delay (30-600A).

E. Other Branch Circuits: Class J, time delay.

3.3 INSTALLATION

A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

3.4 IDENTIFICATION

A. The requirements listed below are in addition to the requirements listed in Division 26 “Electrical Identification”.

B. Install labels indicating fuse replacement information on inside door of each fused switch.

END OF SECTION 262813

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SECTION 262816 – DISCONNECT SWITCHES

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Disconnect Switches.

B. Molded-Case Circuit Breakers and Switches.

C. Enclosures.

1.2 REFERENCES

A. FS W F 870 Fuse Holders (For Enclosed Cartridge Fuses).

B. FS W S 865 Switch, Box, (Enclosed), Surface Mounted.

C. NEMA KS 1 Enclosed Switches.

1.3 SUBMITTALS

A. Include outline Drawings with dimensions, and equipment ratings for voltage, capacity, horsepower, and short circuit.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Square D Company.

B. Siemens.

C. Eaton (Cutler Hammer).

D. General Electric by ABB.

E. No Other Manufacturers will be considered.

2.2 HEAVY DUTY TYPE FUSED AND NON-FUSED DISCONNECT SWITCHES

A. All switches shall have switch blades which are visible when the switch is OFF and the cover is open.

B. Lugs shall be mechanical type, front removable and UL listed for 60°C or 75°C conductors in switches rated 30 through 100 ampere, 75°C conductors in switches rated 200 through 1200 ampere, copper conductors.

C. Switches rated over 1200 amperes shall be provided as switchboard sections, with all applicable accessories.

D. All current carrying parts shall be plated to resist corrosion.

E. Switches shall have removable arc suppressors to facilitate easy access to line side lugs.

F. Switches shall have provisions for a field installable electrical interlock.

G. Switch operating mechanism shall be quick make, quick break such that, during normal operation of the switch, the operation of the contacts shall not be capable of being restrained by the operating handle after the closing or opening action of the contacts has started.

H. The operating handle shall be an integral part of the box, not the cover.

I. The handle position shall travel at least 90 degrees between OFF and ON positions to clearly distinguish and indicate handle position.

J. All switches shall have a dual cover interlock mechanism to prevent unintentional opening of the switch cover when the switch is ON and prevent turning the switch ON when the cover is open. The cover interlock mechanism shall have an externally operated override but the override shall not permanently disable the interlock mechanism. The tool used to override the cover interlock mechanism shall not be required to enter the enclosure in order to override the interlock.

K. The enclosure shall have ON and OFF markings on the cover to clearly identify the position of the switch.

L. All switches shall have provisions to lock the operating handle in the OFF position.

M. Switches shall be horsepower rated for ac and/or dc as indicated on the plans.

N. The UL listed short circuit current rating of the switches shall be: 200,000 rms symmetrical amperes when used with or protected by Class R fuses (30 through 600 ampere switches employing appropriate fuse rejection schemes).

O. Switch Accessories:

1. Provide the following where required/indicated on the documents:

    a. Where switches are designated to be used as service entrance, the switch shall be labeled for such use.
    b. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
    c. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
    d. Isolated Ground Kit: Internally mounted; insulated, labeled for copper and aluminum neutral conductors.
    e. Where fused switches are designated to have type "R" fuses, the switch shall be provided with rejection clips.

f. Provide fuse clip adaptors as required to accommodate smaller fuses when required.
g. Auxiliary Contact Kit: Two NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open. Provide contact rating as required to accommodate application.

2.3 MOLDED-CASE CIRCUIT BREAKERS AND SWITCHES

A. Circuit breakers shall be constructed using glass-reinforced insulating material. Current carrying components shall be completely isolated from the handle and the accessory mounting area.

B. Circuit breakers shall have a toggle operating mechanism with common tripping of all poles, which provides quick-make, quick-break contact action. The circuit-breaker handle shall be over center, be trip free, and reside in a tripped position between on and off to provide local trip indication. Circuit-breaker escutcheon shall be clearly marked on and off in addition to providing international I/O markings. Equip circuit breaker with a push-to-trip button, located on the face of the circuit breaker to mechanically operate the circuit-breaker tripping mechanism for maintenance and testing purposes.

C. The maximum ampere rating and UL, IEC, or other certification standards with applicable voltage systems and corresponding interrupting ratings shall be clearly marked on face of circuit breaker. Circuit breakers shall be 100 percent rated.

D. MCCBs shall be equipped with a device for locking in the isolated position.

E. Lugs shall be suitable for 60 deg C 125 ampere circuit breakers and below and 75 deg C over 125 ampere.

F. Switches rated over 1200 amperes shall be provided as switchboard sections, with all applicable accessories.

G. Standard: Comply with UL 489 with interrupting capacity to comply with available fault currents.

H. Electronic Trip Circuit Breakers: Field-replaceable rating plug, rms sensing, with the following field-adjustable settings:

1. Instantaneous trip.
2. Long- and short-time pickup levels.
3. Long- and short-time time adjustments.
4. Ground-fault pickup level, time delay, and I-squared t response, when ground-fault is required or indicated.

I. Ground-Fault Circuit-Interrupter (GFCI) Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip). Provide where indicated or required by code.

J. Ground-Fault Equipment-Protection (GFEP) Circuit Breakers: With Class B ground-fault protection (30-mA trip). Provide where indicated.

K. Features and Accessories:

1. Lugs: Mechanical type, suitable for number, size, trip ratings, and conductor material.
2. Ground-Fault Protection: Comply with UL 1053; integrally mounted type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
3. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
4. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
5. Electrical Operator: Provide remote control for on, off, and reset operations.

2.4 ENCLOSURES

A. Switch and breaker enclosure shall be NEMA 1 unless otherwise on the Drawings or required by the NEC in accordance with the project conditions.

1. Exterior switches and breakers shall be rated NEMA 3R, unless noted otherwise.
2. Kitchen and wash-down areas shall be provided with NEMA 4X with stainless steel enclosure, unless noted otherwise.

B. The enclosure shall be finished with Gray baked enamel paint which is electrodeposited on cleaned, phosphate pretreated steel (Type 1), or Gray baked enamel paint which is electrodeposited on cleaned, phosphate pretreated galvannealed steel (Type 3R).

C. Tangential knockouts shall be provided to facilitate ease of conduit entry for switches rated 30 through 200 amperes.

D. Enclosures for Type 3R switches through 200 amperes shall have provisions for interchangeable bolt on hubs in the top end wall.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install disconnect switches to meet N.E.C. working clearance requirements.

B. Install fuses in fusible disconnect switches.

3.2 IDENTIFICATION

A. The requirements listed below are in addition to the requirements listed in Division 26 “Electrical Identification.”

B. Provide labeling on the exterior of each disconnect switch Stating the following:

1. What the piece of equipment is fed from the switch.

2. Where the piece of equipment is fed from the switch.
3. Size, type and quantity of fuses within cabinet.

3.3 FIELD QUALITY CONTROL

A. Subsequent to completion of installation of disconnects, energize circuits and demonstrate capability and compliance with requirements. Demonstrate switch operation through six (6) opening/closing cycles with circuit unloaded. Open each switch enclosure to display interior, mechanical and electrical connections and fuse installation, and for verification of type and rating of fuses installed. Where possible, correct deficiencies at project site, then retest or demonstrate compliance; otherwise, remove and replace with new units and retest.

END OF SECTION 262816

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SECTION 265100 – LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes interior LED lighting fixtures, LED lighting fixtures mounted on exterior building surfaces, emergency lighting units, and accessories.

1.2 SUBMITTALS

A. Product Data: For each type of lighting fixture indicated, provide typical cutsheets. Include data on features, accessories, and the following:

1. Light output in lumens, color temperature (CCT), color rendering index (CRI) and energy efficiency data.
2. Lighting fixture accessories.
3. Dimensions of fixtures.

B. Coordination: The electrical contractor shall be responsible to coordinate all light fixtures with ceiling installer before installation of ceiling grid. The electrical contractor shall also coordinate light fixture installation with HVAC and plumbing contractor for installation of piping and ductwork. Should there be any conflicts, they should be brought to the attention of the Architect/Engineer prior to the installation of the ceiling grid. Any conflicts not brought to the attention of the Architect/Engineer before installation of ceiling, the electrical contractor shall bare all costs associated with rework to install light fixtures, piping, ductwork, ceiling grid, etc.

1.3 QUALITY ASSURANCE

A. Fixtures, Emergency Lighting Units, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction.

B. Comply with NFPA 70.

C. NFPA 101 Compliance: Comply with visibility and luminance requirements for exit signs.

1.4 COORDINATION

A. Fixtures, Mounting Hardware, and Trim: Coordinate layout and installation of lighting fixtures with ceiling system and other construction.

B. Lighting Control: Verify compatibility of lighting controls (analog dimmers and digital systems) with lighting fixtures to be installed. Where controls are not compatible with the lighting to be installed, bring to the attention of the Architect/Engineer in writing prior to ordering lighting fixtures or controls.

1.5 WARRANTY

A. Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within the project specified warranty period.

B. Manufacturer warranty: Contractor shall ensure manufacturer published warranty furnished with the luminaires remain in-tact through the project as well as the project warranty period. Any luminaires that are damaged during the project shall be replaced at no additional cost to the owner in order to ensure maintenance of the product warranty.

1.6 EXTRA MATERIALS

A. Exit Signs: Provide two (2) 2-sided & (2) 1-sided exit signs, matching the units being specified for the project.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Provide from manufacturers as specified in the Lighting Fixture Schedules or 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. 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.

C. Recessed luminaires shall comply with NEMA LE 4.

2.3 FIXTURES AND FIXTURE COMPONENTS, GENERAL

A. Metal Parts: Free from burrs, sharp corners, and edges.

B. Sheet Metal Components: Steel, unless otherwise indicated. Form and support to prevent warping and sagging.

C. Doors, Frames, and Other Internal Access: Smooth operating, free from light leakage under operating conditions, and arranged to permit relamping without use of tools. Arrange doors, frames, lenses, diffusers, and other pieces to prevent accidental falling during relamping and when secured in operating position.

D. Reflecting Surfaces: Minimum reflectance as follows, unless otherwise indicated:

1. White Surfaces: 85 percent.

2. Specular Surfaces: 83 percent.
3. Diffusing Specular Surfaces: 75 percent.
4. Laminated Silver Metallized Film: 90 percent.

E. Lenses, Diffusers, Covers, and Globes: 100 percent virgin acrylic plastic or annealed crystal glass, unless otherwise indicated.

1. Plastic: High resistance to yellowing and other changes due to aging, exposure to heat, and ultraviolet radiation.
2. Lens Thickness: 0.156 inch minimum, unless greater thickness is indicated.

F. Metal Finishes: Variations in finishes are unacceptable in the same piece, or in adjacent fixtures.

1. Exterior luminaires shall be provided with the same finish, regardless of manufacturer. Custom finishes must be provided were required to ensure same finish.
2. Pole light heads and poles shall match. Color chips and custom finishes shall be applied to ensure they match, regardless of manufacturer.

2.4 LED DRIVERS

A. Provide low-energy LED drivers, capable of operating the LEDs indicated. Drivers shall operate at an input voltage between 120 to 277 VAC at an input frequency of 60 Hz +/- 10%. Light output shall remain constant for line voltage fluctuations within the range described. Drivers shall comply with EMI and RFI limits set by the FCC (CFR 41 Part 18) for non-residential applications and not interfere with normal electrical equipment. Drivers shall meet applicable ANSI standards and must be UL listed with the fixtures. In order to maximize combability, drivers shall provide 0-10V dimming operation, unless noted otherwise.

1. Where fixtures are connected to a switching device on the drawings, the 0-10V terminations shall remain unconnected.

B. Compatibility: Certified by manufacturer for use with specific dimming system indicated for use with each dimming ballast.

2.5 EXIT SIGNS

A. General Requirements: Comply with UL 924 and the following:

1. Sign Colors and Lettering Size: Comply with authorities having jurisdiction.
2. Internally Lighted Signs: As follows:

a. Lamps for AC Operation: Light-emitting diodes, 70,000 hours minimum rated lamp life.

2.6 LAMPS

A. LED lamps shall comply with the LM-79 and LM-80 standards and be provided to meet the following minimum specifications:

1. Recessed 1'x4', 2'x2' and 2'x4'fixtures: minimum 50,000 hours at 70% lumen output.
2. Recessed downlights: minimum 50,000 hours at 70% lumen output.

B. LED lamps shall be rated as follows, unless specified otherwise:

1. Interior luminaires:

a. CCT: 3500K nominal.
b. CRI: 80% minimum.

2.7 FIXTURE SUPPORT COMPONENTS

A. Single-Stem Hangers: ½-inch steel tubing with swivel ball fitting and ceiling canopy. Finish same as fixture.

B. Twin-Stem Hangers: Two, ½-inch steel tubes with single canopy arranged to mount a single fixture. Finish same as fixture.

C. Rod Hangers: 3/16-inch- minimum diameter, cadmium-plated, threaded steel rod.

D. Hook Hangers: Integrated assembly matched to fixture and line voltage and equipped with threaded attachment, cord, and locking-type plug.

E. Aircraft Cable Support: Use cable, anchorages, and intermediate supports recommended by fixture manufacturer.

F. Independent Support Anchors: Anchors shall be on every fixture at the four (4) opposite corners. The contractor is required to independently support all recessed 1’x4’, 2’x2’, 2’x4’, 4’x4’, 2’ diameter or larger fixture from all four corners. Circular fixtures smaller than 2’ diameter, linear slot fixtures, etc. shall be support from at least two (2) opposite corners. Provide additional supports as recommended by the manufacturer.

G. Ceiling support steel for light fixtures: Support steel (unistrut) shall be installed to provide additional support for light fixtures from ceiling grid. Unistrut shall be installed above ceiling grid T-bars where the weight of the light fixtures require additional ceiling supports. Unistrut shall be supported independently from ceiling system.

2.8 FINISHES

A. Fixtures: Manufacturer's standard, unless otherwise indicated.

B. Paint Finish: Applied over corrosion-resistant treatment or primer, free of defects.

C. Metallic Finish: Corrosion resistant.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before luminaire installation.

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

3.2 TEMPORARY LIGHTING

A. The use of permanent lighting shall not be used for temporary lighting, unless approved, in writing, by the Architect/Engineer.

3.3 INSTALLATION

A. Fixtures: Set level, plumb, and square with ceiling and walls, and secure according to manufacturer's written instructions and approved submittal materials.

B. Support for Fixtures in or on Grid-Type Suspended Ceilings. Fixtures shall be independently supported from building structure from all four corners of recessed fixtures including 2x4, 1x4, 2x2, 4x4, etc. and from opposite corners from recessed downlight and 1x1 fixtures to building steel. Wire shall be galvanized steel and rated for fixture, but not less than 14 gauge. Braided wire shall be acceptable.

1. Fixtures must be tied to structure so that failure of a single wire does NOT constitute failure of the independent support (i.e. at least two (2) wires must be tied to structure independently).

C. Install a minimum of four ceiling support system rods or wires for each fixture. Locate not more than 6 inches from fixture corners.

D. Fixtures of Sizes Less Than Ceiling Grid: Arrange as indicated on reflected ceiling plans or center in acoustical panel, and support fixtures independently with at least two 3/4-inch metal channels spanning and secured to ceiling tees.

E. Suspended Fixture Support: As follows:

1. Chain Hung: Suspend with jack chain from structure.
2. Do no support suspended fixtures from grid. Fixtures must be supported from building structure.

F. Light fixtures shall be installed over junction boxes so they can be removed at a later date to access the wiring in the junction box.

G. Undercabinet Lighting: When installing undercabinet lighting, take care to hide all wiring. If there is a valance under the cabinet, wiring may exit the wall below the cabinet, and be run tight to the backside of the valance. If there is no valance, wiring shall exit the wall within the cabinet at a lower corner, run along the edge of the bottom shelf to the front of the cabinet to feed the end of the undercabinet light fixture. All exposed wiring shall be MC cable, and be tightly trained using straps and mechanical fasteners.

H. Where digital or analog dimming devices are indicated to control light fixtures, the required low and/or line voltage wiring shall be provided to control the fixture. Any and all additional accessories required shall be provided in their entirety.

3.4 CONNECTIONS

A. Ground equipment.

B. Furnish and install code compliant fixture disconnecting devices.

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.

3.5 FIELD QUALITY CONTROL

A. Inspect each installed fixture for damage. Replace damaged fixtures and components.

B. Tests: As follows:

1. Verify normal operation of each fixture after installation.

    a. Malfunctioning Fixtures and Components: Replace or repair, then retest. Repeat procedure until units operate properly.

C. Corrosive Fixtures: Replace during warranty period.

3.6 CLEANING AND ADJUSTING

A. Clean fixtures internally and externally after installation. Use methods and materials recommended by manufacturer.

B. Adjust aimable fixtures to provide required light intensities. Inform Architect/Engineer when aiming fixtures.

END OF SECTION 265100

SECTION 275125 – SOUND REINFORCEMENT SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. The Contractor shall furnish and install all materials, labor, and equipment, as herein specified, a locally controlled sound reinforcement system including wire, loudspeakers, console, etc. all ready for operation. The sound reinforcement system shall provide all components necessary to pick-up, process, amplify, and reproduce both voice and music sources.

B. System shall be installed in the Gymnasium.

C. Provide interconnections as listed in Part 2.

D. Provide demonstration, training and commissioning as listed in Part 3.

E. A preferred vendor capable of meeting all requirements of these specifications is Berkshire Systems Group, Inc. (800-344-4012).

1.2 SUBMITTALS

A. Submit manufacturer's product literature and installation instructions for all of the major components required for a complete and fully operational system. Submit system wiring diagrams for approval.

B. Submit manufacturer's printed instructions for maintenance of all installed components, including methods for maintaining proper conditions and environment to provide optimum performance. Provide three complete sets of operating instructions including wiring and circuit diagrams.

C. Submit dimensioned drawing showing location and height of speakers, and aiming angles for review. Care shall be taken in locating speakers to respect the architecture of the space, as well as acoustics. Drawings shall also show locations of all permanently installed devices (i.e. racks, jacks, power needs, etc.)

1.3 QUALIFICATIONS

A. Firms regularly engaged in the manufacture of professional and commercial sound system components with a minimum of five years' experience in the design and installation of systems equal in size and type required by this project shall be accepted.

B. The equipment supplier must maintain a local service organization within a fifty (50) mile radius of the installation with spare service replacement components and accessories as needed to ensure a potential down time of no more than twenty-four (24) hours.

C. The supplier must be an authorized representative of the equipment specified with authority to provide warranty rights and rebates. Full-time technicians shall be trained and certified in the installation and service of the equipment. A minimum NICET level 2 or EST Level 2 certification in Low Voltage Communication Systems is required for each full-time technician. Qualified installer must provide twenty-four (24) hours a day seven (7) days a week, as needed for system service and instructional procedures.

D. The system supplier must provide a minimum of three (3) completed project references identifying project names with contacts for sound system installations similar in scope to this project that have been completed within the last two years.

E. The supplier must provide a summary of capabilities, which satisfactorily demonstrates that the sound system vendor maintains the physical plant, personnel, and equipment necessary to provide the specified systems. The supplier must provide evidence of their test equipment inventory as of the submittal date. This inventory at a minimum must include:

1. 1/3 Octave Spectrum Analyzer with Calibrated Microphone
2. Dual Channel 20mHz. Oscilloscope
3. Calibrated SPL Meter
4. SmaartLive V9 Audio Measurement Software and related computer
5. Audio Test Generator with Pink Noise
6. Impedance Meter
7. Cable Polarity Tester

F. The supplier must utilize acoustic simulation modeling software in order to accurately model the space. This software shall be used to accurately position and aim the speakers in the space. Software similar to E.A.S.E. shall be utilized, where indicated.

G. All of the qualification information shall be reviewed by the Owner's representative to verify that the Sound System Supplier maintains the capabilities and experience necessary to ensure that a satisfactory system installation is accomplished. Should the Owner determine that the submitted qualifications do not meet the specified requirements, the bidding Contractor shall be required, at no additional cost to the Owner, subcontract the services of a sound system vendor whose qualifications meet the specified requirements.

1.4 MANUFACTURER

A. The naming of the manufacturer or item is not intended to be restrictive, but rather to establish criteria for system design and quality. Other manufacturers shall be considered for use if submitted for substation request per non-technical specifications prior to the bid date. The substitution submission shall include all catalog cut sheets and a line-by-line comparison of the specified product, including inter-panel wiring diagrams and schematics. In addition, samples may be required to perform proper evaluation of the proposed alternate at no additional charge.

1.5 PERFORMANCE AND OPERATION

A. Following are general performance and operation requirements for all systems:

1. Each system shall be locally controlled sound reinforcement systems that operate independently from the main intercommunications system. Each system shall be provided with a tie into the intercommunications for priority override paging.

    a. Programming of the override shall be verified with the owner. There may be a desire to bypass this override at the time of installation; however, the override relays shall be part of the system, and identified on the as-builts and O&M manuals.

2. All amplification and signal processing equipment components shall be located in equipment cabinets with locking front doors per products section. The manufacturer's rack mounted products of suitable hardware shall securely fasten all equipment in the equipment cabinet. A remote on/off keyed switch with an LED indicator lamp shall be included on a custom two-gang plate to show the status of the system operation.
3. Each system shall provide a high threshold of gain before feedback and shall accurately reproduce and amplify all voice and music signal without feedback, oscillation, distortion, or other unwanted effects or interference.
4. Remote antennas shall be provided for wireless microphones and assistive listening systems if required for a fully functioning system whether or not specifically specified in part 2.
5. Each system shall accept microphone and stereo line-level inputs, and faithfully and accurately amplify those signals uniformly to all seated occupants. The audio shall be monaural.

PART 2 - PRODUCTS

2.1 SIGNAL PROCESSING, AMPLIFICATION, AND CONTROL EQUIPMENT

A. The Gymnasium shall be provided with a new locally controlled sound reinforcement system with equipment as follows. The system shall be provided with two (2) dedicated 20-amp power circuits.

B. Provide one (1) Biamp TesiraFORTÉ DAN AI Digital Audio Signal Processor with 12 analog microphone/line inputs and 8 analog outputs, 32 channels of Dante digital audio inputs and 32 channels of Dante digital audio outputs, and up to 8 channels of configurable USB audio. The processor shall have internal DSP processing and shall provide the necessary audio signal routing, mixing, and distribution for the Paging, Dispatch Radio, and Music Systems. The processor shall support Ethernet connections for programming and control through an RJ-45 connector and shall include a dedicated Gigabit Ethernet connection for Dante digital audio networking. The processor shall include a 4-pin General Purpose Input and Output (GPIO) connection for sending or receiving logic signals. The programming of the GPIO functions shall be software configurable. The processor shall include an RS-232 connection for control data transmission into or out of the processor, and such operation shall be software

programmable. The processor shall include a USB connection on a standard USB-B type connector. Available system processing components shall include, but not be limited to, mixers, equalizers, filters, crossovers, dynamics/gain controls, routers, delays, remote controls, meters, generators, and diagnostics. The processor shall be programmed to provide independent audio routing, source selection, and level control for each of the three (3) audio systems. The processor shall be installed in the centrally located wall-mounted equipment rack. The processor shall be CE marked, UL listed, and compliant with the RoHS directive. The manufacturer's warranty on the processor shall be five (5) years.

1. Provide three (3) Biamp TEC-1S Ethernet Control Panels. Each control panel shall be a Power-over-Ethernet (PoE) network appliance with an OLED graphical display and capacitive-touch scroll wheel for menu navigation and selection. The control panels shall provide programmable remote control of audio volume, source selection, muting, and preset functions. Each control panel shall communicate with the central DSP via an Ethernet network connection. The control panels shall be programmed to provide independent control of the inputs and outputs on the SERVER-IO. The control panels shall provide user-adjustable audio levels and source selection functions as required for the operation of each respective system. The control panels shall be surface mounted at the rack location and at the two (2) locations indicated on the drawings.

C. Provide one (1) TASCAM RX-BT10MKII Professional Bluetooth Audio Receiver, or approved equal, to provide wireless audio connectivity from Bluetooth-enabled smartphones, tablets, and other compatible devices to the Music System. The receiver shall incorporate Bluetooth 5.1 Class 1 technology and shall support A2DP and AVRCP Bluetooth profiles and SBC and AAC audio codecs. The receiver shall provide two (2) balanced XLR line-level outputs and two (2) unbalanced RCA line-level outputs with selectable stereo or summed mono operation. The receiver shall have a frequency response of 20 Hz to 20 kHz and a signal-to-noise ratio of 90 dB or greater. The receiver shall include a detachable Bluetooth antenna, front-panel pairing button, Bluetooth connection status indicator, and adjustable audio output level control. The receiver shall support customizable Bluetooth device naming for identification and pairing with authorized user devices. The receiver shall include a remote pairing connection utilizing a two-pin Euroblock connector for connection of an optional remote momentary push-button switch. The receiver shall include a metal enclosure, manufacturer-provided mounting brackets, and an external power supply. The receiver shall be installed in the centrally located audio equipment rack and connected to the Biamp TesiraFORTÉ digital signal processor to provide wireless audio input to the Public Address System.

1. Provide bracket as required to mount in rack.

D. Provide one (1) Danley Sound Labs DNA20K8C eight-channel, high-power Class D digital power amplifier, equipped with the factory-installed eight-channel Dante digital audio network interface. The amplifier shall provide eight (8) independent channels of amplification with a total rated output power of 20,000 watts RMS. Each channel shall provide up to 2,500 watts into 4-ohm loads, 1,500 watts into 8-ohm loads, and 1,970 watts for 70V distributed speaker systems, under the manufacturer's specified operating conditions..The amplifier shall incorporate integrated 96kHz digital signal processing (DSP) and shall provide independent input and output routing, equalization, crossover

filters, delays, gain adjustments, polarity control, and loudspeaker protection limiters. The amplifier shall provide Ethernet-based network control, configuration, monitoring, and diagnostics. The amplifier shall incorporate protection circuitry against excessive output current, short circuits, excessive temperature, DC output, sustained clipping, and abnormal power supply conditions. The amplifier shall include a universal auto-sensing switch-mode power supply operating from 85V to 240VAC and a forced-air cooling system with variable-speed fans.

E. Provide one (1) Shure SLXD24+/SM58 digital wireless microphone system consisting of one (1) SLXD4+ rack-mount digital receiver and one (1) SLXD2+/SM58 handheld transmitter with SM58 dynamic cardioid microphone capsule. System shall provide 24-bit digital audio with greater than 118 dB dynamic range, AES-256 encryption, automatic frequency coordination and synchronization, and a minimum operating range of 300 feet (100 meters) line-of-sight. Receiver shall provide balanced XLR and unbalanced ¼-inch audio outputs and include rack-mount hardware, antennas, and power supply. Provide two (2) UA874 Active Directional Antennas with proper mounting hardware. Include all necessary antenna splitters and cables to ensure proper operation.

F. Provide one (1) SurgeX Surge Eliminator and Power Conditioner, model SX1120RT. The unit shall be in a magnetic shielding enclosure, operate from 120VAC, and have a 9-foot grounded, 3-wire #12 line cord. The unit shall have a load rating of 20 amps at 120VAC, a self-test circuit with visual indicator, and provide EMI/RFI filtering, inrush current elimination, and catastrophic over/under voltage shutdown.

G. The above equipment shall be contained in a fully welded, floor-standing equipment cabinet with a locking, vented front door. The cabinet shall be constructed of heavy-gauge steel and shall provide thirty-five (35) rack units of usable equipment mounting space with a nominal depth of twenty-seven (27) inches. The rack shall accommodate standard 19-inch EIA rack-mount equipment and shall include front and rear mounting rails for installation of the specified audio equipment. The cabinet shall be equipped with a locking, perforated steel front door to provide ventilation and airflow for the installed equipment. Provide appropriate ventilation provisions to accommodate the heat generated by the installed digital audio processors, power amplifiers, and associated equipment. Provide matching blank panels for all unused rack spaces. The equipment cabinet shall be equipped with a four (4) rack-space locking security drawer. Provide Lowell Manufacturing model LER-3527, 35U floor-standing equipment rack, 27-inch deep, complete with compatible locking vented front door and required accessories.

H. Provide all necessary connectors, hardware, wire management, power supplies, combiners, switch panels, power panels, etc. to enable complete system functions. Include a passive summing devices for stereo connections to the system mixers as required for auxiliary and projector inputs.

2.2 LOUDSPEAKERS

A. Main Gym:

1. Provide twelve (12) Danley Sound Labs model OS80-W high-output, full-range, weather-resistant loudspeaker systems, as detailed on the drawings. The loudspeaker shall incorporate Danley Sound Labs' proprietary horn-loaded

loudspeaker technology, designed to provide controlled sound dispersion, high speech intelligibility, and high-output audio reproduction for large indoor athletic facilities. The loudspeaker shall provide a nominal 80-degree coverage pattern and shall be suitable for high-level mounting applications requiring consistent sound distribution throughout the designated audience areas. The loudspeaker system shall be constructed using a durable, weather-resistant enclosure and shall incorporate factory-engineered transducers and acoustic components designed to provide full-range audio reproduction with controlled directivity. Performance characteristics, including frequency response, nominal impedance, sensitivity, maximum sound pressure level, and continuous power handling, shall meet the manufacturer's published specifications for the Danley OS80-B loudspeaker. All loudspeakers shall be suspended and properly secured using manufacturer-approved mounting and rigging hardware designed specifically for the loudspeaker and the structural surface or material to which it is attached. All mounting assemblies shall be rated to safely support the loudspeaker and associated hardware, and shall be installed in accordance with the manufacturer's recommendations and applicable structural and safety requirements. Provide factory-approved mounting brackets, rigging accessories, and safety hardware as required for each loudspeaker. Use of loudspeaker systems or mounting arrangements not meeting these safety criteria shall be deemed unacceptable.

a. Provide with a **White** finish.

B. Main Gym Subwoofer

1. Provide one (1) Danley Sound Labs model TH118XL-I high-output, low-frequency subwoofer loudspeaker system, black finish, as detailed on the drawings. The subwoofer shall utilize Danley Sound Labs' patented Tapped Horn technology and shall incorporate one (1) 18-inch long-excursion low-frequency driver, designed to provide high-efficiency, high-output bass reproduction with low distortion. The subwoofer shall be utilized to supplement the twelve (12) Danley OS80 full-range loudspeaker systems and provide extended low-frequency audio reproduction throughout the Athletic Center. Performance characteristics shall meet or exceed: Frequency Response (-3dB): 35Hz to 270Hz; Operating Range (-10dB): 26Hz to 300Hz; Continuous Power Handling: 1,700 watts; Peak Power Handling: 6,800 watts; Nominal Impedance: 4 ohms; Sensitivity: 105dB SPL at 2.83V/1 meter; Maximum SPL: 134dB continuous / 140dB peak. The subwoofer shall provide omnidirectional low-frequency coverage. The enclosure shall be constructed of 18mm, 13-ply Baltic birch plywood with a durable, impact-resistant black polyurea coating and protective steel grille. The subwoofer shall include two (2) Neutrik NL4 Speakon connectors wired in parallel and factory-provided M10 threaded mounting and suspension points for permanent installation.

a. Provide with a **White** finish.

2.3 ACCESSORIES

A. Provide three (3) Shure model SM58S cardioid vocal microphones with an on/off switch.

1. Provide two (2) Atlas/Soundolier MS-12CE microphone stands.

2. Provide three (3) Atlas/Soundolier DS-7E desk microphone stands.
3. Provide three (3) twenty-five (25) foot microphone cables.

B. All microphone receptacles shall utilize Switchcraft model D3F connectors where indicated on the drawings. All microphone and auxiliary input plates shall be engraved with permanent lettering and numbering. Engraved characters shall be filled with black acrylic paint or color approved by the Owner.

C. At auxiliary input locations indicated on the drawings, provide 3.5mm (1/8") and left/right RCA inputs audio inputs in a single gang box and plate for auxiliary inputs.

1. Provide an additional aux. input at the rack in a blank panel.

D. Provide one (1) ProCo iFace Portable Audio Player Interface to allow simple and reliable connection of stereo -10dBV audio devices such as MP3 players, iPods, laptop computers, and consumer-type CD and DVD players to the balanced microphone inputs located on the drawings.

2.4 ASSISTIVE LISTENING SYSTEMS

A. An Assistive Listening System shall be provided with the specified sound system to comply with applicable Americans with Disabilities Act (ADA) accessibility requirements. Provide one (1) Williams AV model FM 557-24 PRO D FM+ Assistive Listening System, consisting of a rack-mounted FM T55C D transmitter equipped with Dante digital audio networking capabilities. The transmitter shall simultaneously support FM transmission within the 72-76 MHz frequency band and audio streaming over a facility-provided Wi-Fi network. The transmitter shall incorporate digital signal processing (DSP), adjustable audio input levels, audio processing controls, an OLED display, and Ethernet connectivity for system configuration and monitoring. The transmitter shall receive digital audio signals directly from the specified Biamp Tesira Digital Audio Signal Processor via the Dante audio network.

B. The system shall include quantity of Williams AV PPA R37N portable FM receivers as specified, each equipped with a channel selection control and capable of receiving seventeen (17) selectable wideband FM frequencies within the 72-76 MHz frequency band. Each receiver shall include an EAR 022 surround earphone. Provide quantity of NKL 001 neckloops for compatibility with hearing aids and cochlear implants equipped with telecoils.

1. Gymnasium: Provide (56) receivers and (14) neckloops.

C. The system shall include CHG 3512 twelve-position battery chargers and BAT 026-2 rechargeable AA NiMH batteries of sufficient quantity of supply batteries to all receivers and charge all receivers at the same time. Provide ANT 005 remote coaxial antenna with associated cabling and mounting accessories, quantity required to accommodate the space. The antenna(s) shall be installed within the area served by the sound system to provide reliable FM reception throughout the designated listening area. Field verify the exact antenna location with the Architect prior to rough-in.

2.5 INTERCONNECTIONS

A. Provide necessary components, wiring, etc. to interconnect all sound systems with the master intercom system so that during a general page, the remote system will mute.

1. Verify each space with the owner. Should the owner request that the system not be muted, the wiring shall remain in place, with the system programmed to ignore the input, so that the system can be programmed to must upon page in the future.

B. Provide necessary components, wiring, etc. to interconnect all sound system with the Fire Alarm System so that during an alarm the remote system will mute.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with installation instructions provided by system manufacturer. Provide type of cables as shown on plans and schedules.

B. All wiring shall be plenum rated where required by code.

C. Install system to comply with drawings and final shop drawings in compliance with manufacturer's printed instructions.

D. Cable identification: shall be provided on both ends of each cable and termination with the owner’s room number and the wiring block or device to which it is connected. Tags shall be permanent and neat.

E. Furnish and install necessary conduit, raceways, pull boxes, outlet boxes and wire to provide a complete system or systems as herein specified. All wiring shall be tested for continuity and freedom of all grounds and short circuits.

F. Each cable run between the amplifiers and remote locations shall be one continuous cable.

G. The Contractor shall use the types of wire recommended by the Sound Equipment Manufacturer. However, the size and quality shall not be less than that previously specified or indicated on the drawings. If cross talk, appreciable loss of volume or distortion occurs after installation has been completed, it shall be the mutual responsibility of the Contractor and Manufacturer to correct any such condition without cost to the owner. The Contractor in no case shall use the type of wire which he merely assumes to be the best. This recommendation shall be from the equipment manufacturer.

H. Remote Reinforcement Sound System loudspeakers shall be connected to their local amplifiers with minimum 12awg cable when low impedance (4 or 8 ohms) and minimum 16awg cable when high impedance (70 volt line).

I. The central control console shall be provided with a 10AWG ground wire to earth ground. Conduit ground shall not be acceptable for this purpose.

J. All microphone wiring shall be No. 22 AWG twisted pair stranded with aluminum shield of 100% coverage and rubber or vinyl plastic jacket. Capacitance between conductors shall not exceed 30 mmf per foot. All microphone wiring shall be run in conduit with no other wiring.

K. Provide necessary connections to the intercommunications system to must the local sound system during a page.

L. Install remote antennas for the AM/FM tuners on the roof per manufacturer's recommendations.

M. Install all remote antennas for assistive listening and wireless microphones as required, per manufacturer's recommendations in the spaces for fully functioning systems.

3.2 SUPERVISION

A. Installation of these systems shall be supervised by a factory trained representative who shall accompany the Owner's representative on an inspection of the entire system and shall demonstrate the entire systems performance.

B. A complete operational test of the entire system shall be performed to demonstrate proper system function in accordance with the specified requirements. Correct any malfunctions within the system where necessary.

C. All remote sound reinforcement systems shall be tuned by a qualified technician. The technician shall provide printed documentation of all system settings and raw and final system equalization settings as determined by real time analyzer from a minimum of 3 averaged locations in each space. Provide reports in close-out documentation.

3.3 DEMONSTRATION AND TRAINING

A. Once system is operational, provide a complete demonstration of the entire system to the owner showing the usage of all components of the system to allow acceptance of the system by the Owner.

B. Upon acceptance of the system by the Owner, arrangements shall be made to provide a minimum of eight (8) hours of training for each system for the Owner's representatives in proper and full potential operation of the system. The training session shall be scheduled through the Electrical Contractor, Construction Manager, Electrical Engineer, and Architect.

C. Provide three (3) complete sets of bound operating instructions including circuit diagrams, part numbers, names, addresses and telephone numbers of parts and equipment sources.

3.4 COMMISSIONING

A. Once the system is installed and functioning, the installer shall set up a meeting with the owner and contractor to tune each of the specified systems. The installer shall account for a minimum of four hours to spend in each space.

B. Provide additional commissioning as follows:

1. Approximately 6-9 months after substantial completion, the installer shall contact the owner to set up a meeting. This meeting shall be used to “re-tune” the system by moving speakers, aiming the speakers and/or reprogramming the mixers to the owner’s satisfaction. The installer shall also review any training that may have previously occurred if required by the owner. The installer shall account for a minimum of four (4) hours to spend in each space.
2. Approximately 12 months after substantial completion, the installer shall contact the owner to set up a final meeting. This meeting shall be used for any final program changes as well as additional training. The installer shall account for a minimum of four (4) hours to spend in total.

END OF SECTION 275125

SECTION 284621 - FIRE ALARM AND DETECTION SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. It is the intent of these specifications, drawings, schedules and riser diagrams to describe the minimum requirements to furnish and install a modification to the exiting **Siemens XLS Fire Alarm System**. Provide compatible components as identified on the documents. The system shall include:

1. Addressable Monitoring and Control.
2. Manual Operator Switches and Annunciation.
3. Manual Stations.
4. Addressable Smoke Detectors with Application Specific Detection.
5. Addressable Duct Smoke Detectors with Application Specific Detection.
6. Addressable Heat Detection.
7. Addressable Continuous Linear Heat-Detector Systems and Air-Sampling Smoke Detector Systems.
    a. For use in elevator pits and shafts.
8. Addressable Monitoring and Control Modes for:
    a. Air Handling Unit Control.
    b. Smoke Damper Control.
    c. Magnetic Door Holders.
        1) Additional low voltage button, with label, shall be provided at the building administration area to release all mag locks in the building, in the event that there is an emergency.
9. Remote Annunciation and Control.
10. Remote Network panels.
11. Visual Indicating Appliances.
12. Audible Indicating Appliances. (Speakers)
13. Central Station Reporting of Alarm, Trouble and Supervisory Conditions.
14. Standby Batteries.
15. Record documents in Document Storage Box.
16. Conduit, Wire, Outlet Boxes, Miscellaneous Parts.
17. Other items required for a complete and operational system.

B. The Contractor shall be responsible for submitting all drawings, riser diagrams, calculations etc. to local authority for their approval. All components require U.L. and FM compliance. The Contractor shall be required to provide UL and FM certification documentation to township officials to meet all township requirements before the township will accept the system. The Contractor shall be responsible to review all annunciator, Knox Box and sprinkler gong locations with local officials prior to beginning

work. The Contractor shall be responsible for any and all permits required by the township.

C. The Contractor shall verify that all peripheral devices (initiation and annunciation) is compatible with the system. If an alternate manufacturer of peripheral device is required for compatibility with the system, the contractor shall supply the alternate manufacture at no additional cost to the Owner. The alternate manufactured device shall be equivalent in performance and appearance to the specified.

D. Provide training as listed in part 3.

1.2 CODES AND STANDARDS

A. NEC Compliance: Comply with the National Electric Code (NEC), latest version in effect as of the bid due date of this project, as applicable to construction and installation of fire alarm and detection system components and accessories.

B. The Fire Alarm System Supplier shall contract with an independent Electrical Inspection Agency to inspect the fire alarm system installation for compliance with Article 760 of the NEC and other applicable articles of the NEC. The Inspection Agency shall be a different company than the Electrical Inspection Agency used by the Electrical Contractor. An approval certificate from the Electrical Inspection Agency shall be submitted to the Architect and Engineer before final approval of the system is granted.

C. The name of the Electrical Inspection Agency is to be submitted with the shop drawings for approval by the Architect and Engineer of record for this project.

D. NFPA Compliance: Comply with latest edition of NFPA 72 National Fire Alarm Code, as applied to construction and installation of fire alarm and detection system components and accessories. The Contractor shall be responsible to have the Fire Alarm manufacturer review the drawings prior to installation of any device. Any device(s) required to be added or relocated to meet NFPA requirements shall be submitted prior to installation.

E. ADA Compliance: Provide fire alarm system signaling components which meet the Americans with Disabilities Act (ADA) and any subsequent modifications and clarifications to this law.

F. U.L Compliance and Labeling: Provide fire alarm and detection system components which are U.L. listed and labeled for their intended use and service. In addition to the fire alarm equipment listing requirements, if the local municipality requires, the Fire Alarm System Equipment Supplier shall be U.L. listed as an Alarm Service Company for Local, Remote, Auxiliary and Proprietary Protective Signaling Systems. The U.L. Listing Certification number for the Alarm Service Company shall be included in the submittal information.

G. Commonwealth of Pennsylvania: The complete installation shall be installed in a manner to provide a system that meets the requirements of the Pennsylvania Construction Code Act (Title 34) as adopted on April 11, 2003 and the Uniform Construction Code.

H. Local Code Requirements: Comply with the latest codes as adopted by the local code authority having jurisdiction (AHJ) and implemented by its building code services bureau. The Contractor and equipment supplier shall assist the building code services bureau inspectors in the final test of equipment and operation of the system.

I. NICET Certification: The Equipment Supplier shall employ at least one individual full time in the office supporting this project that has attained NICET Level III Certification in Fire Alarm Systems. All submittals and drawings shall be approved, initialed and show the NICET Certification Number of the individual maintaining the certification and taking responsibility for the documentation. As an alternate to the NICET Level III requirement, all submittals, drawings, and testing shall be reviewed, witnessed, and stamped sealed by a Professional Engineer (PE), licensed in the State of Pennsylvania, and the PE shall present a final letter of certification of the system at the completion of the project.

1. While the system has been designed as part of the bidding documents, it is the Vendor's responsibility to review all equipment locations to ensure compliance with the supplied products. The Vendor shall also provide all required battery calculations, wiring requirements, etc. for a complete and functioning code compliant system. Should a deficiency be found during the review process, the Vendor shall submit, in writing, all deficiencies for Engineer review.

1.3 DESCRIPTION OF WORK

A. It is the intent of these Specifications and Drawings to describe the minimum requirements to furnish and install a complete fire alarm system. The system shall be addressable type to include manual stations, automatic detectors, visual indicating appliances, audible indicating appliances, equipment and connections for remote Central Station monitoring, sprinkler flow and tamper switch monitoring, duct detectors, air handling unit control, standby batteries, conduit, wire, outlet boxes, elevator recall, door hold open devices, kitchen hood systems and any other items required to provide a complete and operational system.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: A factory authorized installer is to perform the work of this section. The authorized installer shall include a service department and employ factory trained and NICET certified technicians, and shall be located within 100 miles of this project location. The installer shall have a minimum of 5 years' experience installing fire protective signaling systems.

B. Each and all items of the Fire Alarm System shall be listed as a product of a single fire alarm system manufacturer under the appropriate category by Underwriters Laboratories, Inc. (UL), and shall bear the "UL" label.

C. The Manufacturer shall be a nationally recognized company specializing in fire alarm and detection systems.

1.5 SUBMITTALS

A. Submit under provisions of Division 26 “Basic Electrical Requirements.”

B. The installing contractor and/or equipment manufacturer shall provide complete and detailed shop drawings and include:

1. Detailed written system description describing system functions and operation. All specification deviations shall be clearly noted and marked.
2. Control panel wiring schematic and interconnections.
3. Complete point to point wiring diagram showing terminal connections to all system devices.
4. Riser wiring diagram and associated zones.
5. Complete floor plan drawings locating all devices associated with the fire alarm system.
6. Factory data sheets on which piece of equipment to be used and so marked as to model, dimensions, size, voltage, and configuration.
7. Complete Bill of Material for reference.
8. Programming matrix defining all input/output functions and zoning.
9. Provide complete battery calculations for both alarm and supervisory mode.
10. Provide audibility calculations shop drawings per IFC 907.

C. The equipment supplier must have a minimum NICET Level 3 Certification, or Submittals and Drawings must be stamped by a Registered Fire Protection Engineer.

D. Submit a copy of NICET Level III Certificate and technician's factory certification cards.

E. All submittal data will be in bound form with contractor's name, supplier's name, project name, and State Fire Alarm License number adequately identified.

F. When preparing submittals and any required final programming, use a room number schedule generated by the architect and/or the owner, which indicates the actual room numbers that will be used when the building is occupied. If the schedule is not available, revise the initial submittal, when a schedule is available, to reflect the proper room numbers.

1. For existing buildings/spaces undergoing renovations, the vendor shall review the entire fire alarm system, and revise room names and numbers as required to reflect current actual conditions for all devices and zone loops throughout the entire building. Provide all programming as required to accomplish this task.

G. **Project Completion Documentation:**

1. At the completion of the project, the following documentation shall be provided in compliance to Division 26 “Basic Electrical Requirements” and Division 01 sections, as well as included in the Document Storage Box:

a. Complete set of Operation and Maintenance manuals.
b. Program documentation as specified in this section.

c. Complete set of As-Built fire alarm drawings, indicating all device programming and identification, and battery calculations. Drawings must include all newly installed equipment, as well as any exiting equipment scheduled to remain.
d. All other NFPA and UCC required documentation.

1.6 WARRANTY AND MAINTENANCE SERVICE

A. The Contractor shall warrant the fire alarm equipment and wiring to be free from inherent mechanical and electrical defects for a period of two (2) years from the date of the final acceptance of the system of the last phase of the project. The Fire Alarm System equipment shall have a warranty of two (2) years from date of the last phase of the project. Defective equipment shall be replaced at no cost to the Owner during this two-year warranty period.

B. Maintenance Service Contract: Provide warranty maintenance of fire alarm systems and equipment for a period of two (2) years, using factory-authorized service representatives.

C. Basic Services: Systematic, routine maintenance visits on at times scheduled with the Owner. In addition, respond to service calls within 24 hours of notification of system trouble. Adjust and replace defective parts and components with original manufacturer's replacement parts, components, and supplies.

D. Additional Services: Perform services within the above period not classified as routine maintenance or as warranty work when authorized in writing. Compensation for additional services must be agreed upon in writing prior to performing services.

E. Testing & Inspections: Perform NFPA 72 and the Pennsylvania Department of Labor & Industry, Uniform Construction Code required testing and inspections during the two (2) year period at no additional cost to the owner.

F. Renewal of Maintenance Service Contract: No later than 60 days prior to the expiration of the maintenance services contract, deliver to the Owner a proposal to provide contract maintenance and repair services for an additional one-year term. Owner will be under no obligation to accept maintenance service contract renewal proposal.

1.7 ADDITIONAL DOCUMENTAITON AND PROGRAMMING REQUIREMENTS

A. The vendor shall provide drawings showing all fire alarm devices and their device identification in the software. These drawings must include all devices, whether shown on the project drawings, or not, and shall include any existing devices that are remaining to be reused.

B. At the end of the project, the vendor shall program all device point identification to match existing room numbering at the completion of the project.

1. For existing buildings/spaces undergoing renovations, the vendor shall review the entire fire alarm system, and revise room names and numbers as required to reflect current actual conditions for all devices and zone loops

throughout the entire building. Provide all programming as required to accomplish this task.

C. At project completion, all of the above documentation shall be provided as part of the operation and maintenance manuals and as-built documentation.

1.8 ADDITIONAL DEVICES

A. The contractor shall include in the bid, the cost to furnish and install the following devices. The contractor shall assume final finish as been applied and include 100' of wiring, backboxes, conduit, etc. required for installation. Any devices not installed, the contractor shall turn over to the owner as spare stock:

1. Manual Stations: Two (2) devices.
2. Wall Mounted Strobe Units: Five (5) devices.
3. Ceiling speakers: Five (5) devices.
4. Wall Mounted Audible/Visual Units: Three (3) devices.
5. Ceiling Mounted Audible/Visual Units: five (5) devices.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Siemens XLS.

B. No other manufacturer shall be accceptable.

2.2 FIRE ALARM AND DETECTION SYSTEMS

A. General: Provide fire alarm and detection system products of types, sizes and capacities indicated that comply with manufacturer's standard design, materials, and components; construct in accordance with published product information, and as required for complete installation. Provide fire alarm and detection systems for applications indicated, and with the following sequence of operations, components and function features.

B. The system shall be addressable type, to include manual stations, automatic detectors, visual indicating appliances, audible indicating appliances, remote annunciators, equipment and connections for remote monitoring, sprinkler flow switch, sprinkler tamper switch, duct detector, standby batteries, conduit, wire, outlet boxes and any other items required to provide a complete and operational system.

C. Provide fire alarm and detection systems for applications indicated, and with the following sequence of operations, components, and function features.

D. Operation: The system specified is an addressable type system that provides the capability of monitoring individual devices such as smoke detectors, heat detectors, manual pull stations, sprinkler activating devices and other auxiliary functions for alarm and trouble indications. All items monitored for alarm and/or trouble conditions shall be capable of custom programming a minimum of 232 alpha/numeric character

identification that is displayed on the control unit. In addition to the text message the user can view a graphic map with an icon indicating the location of the event in the building. Custom programming of automatic operation for individual devices for alarm signaling, fire department reporting, remote annunciation and other auxiliary control functions shall be provided. The system shall have a minimum capacity of 2500 input and 2500 output devices within the Main Processor. If the system needs grow beyond of 2500 points, the system shall be able to be networked to identical panels. In addition, the system shall have the following functions:

1. Initiating Device Calibration Check: It shall be possible to check the calibration at each initiating device at the control unit to verify correct operation.
2. Detector Sensitivity Check/Adjustment: Provide the capability of checking and adjusting individual detectors for alarm condition sensitivity from the control unit. The detector sensitivity monitoring shall meet and be listed by Underwriters' Laboratory for this function.
3. Coded Signaling: Operate audible notification appliance signals on a Coded manor in accordance with the National Standard. The system shall have the ability to code each device with a distinctive code. This code shall be software selectable.
4. Compare Function: Software to allow for a printout of a comparison of the original or previous program and any software modifications that are made to indicate any deficiencies caused by reprogramming. Systems not providing a compare printout function shall require 100% re-testing after every software modification and furnish a print out with each device being re-tested to the institution.
5. Detector Maintenance Monitoring: Provide monitoring of smoke detector chambers for gradual build-up of foreign materials in the sensing chamber. When the control senses a high level of contamination, the control panel shall cause a trouble condition and indicate the specific detector that needs maintenance.
6. Automatic Drift Compensation: All smoke detectors shall be monitored for changes in sensitivity ranges and automatically adjust the detection window, up or down, to compensate for environmental changes or degradation of detector components.
7. Visual Indicating Appliances Control: All visual indicating appliances shall be synchronized throughout the facility.
8. Application Specific Detection: Smoke detectors shall be individually programmed to provide the maximum sensitivity allowed by UL standards to actual fire phenomena and be discriminatory to deceptive phenomena that cause unwanted alarms. The program shall allow for a selection of 11 application specific environments to choose from as listed below. These selections shall be submitted for application to the Engineer before final acceptance of the system. Systems not including this feature shall provide both ionization and photoelectric detection at each location, programmed with algorithms to provide the earliest possible detection and minimize unwanted alarms.

Application Specific	Normal Environment
Office	Reasonably clean, climate-controlled atmosphere
Warehouse	Airborne dust, equipment, fork truck, light-to-medium dock area exhaust fumes

Lobby	Relatively clean area, temperature changes, cellular telephones, cigarette/cigar smoking fumes
Computer Room	Very controlled environment: clean, temperature closely regulated, high-cost clean machinery operating, no smoking, high air velocity
Healthcare	Higher-level; risk, relatively clean, electronic equipment
Dormitory	Airborne dust, temperature changes, living quarters, cooking fumes, smoking
Parking Garage	Airborne dust, car and diesel fumes, temperature swings
Utility Room	Normal to somewhat dirty environment, heat from running equipment
Hostile Environment	Dirty, dusty, humid, operating equipment, RF present, wide temperature swings
Precious Storage	Sensitive materials or equipment storage, clean dust-free environment, earliest warning desired
Duct	Installation in air handling systems

9. Alarm Verification: Provide field programmable alarm verification for all smoke detectors that allows a time delay of up to 50 seconds before a smoke detector signals the alarm. This feature shall not be utilized or required with application specific detectors where no delays of reporting of fire phenomena are necessary and ‘deceptive phenomena’ is ignored.
10. Detector Maintenance Monitoring: Provide monitoring of smoke detector chambers for gradual build-up of foreign materials in the sensing chamber. When the control senses a high level of contamination, the control panel shall cause a trouble condition and indicate the specific detector that needs maintenance.
11. Automatic Drift Compensation: All smoke detectors shall be monitored for changes in sensitivity ranges and automatically adjust the detection window up or down to compensate for environmental changes or degradation of detector components.
12. Battery Standby: Provide in the control unit cabinet, batteries that will operate all system initiating devices for a minimum of 24 hours during power outage and operate the entire system for a minimum of 2 hours of emergency operation or 15 minutes of evacuation alarm at maximum connected load. The batteries shall be sealed type and automatically recharge after normal power is restored.
13. Device Bypassing: Provide the capability through the control panel keypad to individually disarm an initiating device or output circuit. If an initiating device such as a smoke detector malfunctions, disarming and bypassing the unit shall be

possible without affecting other devices within the system. Output control functions such as notification appliance circuits or fun shut down shall be capable of being individually bypassed during tests or abnormal conditions. A trouble condition shall be created when any initiating or output device is disarmed or bypassed.

14. Event History Storage: All events of the system shall be logged in non-volatile history buffer with a minimum capacity of 1000 events. The events may be recalled by category.
15. Walk Test: A walk test feature shall be provided that allows testing individual zones, loops or the entire system in either a silent or audible basis. In either test, programmed functions shall be bypassed.
16. Fully Field Programmable: The complete system operation shall be programmed via a standard laptop computer. The program shall be capable of being stored in the computer hard disk, storage media and printed on standard continuous form paper. The complete program shall be turned over to the Owner upon acceptance of the system. The program shall be in digital format on storage media as well as a printed hard copy.
17. Compare Program: The system program shall allow for a printout of any and only changes that have been made to the program since the last program event or session. This printout shall indicate the time and date of the previous and current program sessions. Once the system is accepted by the authority having jurisdiction (AHJ), a copy of the current program must be signed by the AHJ on the first page and last page of the continuous form printout. Any changes to the program after this time and date, must be submitted for approval by the AHJ in printed form or the entire system must be re-tested and approved at the discretion of the Department of General Services Engineer and the AHJ. With the compare program printout, all the devices and their operation shall be tested in accordance with NFPA 72 which requires an additional 10% of the unchanged portion of the system, up to a total of 50 devices, to be tested. Documentation shall be provided that these tests were made after each programming change or session that is downloaded to the system.

2.3 MATERIALS AND EQUIPMENT

A. Fire Alarm Control Panel:

1. Existing to remain.

B. Power Supply:

1. The system Power Supply/Charger shall be a 12-amp supply with battery charger. The power supply shall be filtered and regulated. The system power supply shall have 4 relays, 1 for common alarm, one for common trouble and two programmable relays. The power supply shall be rated for 120/240 VAC 50/60 Hz.
2. The battery charger shall be able to charge the system batteries per battery specifications. Battery charging shall be microprocessor controlled and programmed with a special software package to select charging rates and battery sizes.

3. The battery charger shall be able to accept, and be provided with Thermistor for monitoring battery temperature to control charging rate.

C. Off-Site Communications:

1. Existing to remain.

D. Initiation Devices:

1. All initiation devices shall be insensitive to initiating loop polarity. Specifically, the devices shall be insensitive to plus/minus voltage connections on either Style 4 or Style 6 circuits.
2. Smoke Detectors:

    a. Smoke detectors shall be ceiling mounted digital addressable photoelectric type smoke detectors with integrated heat sensors. The combination detector head and twist lock base shall be U.L. listed compatible with the fire alarm control panel.
    b. The base shall permit direct interchange with the heat detector. The base shall be the appropriate twist lock base.
    c. The smoke detector shall have a flashing status LED for visual supervision. When the detector is actuated, the flashing LED will latch on steady at full brilliance. The detector may be reset by actuating the control panel's reset switch. The sensitivity of the detector shall be capable of being selected and measured by the control panel without the need for external test equipment.
    d. The vandal security-locking feature shall be used in those areas as indicated on the drawing. The locking feature shall be field selectable when required. It shall be possible to perform a sensitivity test of the detector without the need of generating smoke. The test method shall simulate the effects of products of combustion in the chamber to ensure testing of the detector circuits.
    e. Detectors shall have completely closed back to restrict entry of dust and air turbulence and have a 30-mesh insect screen. Electronics of the unit shall be shielded to protect against false alarms from E.M.I. and R.F.I.

3. Heat Detectors:

    a. Furnish and install digital addressable heat detectors. The combination heat detector and twist lock base shall be U.L. listed compatible with the fire alarm control panel.
    b. The base shall permit direct interchange with the photoelectric smoke detector. The base shall be appropriate twist lock base.
    c. The heat detector shall have a flashing status LED for visual supervision. When the detector is actuated, the flashing LED will latch on steady at full brilliance. The detector may be reset by actuating the control panel's reset switch.
    d. The vandal security-locking feature shall be used in those areas as indicated on the drawings. Electronics of the unit shall be shielded to protect against false alarms from E.M.I. and R.F.I.

4. Combination Fire and Carbon Monoxide Detectors:

    a. Combination fire and carbon monoxide detectors shall be ceiling mounted digital addressable detectors with integrated sensing elements, including smoke, CO, light/flame and heat. The detector head and twist lock base shall be U.L. listed compatible with the fire alarm control panel.
    b. The smoke detector shall have a flashing status LED for visual supervision. The detector may be reset by actuating the control panel's reset switch. The sensitivity of the detector shall be capable of being selected and measured by the control panel without the need for external test equipment.
    c. The vandal security-locking feature shall be used in those areas as indicated on the drawing. The locking feature shall be field selectable when required. It shall be possible to perform a sensitivity test of the detector without the need of generating smoke. The test method shall simulate the effects of products of combustion in the chamber to ensure testing of the detector circuits.

5. Duct Detectors:

    a. Duct Detector shall include an enclosure with a photoelectric smoke head as previously specified and auxiliary output. Duct Detectors shall be provided with remote indicator lights and appropriate sampling tube for duct size.
    b. Duct Detectors shall be provided with NEMA 4X enclosure and strip heat as required for exterior applications, powered from the fire alarm system. Provide sufficient power and wire as required to operate detector.
    c. Program duct detectors as directed by owner/fire marshal.

6. Manual Pull Stations:

    a. Manual Fire Alarm Stations shall be double action type, with a key operated test-reset lock in order that they may be tested, and so designed that after actual emergency operation, they cannot be restored to normal except by use of a key. The reset key shall be so designed that it will reset manual station and open FACP without use of another key. An operated station shall automatically condition itself so as to be visually detected, as operated, at a minimum distance of fifty feet, front or side. Manual stations shall be constructed with clearly visible operating instructions on the front of the stations in raised letters. Stations shall be suitable for surface mounting on matching back box, or semi-flush mounting on a standard single-gang box, and shall be installed within the limits defined by the Americans with Disabilities Act (ADA) dependent on manual station accessibility or per local requirements.
    b. Manual Fire Alarm Stations shall utilize push in/pull down operation.
    c. Housing material shall be metal or LEXAN polycarbonate resin.

7. Addressable Interface Devices:

    a. Addressable Interface devices compatible with the system shall be provided to monitor contacts for such items as water-flow, tamper, pressure, and PIV switches, Knox Box, Air Handling Unit Fans that are required by codes to be controlled, Kitchen Hood Suppression System, and Elevator Recall Modes

connected to the fire alarm system. These interface devices shall be able to monitor a single or dual contacts. An address will be provided for each contact. Where remote supervised relay is required, the interface shall be equipped with a SPDT relay rated for 4 amps resistive and 3.5 amps inductive.

8. Device Guards:

   a. Wire cages, vandal covers and other types of guards shall be provided for devices located in spaces where damage can occur, including, but not limited to gymnasiums, locker areas, weight and aerobic rooms, etc.

E. Notification Appliances:

1. Finishes:

   a. All celling devices shall be white with red lettering, unless noted otherwise.
   b. All wall mounted devices shall match existing, unless noted otherwise.

2. The speaker/strobe or speaker appliance as indicated on the drawings shall be a multiple tap speaker having taps for ¼, ½, 1 and 2 watts. The speaker/strobes shall have a synchronized strobe light with multiple candela taps to meet the intended application. The strobe light taps shall be adjustable for 15, 30, 75, and 110 candela. Do not load any circuit beyond 75 % of its capacity.
3. The strobe only appliance as indicated on the drawings shall be a synchronized strobe light with multiple candela taps to meet the intended application. The strobe light taps shall be adjustable for 15, 30, 75, and 110 candela. Do not load any circuit beyond 75 % of its capacity.
4. Where shown on the drawings, provide strobe units in combination with the audible indicating appliances. Strobes shall be supervised and synchronized within each circuit.
5. Wire cages, vandal covers and other types of guards shall be provided for devices located in spaces where damage can occur, including, but not limited to gymnasiums, locker areas, weight and aerobic rooms, etc
6. An alarm extender panel shall be provided where needed. The power supply shall be a minimum of 8 amps. The power supply shall contain four supervised notification circuits strobes and audibles. There shall be a 1 amp filtered auxiliary power limited output.
7. Provide Weatherproof Strobe, Speaker and Speaker/Strobe Units with NEMA 4X enclosures when located exterior of the building and where indicated on the drawings. These units shall have the same feature as speaker/strobe unit mentioned above and shall be weatherproof and rated for outdoor use. Furnish with surface weatherproof backbox.
8. Where notification appliances are indicated, provide manufacturer approved weather proof enclosures, etc.
9. Where devices are indicated to be installed in the ceiling, provide comparable devices designed to be installed in the ceiling.
10. Where devices are indicated to be installed on walls requiring surface installation in lieu of recessed, devices shall be mounted using a manufacturer's prescribed matching enamel outlet box. Finish of box shall match device.

F. Other Conditions:

1. After installation of smoke detectors, in potentially dusty areas, the Contractor shall provide an airtight plastic cover over the units to keep contaminants from entering the unit in all areas, until time of acceptance. It is the responsibility of the Contractor to either clean or replace any devices that have become soiled or contaminated by construction dirt.
2. The fire alarm equipment distributor shall stock the recommended spare parts listed for the UL certification.

G. Knox Box: Existing to remain.

H. Annunciator: Existing to remain.

I. Door Holders: Provide 24 VDC magnetic door holders and connect to the fire alarm door control circuit. The door holders shall be wall mounted unless otherwise noted on the drawings. The door holders shall be controlled for fail safe operation and shall not hold open during normal power failure. Provide with finish matching door hardware.

J. Document Storage Box: Existing to remain.

2.4 INTERCONNECTIONS

A. Connection to the Lighting Control System: Provide auxiliary relay to connect to the Lighting Control System. This relay shall be programmed to indicated to the lighting control system when the building goes into alarm so that all of the connected lights can go to full output. Coordinate the exact requirements with the Lighting Control System manufacturer.

PART 3 - INSTALLATION

3.1 GENERAL

A. Examine areas and conditions under which fire alarm system is to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in a manner acceptable to the Installer.

B. Install system and materials in accordance with manufacturer's instructions and rough-in drawings, and details on the drawings. Install electrical work and use electrical products of these specifications.

C. The Contractor shall install backboxes flush in wall with conduit to above accessible ceilings for fire alarm system. The contractor shall coordinate locations and backbox sizes.

D. This contractor is responsible for furnishing and installing all devices in ceiling tiles, including but not limited to backboxes, and supports.

E. In addition to providing smoke detectors at the locations indicated on the drawings, and within these specifications, smoke detectors shall be provided at all fire alarm control

units and transponders, notification appliance circuit power extenders, supervising station transmitting equipment and other NFPA and IFC required areas.

3.2 LABELING

A. All devices shall be labeled with their device point identification, matching the program ID. Provide loop identification for devices without specific point identification.

B. For devices located above the ceiling, provide identification of the device, as well as on the T-bar directly below the device. Identification information shall also be provided on remote indicators installed for duct detectors.

C. Devices requiring power (FACP, remote battery cabinets, etc.) shall be provided with label of circuit feeding device.

3.3 EQUIPMENT INSTALLATION

A. Notification Appliances: Mount semi-flush in recessed backboxes. Where surface mounting is approved, use manufacturer's standard surface backbox with finish matching device (provide red for red devices and white for white devices).

1. The use of pre-punched, or standard galvanized 4” square boxes shall not be acceptable under any circumstances.

B. Manual Pull Stations: Mount semi-flush in recessed back boxes. Where surface mounting is approved, use manufacturers standard surface Red backbox.

1. The use of pre-punched, or standard galvanized 4” square boxes shall not be acceptable under any circumstances.

C. Ceiling Mounted Smoke Detectors: Not less than 4” from a side wall to the near edge. For exposed solid-joist construction, mount detectors on the bottom of joists. On smooth ceilings, install not more than 30 ft. apart in any direction.

D. Notification Appliances: Mount semi-flush in recessed backboxes. Where surface mounting is approved, use manufacturer's standard surface backbox with finish matching device (provide red for red devices and white for white devices).

1. The use of pre-punched, or standard galvanized 4” square boxes shall not be acceptable under any circumstances.

E. Audible Alarm Indicated Devices: Install not less than 6” below the ceiling. Install Speakers on flush mounted back boxes with the device operating mechanism concealed behind a grille. Combine audible and visible alarms at the same location into a single unit.

F. Visible Alarm Indicated Devices: Install at least 6” below the ceiling and at a Maximum height of 96 inches.

G. Remote Network Panel: Install with tops of cabinets not more than 72” above the finished floor. Verify exact height with local authority having jurisdiction.

H. Notification Appliances: Mount semi-flush in recessed backboxes. Where surface mounting is approved, use manufacturer's standard surface backbox with finish matching device (provide red for red devices and white for white devices).

I. Remote Battery Panels: Install in mechanical or electrical spaces when available. Janitor closets may be used, if installed high on wall, away from water. Only use storage closets when necessary, and install high and out of the way of Owner storage space.

3.4 WIRING

A. Wiring connections shall be made by the Contractor as shown on drawings furnished by the representative of the equipment manufacturer. Power shall not be applied to the system until the representative of the manufacturer has approved the connections to the control equipment.

B. The system shall be installed in a manner approved by the State Inspections Department and the National Electric Code utilizing approved raceways or approved fire alarm cable.

C. Power for all fire alarm devices, including, but not limited to control panel, remote battery panels, initiation devices and annunciation devices, 120V and less shall be provided. Any power at 120V shall be connected to the nearest available panelboard on a 20A, 1P breaker. Provide a handle locking devices. The breaker or breakers for the fire alarm system shall be clearly marked.

D. All fire alarm cabling shall be plenum rated. Contractor shall install in a code compliant method. Fire alarm cable shall **not** be installed in the cable tray or with data cabling within J-hooks.

E. Fire alarm circuit identification shall meet N.E.C. Article 760.

3.5 FIELD QUALITY CONTROL

A. The manufacturer shall provide local representative to review the system installation with installers to assure proper wiring and installation methods are used. Job visits shall be made by representatives of the equipment manufacturer as necessary through construction.

B. Demonstration of System Operation: After adjustments to the system have been completed, arrange for a demonstration of the system operation for personnel designated by the Owner.

C. Notify in writing through the prime Contractor, the Architect, Consulting Engineer and the Owner of the time and date the demonstration will take place. Provide a technician representing the equipment manufacturer to conduct the system demonstration.

D. Pre-Testing: After installation, align, adjust, and balance the system and perform complete pre-testing. Determine, through pre-testing, the compliance of the system with requirements of drawings and specifications. Correct deficiencies observed in pre-testing. Replace malfunctioning or damaged items with new ones, and retest until

satisfactory performance and conditions are achieved. Prepare forms for systematic recording of acceptance test results.

E. Report of Pre-Testing: After pre-testing is complete, provide a letter certifying the installation is complete and fully operable, including the names and titles of witnesses to preliminary tests.

F. Final Test Notice: Provide a minimum of five (5) days' notice in writing when the system is ready for final acceptance testing.

G. Minimum System Tests: Test the system according to procedures outlined in NFPA 72. Minimum required tests are as follows:

1. Verify the absence of unwanted voltages between circuit conductors and ground.
2. Test all conductors for short circuits using an insulation testing device.
3. With each circuit pair, short circuit at the far end of the circuit and measure the circuit resistance with an ohmmeter. Record the circuit resistance of each circuit on record drawing.
4. Verify that the control unit is in the normal condition as detailed in the manufacturer's operation and maintenance manual.
5. Test initiating and indicating circuits for proper signal transmission under open circuit conditions. One connection each should be opened at not less than 10% of initiating and indicating devices. Observe proper signal transmission according to class of wiring used.
6. Test each initiating and indicating device for alarm operation and proper response at the control unit. Test smoke detectors with actual products of combustion.
7. Test the system for all specified functions according to the approved operation and maintenance manual. Systematically initiate specified functional performance items at each station, including making all possible alarm and monitoring initiations and using all communications options. For each item, observe related performance at all devices required to be affected by the item under all system sequence. Observe indicating lights, displays, signal tones, and Annunciator indications. Observe all voice audio for routing, clarity, quality, freedom from noise and distortion, and proper volume level.
8. Test Both Primary and Secondary Power: Verify by test that the secondary power system is capable of operating the system for the period and in the manner specified.

H. Re-Testing: Correct deficiencies indicated by tests and completely retest work affected by such deficiencies. Verify by the system test that the total system meets specifications and complies with applicable standards.

I. Report of Tests and Inspections: Provide a written record of inspections, tests, and detailed test results in the form of a test log. Submit log on the satisfactory completion of tests.

J. Tag all equipment, stations, and other components at which tests have been satisfactorily completed.

3.6 TRAINING

A. Provide the services of a factory-authorized service representative to demonstrate the system and train Owner's maintenance personnel as specified below.

1. Train Owner's maintenance personnel in the procedures and schedules involved in operating, troubleshooting, servicing, and preventive maintaining of the system. Provide a minimum of 8 hours' training.
2. Schedule training with the Owner at least seven days in advance.

3.7 SEQUENCE OF OPERATIONS

A. In additions to the operations and functions listed, the following shall also occur:

1. Where duct mounted smoke detectors are indicated specifically for air handling unit control, the associated air handling unit shall be connected to the fire alarm system via interface module. An auxiliary relay base shall not be used, unless noted otherwise.

    a. Upon a duct mounted smoke detector alarm condition, the connection to the mechanical equipment’s starter via interface module shall shut down its respective unit. A supervisory signal shall be sent to the fire alarm control panel which in turn will send a signal to the automatic temperature control (ATC) system. The ATC system, depending on its programming, may shut down all or some of the other mechanical equipment in the building.

2. Where smoke detectors are indicated for smoke dampers, individual interface modules shall be wired to each damper, and an additional interface module shall be wired to the ductwork’s associated air handler.

    a. Upon activation of a smoke detector associated with a specific damper, or at the unit feeding the ductwork with the damper, the interface module at the air handler starter shall shut down the unit and follow duct mounted smoke detector procedures. In addition, all smoke dampers associated with that particular air handler in addition to transfer ducts shall also close. Notification shall be sent to the fire alarm system and the ATC system.
    b. The smoke dampers will be provided at 24V. Coordinate power connection to smoke dampers with installing contractor, and provide appropriate power to dampers for control meeting all NFPA requirements.

3.8 TOWNSHIP/FIRE MARSHAL DRAWINGS

A. The Contractor shall provide CADD Drawings on 8 ½” x 11” (or as otherwise required by the local Fire Marshall or authority) sheets showing all As-Built device locations with identification numbers attached. These Drawings shall show all devices within the building. These Drawings shall be turned over to the township representative/Fire Marshal for their approval.

END OF SECTION 284621

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