SECTION 23 01 00 - COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. This Section includes the following:

1. Piping materials and installation instructions common to most piping systems.
2. Mechanical sleeve seals.
3. Sleeves.
4. Equipment installation requirements common to equipment sections.
5. Painting and finishing.
6. Concrete bases.

1.03 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.

F. The following are industry abbreviations for plastic materials:

1. CPVC: Chlorinated polyvinyl chloride plastic.
2. PE: Polyethylene plastic.
3. PVC: Polyvinyl chloride plastic.

G. The following are industry abbreviations for rubber materials:

1. EPDM: Ethylene-propylene-diene terpolymer rubber.

2. NBR: Acrylonitrile-butadiene rubber.

1.04 SUBMITTALS

A. Product Data: For the following:

1. Mechanical sleeve seals.

B. Welding certificates.

1.05 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.

1.06 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.

1.07 COORDINATION

A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for HVAC installations.

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

C. Coordinate requirements for access panels and doors for HVAC items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 08 Section "Access Doors and Frames."

1.10 COMMISSIONING PROCESS

A. General: The Owner's Commissioning Agent (CxA) will lead a commissioning team made up of owner and contractor representatives. Refer to Sections 019113 and 230800 for more information.

1. Members Appointed by Contractor(s): Individuals, each having the authority to act on behalf of the entity he or she represents, explicitly organized to implement the commissioning process through coordinated action. The commissioning team shall consist of, but not be limited to, representatives of each Contractor, including Project superintendent and subcontractors, installers, suppliers, and specialists deemed appropriate by the CxA.
2. Owner's CxA: The designated person, company, or entity that plans, schedules, and coordinates the commissioning team to implement the commissioning process. Owner will engage the CxA under a separate contract.
3. Owner's Facility Representatives: Facility user and operation and maintenance personnel.
4. Engineers: Design professional.

B. Contractor's Responsibilities:

1. Each Contractor shall assign representatives with expertise and authority to act on its behalf and shall schedule them to participate in and perform commissioning process activities including, but not limited to, the following:

a. Evaluate performance deficiencies identified in test reports and, in collaboration with entity responsible for system and equipment installation, recommend corrective action.
b. Cooperate with the CxA for resolution of issues recorded in the Issues Log.
c. Attend commissioning team meetings held on a weekly basis.
d. Integrate and coordinate commissioning process activities with construction schedule.
e. Review and accept construction checklists provided by the CxA.
f. Complete construction checklists as Work is completed and provide to the Commissioning Authority on a weekly basis.
g. Review and accept commissioning process test procedures provided by the Commissioning Authority.
h. Complete commissioning process test procedures.

C. CxA's Responsibilities:

1. Organize and lead the commissioning team.
2. Provide commissioning plan.
3. Convene commissioning team meetings.
4. Provide Project-specific construction checklists and commissioning process test procedures.
5. Verify the execution of commissioning process activities using random sampling. The sampling rate may vary from 1 to 100 percent. Verification will include, but is not limited

to, equipment submittals, construction checklists, training, operating and maintenance data, tests, and test reports to verify compliance with the OPR. When a random sample does not meet the requirement, the CxA will report the failure in the Issues Log.

6. Prepare and maintain the Issues Log.
7. Prepare and maintain completed construction checklist log.
8. Witness systems, assemblies, equipment, and component startup.
9. Compile test data, inspection reports, and certificates; include them in the systems manual and commissioning process report.

1.11 COORDINATION

A. Maintenance Access: Install equipment and devices in such a manner to be readily accessible for testing, adjusting, balancing, inspection and maintenance. All concealed equipment and devices, including but not limited to equipment, valves, dampers, actuators, sensors, gauges, test ports, filter housings, coils, etc., shall be installed above accessible ceilings, within accessible rooms or chases or within normally inaccessible construction with access doors. All access doors are not shown in the project drawings. All access doors shall be coordinated with the Engineer prior to the installation of the equipment or device. Equipment and/or devices not coordinated prior to installation, as judged by the Engineer, shall be removed and reinstalled at no added cost.

B. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for HVAC installations.

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

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

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:

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

2.02 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.

2.03 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 maximum thickness unless thickness or specific material is indicated.

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

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

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

D. Solder Filler Metals: ASTM B 32, 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.

2.04 MECHANICAL SLEEVE SEALS

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

1. Manufacturers:

   a. Advance Products & Systems, Inc.
   b. Calpico, Inc.
   c. Metraflex Co.
   d. Pipeline Seal and Insulator, Inc.

2. Sealing Elements: EPDM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
3. Pressure Plates: Stainless steel. Include two for each sealing element.

4. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.05 SLEEVES

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

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

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

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

1. Underdeck Clamp: Clamping ring with set screws.

PART 3 - EXECUTION

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

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

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping to permit valve servicing.

G. Install piping at indicated slopes.

H. Install piping free of sags and bends.

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

J. Install piping to allow application of insulation.

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

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

M. Permanent sleeves are not required for holes formed by removable PE sleeves.

N. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs.

O. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.

1. Cut sleeves to length for mounting flush with both surfaces.

a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.

2. Install sleeves in new walls and slabs as new walls and slabs are constructed.
3. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:

a. Steel Pipe Sleeves: For pipes smaller than NPS 6.
b. Steel Sheet Sleeves: For pipes NPS 6 and larger, penetrating gypsum-board partitions.
c. Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level. Refer to Division 07 Section "Sheet Metal Flashing and Trim" for flashing.

1) Seal space outside of sleeve fittings with grout.

4. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Division 07 Section "Joint Sealants" for materials and installation.

P. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

1. Install steel pipe for sleeves smaller than 6 inches in diameter.
2. Install cast-iron "wall pipes" for sleeves 6 inches and larger in diameter.
3. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and

sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

Q. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

1. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

R. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 07 Section "Penetration Firestopping" for materials.

S. Verify final equipment locations for roughing-in.

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

3.02 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.

3.03 PIPING CONNECTIONS

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

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

3.04 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.

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

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

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

3.05 PAINTING

A. Painting of HVAC systems, equipment, and components is specified in Division 09 Sections "Interior Painting" and "Exterior Painting."

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

3.06 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Refer to Division 05 Section "Metal Fabrications" for structural steel.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor HVAC materials and equipment.

C. Field Welding: Comply with AWS D1.1.

3.07 ERECTION OF WOOD SUPPORTS AND ANCHORAGES

A. Cut, fit, and place wood grounds, nailers, blocking, and anchorages to support, and anchor HVAC materials and equipment.

B. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Install fasteners without splitting wood members.

C. Attach to substrates as required to support applied loads.

END OF SECTION 230100

SECTION 230500 – HVAC FIRESTOPPING

PART 1 – GENERAL

1.1. SUMMARY

A. This section includes firestopping requirements and information for Division 23 work.

1.2. DEFINITIONS

A. Firestopping: The use of a material or combination of materials in a fire-rated structure (wall or floor) where it has been breached, so as to restore the integrity of the fire rating on that wall or floor.

B. System: The use of a specific firestop material or combination of materials in conjunction with a specific wall or floor construction type and a specific penetrant(s).

C. Barrier: Any bearing or non-bearing wall or floor that has an hourly fire and smoke rating.

D. Through-Penetration: Any penetration of a fire-rated wall or floor that completely breaches the barrier.

E. Membrane-Penetration: Any penetration in a fire-rated wall or floor/roof-ceiling assembly that breaches only one side of the barrier.

F. Approved Testing Agencies: Not limited to: Underwriters Laboratory (UL), Factory Mutual (FM), Warnock Hersey, and Omega Point Laboratory (OPL).

1.3. PERFORMANCE REQUIREMENTS

A. Penetrations: Provide through-penetration and membrane-penetration firestop systems that are produced and installed to resist the spread of fire, passage of smoke and other hot gases according to requirements indicated, to restore the original fire-resistance rating of assembly penetrated.

B. Provide and install complete penetration firestopping systems that have been tested and approved by nationally accepted testing agencies per ASTM E814 or UL 1479 fire tests in a configuration that is representative of field conditions.

1. F-Rated Systems: Provide firestop systems with F-ratings indicated and as required by the Building Code.
2. T-Rated Systems: Provide firestop systems with T-ratings and F-ratings indicated and as required by the Building Code.
3. L- Rated Systems: Provide firestop systems with L- ratings less than 5cfm/sf.
4. W-Rated systems: Provide firestop systems that are resistant to water. For piping penetrations for plumbing and wet-pipe sprinkler systems, provide moisture-resistant through-penetration firestop systems.

C. For penetrations involving non-metallic, CPVC, PVC, or plastic piping, tubing or conduit, provide firestop systems that are chemically compatible in accordance with Manufacturer requirements.

D. For penetrations involving insulated piping, provide firestop systems not requiring removal of insulation.

E. For penetrations involving fire or fire/smoke dampers, only firestop products approved by the damper manufacturer shall be installed in accordance with the damper installation instructions.

F. Firestopping products shall have flame spread ratings less than 25 and smoke-developed ratings less than 450, as determined per ASTM E 84, except firestop products installed in plenum spaces shall have a smoke developed rating less than 50.

G. Engineering Judgment (EJ): Where there is no specific third party tested and classified firestop system available for an installed condition, the Contractor shall obtain from the firestopping material manufacturer an Engineering Judgment (EJ) to be submitted to the Authority Having Jurisdiction (AHJ) and Engineer for approval. The EJ shall follow International Firestop Council (IFC) guidelines.

1.4. ACTION SUBMITTALS

A. Product Data: For each type of firestopping product selected. Manufacturers certification must verify that firestopping materials are free of asbestos, lead and contain volatile organic compounds (VOCs) within limits of the local jurisdiction. Include the following information:

1. Design Listings: Submit system design listings, including illustrations, from a qualified testing and inspecting agency that is applicable to each firestop configuration.
2. Installation Instructions: Submit the manufacturer’s installation instruction for each firestop assembly.
3. Engineering Judgements: Where there is no specific third party tested and classified firestop system available for a particular configuration, the Contractor shall obtain from the firestopping material manufacturer an Engineering Judgment (EJ) for submittal.
4. Firestop Schedule: Submit schedule itemizing the following:

    a. Manufacturer’s product reference numbers and/or drawing numbers.
    b. Listing agency’s design number.
    c. Penetrating Item Description/Limits: Material, size, insulated or uninsulated, and combustibility.
    d. Maximum allowable annular space or maximum size opening.
    e. Construction type.
    f. F rating and, if applicable, T, L, and W ratings.

1.5. QUALITY ASSURANCE

A. Provide firestopping system design listings from UL, FM, Warnock Hersey or OPL in accordance with the appropriate ASTM Standard(s).

B. Single Source Limitations: Obtain firestop systems for all conditions from a single manufacturer.

C. Materials from different firestop manufacturers shall not be installed in the same firestop system or opening.

D. Firestopping material shall be asbestos and lead free and shall not incorporate nor require the use of hazardous solvents.

E. Firestopping sealants must be flexible, allowing for normal movement.

F. Firestopping materials shall not shrink upon drying as evidenced by cracking or pulling back from contact surfaces such that a void is created.

G. Firestopping materials shall be moisture resistant, and may not dissolve in water after curing.

H. Materials used shall be in accordance with the manufacturer's written installation instructions.

I. All firestop materials shall be installed prior to expiration date. Store and handle materials per manufacturer's instructions to prevent deterioration or damage due to moisture, temperature changes, contaminants, or other causes.

1.6. QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum five years' documented experience.

B. Installer: Company specializing in performing Work of this section with minimum five years documented experience approved by manufacturer.

C. Installer shall have all required licensure.

1.7. COORDINATION

A. Coordinate areas prior to firestopping installation with the Owner, Construction Manager and/or all other Contractors.

B. Coordinate construction of openings and penetrating items to ensure that firestopping assemblies are installed according to specified requirements. Opening shall not exceed maximum restrictions allowable for annular spacing per listing or acceptable Engineering Judgments.

C. Coordinate sizing of sleeves, openings, core-drilled holes, or cut openings to accommodate through-penetration firestop systems.

D. Do not conceal firestopping installations until the Owner's inspection agency or Authorities Having Jurisdiction have examined each installation.

E. Schedule firestopping after installation of penetrants and joints but prior to concealing or obstructing access to areas requiring firestopping.

PART 2 – PRODUCTS

2.1. MANUFACTURERS

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

1. Emerson / Nelson Firestop Products
2. Hilti
3. 3M, Fire Protection Products Division
4. Tremco

2.2. FIRESTOPPING

A. Firestopping products specified in system design listings by approved testing agencies may be used providing they conform to the construction type, penetrant type, annular space requirements and fire rating involved in each separate assembly.

B. Accessories: Provide components for each firestop system that is needed to install fill materials and to comply with “Performance Requirements” Article. Use only components specified by the firestopping manufacturer and by the approved testing agencies for the firestop systems indicated. Accessories include, but are not limited to the following items:

1. Permanent forming/damming/backing materials, including the following:

a. Slag wool fiber insulation.
b. Foams or sealants used to prevent leakage of fill materials in liquid state.
c. Fire-rated form board.
d. Polyethylene/polyurethane backer rod.
e. Rigid polystyrene board.

2. Temporary forming materials.
3. Substrate primers.
4. Steel sleeves

C. All firestopping products and systems shall be designed and installed so that the basic sealing system will allow the full restoration of the thermal and fire resistance properties of the barrier being penetrated with minimal repair if penetrants are subsequently removed.

D. Mold Resistance: Provide penetration firestopping with mold and mildew resistance rating of 0 as determined by ASTM G21.

PART 3 – EXECUTION

3.1. GENERAL REQUIREMENTS

A. Provide firestop systems consisting of a material, or combination of materials installed to retain the integrity of fire resistance rated construction by maintaining an effective barrier against the spread of flame, smoke and/or hot gases through penetrations, fire resistive joints, and perimeter openings in accordance with the requirements of the Building Code for this

project.

B. Firestop systems shall be used in locations including, but not limited to, the following:

1. Penetrations through fire resistance rated floor and roof assemblies including both empty openings and openings containing penetrants.
2. Penetrations through fire resistance rated wall assemblies including both empty openings and openings containing penetrants.
3. Membrane penetrations in fire resistance rated wall assemblies where items penetrate one side of the barrier.

3.2. EXAMINATION

A. Examine substrates and conditions for compliance with requirements for opening configurations, penetrating items, substrates, and other conditions affecting performance.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

C. Verify that all pipes, conduits, cables, and/or other items which penetrate fire-rated construction have been permanently installed prior to installation of firestops.

3.3. PREPARATION

A. Surface Cleaning: Clean out openings immediately before installing firestop systems to comply with written recommendations of firestopping manufacturer and the following requirements:

B. Remove from surfaces of opening substrates and from penetrating items foreign materials that could interfere with adhesion of firestop systems.

C. Clean opening substrates and penetrating items to produce clean, sound surfaces capable of developing optimum bond with firestop systems. Remove loose particles remaining from cleaning operation.

D. For those products requiring mixing before application, comply with firestopping manufacturer's written instructions for accurate proportioning of materials, water (if

required), type of mixing equipment, selection of mixer speeds, mixing containers, mixing time, and other items or procedures needed to produce products of uniform quality with optimum performance characteristics for application indicated.

3.4. INSTALLATION

A. General: Install firestop systems to comply with firestopping manufacturer's written installation instructions and published drawings for products and applications indicated.

B. Apply firestopping in accordance with approved testing agencies listed system designs or manufacturer's EJ per the manufacturer's installation instructions.

C. Verify that environmental conditions are safe and suitable for installation of firestop products. Application areas shall be protected from weather, dry and within recommended temperature

and humidity ranges of materials being installed.

D. Install forming/damming/backing materials and other accessories required to support fill materials during their application and in the position needed to produce cross-sectional shapes and depths required to achieve fire resistance ratings required.

E. Install metal framing, mechanical attachments, safing materials and firestop materials as applicable within the system design.

F. Install fill materials for firestop systems by proven techniques to produce the following results:

1. Fill voids, joints and cavities formed by openings, forming materials, accessories, and penetrating items as required to achieve fire-resistance ratings indicated.
2. Apply materials so they fully contact and adhere to substrates formed by openings and penetrating items.
3. For fill materials that will remain exposed after completing work, finish to produce smooth, uniform surfaces that are flush with adjoining finishes.
4. Tool non-sag firestop materials after their application and prior to the time skinning begins. Use tooling agents approved by the firestopping manufacturer.

G. On vertical pipe penetrations, lift riser clamps to permit the installation of firestopping around the entire pipe penetration. For penetrations involving fire or fire/smoke dampers, only firestop products approved by the damper manufacturer shall be installed in accordance with the damper installation instructions.

3.5. FIELD QUALITY CONTROL

A. Inspecting Agency: Authorities Having Jurisdiction, the Owner, or Owner's Representative shall be allowed to perform random destructive testing during inspection of firestop systems

to verify compliance per listings or manufacturer's installation instructions. All areas of work must be accessible until inspection by the applicable Authorities Having Jurisdiction and inspection agencies. The contractor shall be responsible for repairing all tested assemblies with no cost to the owner.

B. Proceed with enclosing firestop systems with other construction only after inspections are complete.

C. Where deficiencies are found as determined by the Engineer, remove and replace firestop systems so they comply with requirements.

3.6. CLEANING AND PROTECTION

A. Clean off excess fill materials adjacent to openings, as work progresses by methods and with cleaning materials that are approved in writing by firestopping manufacturer(s) and that do not damage materials in which openings occur. Leave finished work in neat, clean condition with no evidence of spillovers or damage to adjacent surfaces.

B. Provide final protection and maintain conditions during and after installation that ensure firestop systems are without damage or deterioration at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, cut out and remove damaged or

deteriorated firestop systems immediately and install new materials to produce firestop systems complying with specified requirements.

END OF SECTION 230500

SECTION 230529 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:

1. Pipe hangers and supports.
2. Hanger rods.
3. Inserts.
4. Flashing.
5. Equipment curbs.
6. Sleeves.
7. Mechanical sleeve seals.
8. Formed steel channel.
9. Firestopping accessories.
10. Equipment bases and supports.

1.02 DEFINITIONS

A. Firestopping (Through-Penetration Protection System): Sealing or stuffing material or assembly placed in spaces between and penetrations through building materials to arrest movement of fire, smoke, heat, and hot gases through fire rated construction.

1.03 SYSTEM DESCRIPTION

A. Firestopping Materials: ASTM E119, ASTM E814, UL 263, UL 1479, to achieve fire ratings of adjacent construction in accordance with UL Design Numbers noted on Drawings. *Refer to Division 7.*

B. Surface Burning: ASTM E84 with maximum flame spread / smoke developed rating of 25/50.

C. Firestop interruptions to fire rated assemblies, materials, and components.

1.04 PERFORMANCE REQUIREMENTS

A. Firestopping: Conform to UL for fire resistance ratings and surface burning characteristics. *Refer to Division 7.*

1.05 SUBMITTALS

A. Submittal Procedures: Refer to Division 01 for Submittal procedures.

B. Shop Drawings: Indicate system layout with location including critical dimensions, sizes,

pipe hanger and support locations and detail of trapeze hangers.

C. Product Data:

1. Hangers and Supports: Submit manufacturers catalog data including load capacity.

D. Firestopping Schedule: Submit schedule of opening locations and sizes, penetrating items, and required listed design numbers to seal openings to maintain fire resistance rating of adjacent assembly.

E. Design Data: Indicate load carrying capacity of trapeze, multiple pipe, and riser support hangers. Indicate calculations used to determine load carrying capacity of trapeze, multiple pipe, and riser support hangers.

F. Manufacturer's Installation Instructions:

1. Hangers and Supports: Submit special procedures and assembly of components.
2. Firestopping: Submit preparation and installation instructions.

G. Manufacturer's Certificate: Certify products meet or exceed specified requirements.

H. Design application of hangers and supports for seismic requirements under direct supervision of a Professional Engineer experienced in the design of this work and licensed in North Carolina. Refer to Structural Drawings for the Seismic Design Category.

1.06 QUALITY ASSURANCE

A. Perform Work in accordance with AWS D1.1 for welding hangers and support attachments to building structure.

B. Maintain one copy of each document on site.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Product Requirements: Refer to Division 01 for Requirements for transporting, handling, storing, and protecting products.

B. Accept materials on site in original factory packaging, labeled with manufacturer's identification.

C. Protect from weather and construction traffic, dirt, water, chemical, and damage, by storing in original packaging.

1.08 ENVIRONMENTAL REQUIREMENTS

A. Product Requirements: Refer to Division 01 for Environmental conditions affecting products on site.

B. Do not apply firestopping materials when temperature of substrate material and ambient air is below 60 degrees F.

C. Maintain this minimum temperature before, during, and for minimum 3 days after installation of firestopping materials.

D. Provide ventilation in areas to receive solvent cured materials.

1.09 FIELD MEASUREMENTS

A. Verify field measurements prior to fabrication.

PART 2 PRODUCTS

2.01 PIPE HANGERS AND SUPPORTS

A. Manufacturers:

1. Carpenter & Paterson Inc.
2. Creative Systems Inc.
3. Flex-Weld, Inc.
4. Glope Pipe Hanger Products Inc.
5. Michigan Hanger co.
6. Superior Valve Co.
7. Unistrut Corporation
8. Grinnell Corporation
9. Hilti Corporation
10. ITW Ramset/Redhead, Dynabolt
11. B-Line Systems

B. Hydronic Piping:

1. Conform to ASME B31.9.
2. Hangers for Pipe Sizes 1/2 to 1-1/2 inch: Malleable iron, adjustable swivel, split ring.
3. Hangers for Pipe Sizes 2 to 4 inches: Carbon steel, adjustable, clevis.
4. Hangers for Pipe Sizes 6 inches and Larger: Adjustable steel yoke, cast iron roll, double hanger.
5. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
6. Multiple or Trapeze Hangers for Hot Pipe Sizes 6 inches and Larger: Steel channels with welded spacers and hanger rods, cast iron roll.
7. Wall Support for Pipe Sizes 3 inches and Smaller: Cast iron hooks.
8. Wall Support for Pipe Sizes 4 inches and Larger: Welded steel bracket and

wrought steel clamp.

9. Wall Support for Hot Pipe Sizes 6 inches and Larger: Welded steel bracket and wrought steel clamp with adjustable steel yoke and cast-iron roll.
10. Vertical Support: Steel riser clamp.
11. Floor Support for Cold Pipe: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
12. Floor Support for Hot Pipe Sizes 4 Inches and Smaller: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
13. Floor Support for Hot Pipe Sizes 6 inches and Larger: Adjustable cast iron roll and stand, steel screws, and concrete pier or steel support.
14. Copper Pipe Support: Copper-plated, carbon steel ring.

2.02 ACCESSORIES

A. Hanger Rods: Mild steel threaded both ends, threaded on one end, or continuous threaded.

2.03 CONCRETE ANCHORS AND INSERTS

A. Inserts: Malleable iron case of galvanized steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit threaded hanger rods.

B. Anchors:

1. Sleeve Anchors: Use for light to medium load cement block, thin wall or solid concrete, brick or stone. Static working load shall not exceed 25 percent of ultimate load capacity. Anchors shall be carbon steel sleeve anchors conforming to US Government G.S.A. Specifications FF-S-325, Group II, Type 3, Class 3, Red Head Dynabolt sleeve anchors Series AN, Series HN, Series FS or equal.
2. Wedge Anchors: Use for medium to heavy loads in concrete. Static working load shall not exceed 25 percent of ultimate load capacity. Anchors shall be zinc plated carbon steel wedge anchors conforming to US Government G.S.A. Specifications FF-S-325, Group II, Type 4, Class 1, Red Head Trubolt wedge anchors Series WS or equal.
3. Drop-In Anchors: For medium to heavy loads in heavy-duty concrete materials, thin wall or prestressed concrete. Static working load shall not exceed 25 percent of ultimate load capacity. Anchors shall be carbon steel drop-in anchors conforming to US Government G.S.A. Specifications FF-S-325, Group VIII, Type 1, Red Head Multi-Set drop-in anchors Series RM or equal.
4. Powder Actuated Anchors: Use for light loads in concrete. Tension load shall not exceed 25 percent of rating. Anchors shall be heavy duty pins or studs designed for concrete with a hardness of 52-58 HRC and zinc plated in accordance with ASTM B633, SC 1, Type III.

2.04 FLASHING

A. Metal Flashing: 26-gauge thick galvanized steel.

B. Metal Counterflashing: 22-gauge thick galvanized steel.

C. Lead Flashing:

1. Waterproofing: 5 lb./sq. ft sheet lead.
2. Soundproofing: 1 lb./sq. ft sheet lead.

D. Flexible Flashing: 47 mil thick sheet butyl; compatible with roofing.

E. Caps: Steel, 22-gauge minimum; 16-gauge at fire resistant elements.

2.05 SLEEVES

A. Sleeves for Pipes Through Non-fire Rated Floors: 18-gauge thick galvanized steel.

B. Sleeves for Pipes Through Non-fire Rated Beams, Footings, and Potentially Wet Floors: Steel pipe or 18-gauge thick galvanized sheet metal.

C. Sealant: Acrylic.

2.06 MECHANICAL SLEEVE SEALS

A. Product Description: Modular mechanical type, consisting of interlocking synthetic rubber links shaped to continuously fill annular space between object and sleeve, connected with bolts and pressure plates causing rubber sealing elements to expand when tightened, providing watertight seal and electrical insulation.

2.07 FORMED STEEL CHANNEL

A. Manufacturers:

1. Allied Tube & Conduit Corp.
2. B-Line Systems.
3. Midland Ross Corporation, Electrical Products Division.
4. Unistrut Corp.

B. Product Description: Galvanized 12-gauge thick steel. With holes 1-1/2 inches on center.

2.08 FIRESTOPPING - *refer to Division 7*

2.09 FIRESTOPPING ACCESSORIES

A. Primer: Type recommended by firestopping manufacturer for specific substrate surfaces and suitable for required fire ratings.

B. Dam Material: Permanent:

1. Mineral fiberboard.
2. Mineral fiber matting.
3. Sheet metal.
4. Alumina silicate fire board.

C. Installation Accessories: Provide clips, collars, fasteners, temporary stops or dams, and other devices required to position and retain materials in place.

D. General:

1. Furnish UL listed products or products tested by independent testing laboratory.
2. Select products with rating not less than rating of wall or floor being penetrated.

E. Non-Rated Surfaces:

1. Stamped steel, chrome plated, hinged, split ring escutcheons or floor plates or ceiling plates for covering openings in occupied areas where piping is exposed.
2. For exterior wall openings below grade, furnish mechanical sealing device to continuously fill annular space between piping and cored opening or water-stop type wall sleeve.

PART 3 EXECUTION

3.01 EXAMINATION

A. Administrative Requirements: Refer to Division 01 for Verification of existing conditions before starting work.

B. Verify openings are ready to receive sleeves.

C. Verify openings are ready to receive firestopping.

3.02 PREPARATION

A. Clean substrate surfaces of dirt, dust, grease, oil, loose material, or other matter affecting bond of firestopping material.

B. Remove incompatible materials affecting bond.

C. Install backing materials to arrest liquid material leakage.

D. Obtain permission from Architect/Engineer before using powder-actuated anchors.

E. Do not drill or cut structural members.

3.03 INSTALLATION - INSERTS

A. Install inserts for placement in concrete forms.

B. Install inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.

C. Provide hooked rod to concrete reinforcement section for inserts carrying pipe 4 inches and larger.

D. Where concrete slabs form finished ceiling, locate inserts flush with slab surface.

E. Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut recessed into and grouted flush with slab.

3.04 INSTALLATION - PIPE HANGERS AND SUPPORTS

A. Install in accordance with ASME 31.9.

B. Support horizontal piping as scheduled.

C. Install hangers with minimum ½- inch space between finished covering and adjacent work.

D. Place hangers within 12 inches of each horizontal elbow.

E. Support vertical piping at every floor.

F. Where piping is installed in parallel and at same elevation, provide multiple pipe or trapeze hangers.

G. Support riser piping independently of connected horizontal piping.

H. Provide shielded hangers and supports for non-insulated copper piping to prevent dissimilar metal contact.

I. Design hangers for pipe movement without disengagement of supported pipe.

J. Provide clearance in hangers and from structure and other equipment for installation of insulation.

3.05 INSTALLATION – DUCT HANGERS AND SUPPORTS

A. Design and install duct hangers and supports in accordance with Chapter 4 of the HVAC Duct Construction Standards (SMACNA).

3.06 INSTALLATION - EQUIPMENT BASES AND SUPPORTS

A. Provide housekeeping pads of concrete, minimum 3-1/2 inches thick and extending 6 inches beyond supported equipment. Chamfer edges of pads.

B. Using templates furnished with equipment, install anchor bolts, and accessories for mounting and anchoring equipment.

C. Construct supports of steel members, formed steel channel or steel pipe and fittings. Brace and fasten with flanges bolted to structure.

D. Provide rigid anchors for pipes after vibration isolation components are installed.

3.07 INSTALLATION - FLASHING

A. Provide flexible flashing and metal Counterflashing where piping and ductwork penetrate weather or waterproofed walls, floors, and roofs.

B. Provide acoustical flashing around ducts and pipes penetrating equipment rooms for sound control.

C. Provide curbs for roof installations 14 inches minimum high above roofing surface. Flash and counter-flash with sheet metal; seal watertight. Attach Counterflashing to equipment and lap base flashing on roof curbs. Flatten and solder joints.

D. Adjust storm collars tight to pipe with bolts; caulk around top edge. Use storm collars above roof jacks. Screw vertical flange section to face of curb.

3.08 INSTALLATION - SLEEVES

A. Exterior watertight entries: Seal with mechanical sleeve seals.

B. Set sleeves in position in forms. Provide reinforcing around sleeves.

C. Size sleeves large enough to allow for movement due to expansion and contraction. Provide for continuous insulation wrapping.

D. Extend sleeves through floors 1 inch above finished floor level. Caulk sleeves.

E. Where piping or ductwork penetrates floor, ceiling, or wall, close off space between pipe or duct and adjacent work with firestopping or insulation and caulk [airtight]. Provide close fitting metal collar or escutcheon covers at both sides of penetration.

F. Install chrome plated steel escutcheons at finished surfaces.

3.09 INSTALLATION - FIRESTOPPING

A. Install material at fire rated construction perimeters and openings containing penetrating sleeves, piping, ductwork, and other items, requiring firestopping.

B. Apply primer where recommended by manufacturer for type of firestopping material and substrate involved, and as required for compliance with required fire ratings.

C. Apply firestopping material in sufficient thickness to achieve required fire and smoke rating.

D. Compress fibered material to maximum 40 percent of its uncompressed size.

E. Place foamed material in layers to ensure homogenous density, filling cavities and spaces. Place sealant to completely seal junctions with adjacent dissimilar materials.

F. Place intumescent coating in sufficient coats to achieve rating required.

G. Remove dam material after firestopping material has cured.

H. Fire Rated Surface:

1. Seal opening at floor, wall, partition, ceiling, and roof as follows:

    a. Install sleeve through opening and extending beyond minimum of 1 inch on both sides of building element.
    b. Size sleeve allowing minimum of 1 inch void between sleeve and building element.
    c. Pack void with backing material.
    d. Seal ends of sleeve with UL listed fire resistive silicone compound to meet fire rating of structure penetrated.

2. Where conduit, penetrates fire rated surface, install firestopping product in accordance with manufacturer's instructions.

I. Non-Rated Surfaces:

1. Seal opening through non-fire rated ceiling and roof opening as follows:

    a. Install sleeve through opening and extending beyond minimum of 1 inch on both sides of building element.
    b. Size sleeve allowing minimum of 1 inch void between sleeve and building element.

2. Install escutcheons, floor plates or ceiling plates where conduit penetrates non-fire rated surfaces in occupied spaces. Occupied spaces include rooms with

finished ceilings and where penetration occurs below finished ceiling.

3.10 FIELD QUALITY CONTROL

A. Refer to Division 01 for Quality Requirements and Execution and Closeout Requirements: Field inspecting, testing, adjusting, and balancing.

B. Inspect installed firestopping for compliance with specifications and submitted schedule.

3.11 CLEANING

A. Execution and Closeout Requirements: Refer to Division 01 for Requirements for cleaning.

B. Clean adjacent surfaces of firestopping materials.

3.12 PROTECTION OF FINISHED WORK

A. Execution and Closeout Requirements: Refer to Division 01 for Requirements for protecting finished Work.

B. Protect adjacent surfaces from damage by material installation.

3.13 SCHEDULES

A. Copper and Steel Pipe Hanger Spacing:

PIPE SIZE Inches	COPPER TUBING MAXIMUM HANGER SPACING Feet	STEEL PIPE MAXIMUM HANGER SPACING Feet	COPPER TUBING HANGER ROD DIAMETER Inches	STEEL PIPE HANGER ROD DIAMETER Inches
1/2	5	7	3/8	3/8
3/4	5	7	3/8	3/8
1	6	7	3/8	3/8
1-1/4	7	7	3/8	3/8
1-1/2	8	9	3/8	3/8
2	8	10	3/8	3/8
2-1/2 (Note 2)	9	11	1/2	1/2
3	10	12	1/2	1/2

4	12	14	1/2	5/8
5	13	16	1/2	5/8
6	14	17	5/8	3/4
8	16	19	3/4	3/4
10	18	22	3/4	7/8
12	19	23	3/4	7/8
14	22	25	7/8	1
16	23	27	7/8	1
18	25	28	1	1
20	27	30	1	1-1/4
24	28	32	1-1/4	1-1/4

B. Plastic and Ductile Iron Pipe Hanger Spacing:

PIPE MATERIAL	MAXIMUM HANGER SPACING Feet	HANGER ROD DIAMETER Inches
ABS (All sizes)	4	3/8
FRP (All Sizes)	4	3/8
Ductile Iron (Note 2)		
PVC (All Sizes)	4	3/8

C. Note 1: Refer to manufacturer's recommendations for grooved end piping systems.

D. Note 2: 20 feet maximum spacing, minimum of one hanger for each pipe section close to joint behind bell. Provide hanger at each change of direction and each branch connection. For pipe sizes 6 inches and smaller, subjected to loadings other than weight of pipe and contents, limit span to maximum spacing for water service steel pipe.

END OF SECTION 230529

SECTION 23 05 48 – VIBRATION, WIND, AND SEISMIC CONTROLS FOR HVAC

PART 1 – GENERAL

1.1. SUMMARY

A. Section includes vibration and seismic control devices and related materials, including isolators, mounts, guides and supports.

B. Description: Delegated design of all equipment and materials installed under Division 23.

1. Vibration Isolation: Applies to all HVAC equipment and materials.
2. Wind Restraints: Applies to all HVAC equipment and materials installed outdoors, above-grade.
3. Seismic Bracing: Applies to all HVAC equipment and materials based on the seismic criteria defined in this section.

1.2. ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of vibration isolation, wind restraint and seismic restraint device required.

B. Delegated-Design Submittal: For each vibration isolation, wind restraint and seismic restraint device:

1. Include design calculations and details for selecting vibration isolators, wind restraints, seismic restraints, and vibration isolation bases complying with performance requirements, design criteria, and analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
2. Design Calculations: Calculate static and dynamic loading due to equipment weight, operation, and seismic and wind forces required to select vibration isolators and seismic and wind restraints and for designing vibration isolation bases.

    a. Coordinate design calculations with wind load calculations required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.

3. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes, and seismic loads. Include certification that riser system was examined for excessive stress and that none exists.
4. Seismic and Wind Restraint Details:

    a. Design Analysis: To support selection and arrangement of seismic and wind restraints. Include calculations of combined tensile and shear loads.

b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.

c. Coordinate seismic-restraint and vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.

1.3. QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7 and that is acceptable to authorities having jurisdiction.

B. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.

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

D. Seismic-restraint devices shall have horizontal and vertical-load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are unavailable, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

1.4. QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum five years' documented experience.
B. Installer: Company specializing in performing Work of this section with minimum five years documented experience approved by manufacturer.
C. Installer shall have all required licensure.

PART 2 - PRODUCTS

2.1. MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide product by one of the following for spring and elastomeric isolators:

1. Mason Industries, Inc.
2. Kinetics Noise Control, Inc.
3. Vibration Eliminator Company, Inc.

4. Vibration Mounting & Controls (VMC) Group, Inc.

2.2. PERFORMANCE REQUIREMENTS

A. Wind-Restraint Loading:

1. Basic Wind Speed: See/Match Structural
2. Building Classification Category: See/Match Structural
3. Minimum 30 lb/sq. ft. multiplied by maximum area of HVAC component projected on vertical plane normal to wind direction, and 45 degrees either side of normal.

B. Seismic-Restraint Loading:

1. Site Class as Defined in the IBC: See/Match Structural
2. Seismic Design Category: See/Match Structural
3. Assigned Risk Category as Defined in the IBC:

    a. Component Importance Factor of 1.5:

        1) Life-Safety Dampers
        2) HVAC Systems serving patient areas.

    b. Component Importance Factor of 1.0: All other systems and their components.
    c. Component Response Modification Factor: Per ASCE 7-05 - Chapter 13
    d. Component Amplification Factor: Per ASCE 7-05 - Chapter 13

4. Design Spectral Response Acceleration at Short Periods (0.2 Second):
5. Design Spectral Response Acceleration at 1.0-Second Period:
6. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they are subjected.

C. Seismic Performance: HVAC equipment shall withstand the effects of earthquake motions determined according to ASCE/SEI-7. The term “withstand” means the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified.

2.3. ELASTOMERIC ISOLATION PADS

A. Description: Elastomeric Isolation Pads.

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

    a. Surface Pattern: Waffle pattern.

b. Infused nonwoven cotton or synthetic fibers.

2.4. ELASTOMERIC ISOLATION MOUNTS

A. Description: Double-Deflection, Elastomeric Isolation Mounts.

1. Mounting Plates:

a. Top Plate: Encapsulated steel load transfer top plates, factory drilled and threaded with threaded studs or bolts.
b. Baseplate: Encapsulated steel bottom plates with holes provided for anchoring to support structure.

2. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.5. RESTRAINED ELASTOMERIC ISOLATION MOUNTS

A. Description: Restrained Elastomeric Isolation Mounts.

1. Description: All-directional isolator with seismic restraints containing two separate and opposing elastomeric elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.

a. Housing: Cast-ductile iron or welded steel.
b. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.6. OPEN-SPRING ISOLATORS

A. Description: Freestanding, Laterally Stable, Open-Spring Isolators.

1. Outside Spring Diameter: Not less than 80-percent of the compressed height of the spring at rated load.
2. Minimum Additional Travel: 50-percent of the required deflection at rated load.
3. Lateral Stiffness: More than 80-percent of rated vertical stiffness.
4. Overload Capacity: Support 200-percent of rated load, fully compressed, without deformation or failure.
5. Baseplates: Factory-drilled steel plate for bolting to structure with an elastomeric isolator pad attached to the underside. Baseplates shall limit floor load to 500 psig.
6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

2.7. HOUSED-SPRING ISOLATORS

A. Description: Freestanding, Laterally Stable, Open-Spring Isolators in Two-Part Telescoping Housing.

1. Outside Spring Diameter: Not less than 80-percent of the compressed height of the

spring at rated load.
2. Minimum Additional Travel: 50-percent of the required deflection at rated load.
3. Lateral Stiffness: More than 80-percent of rated vertical stiffness.
4. Overload Capacity: Support 200-percent of rated load, fully compressed, without deformation or failure.
5. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators.

    a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig.
    b. Top housing with attachment and leveling bolt or threaded mounting holes and internal leveling device.

2.8. RESTRAINED-SPRING ISOLATORS

A. Description: Freestanding, Laterally Stable, Open-Spring Isolators with Vertical-Limit Stop Restraint.

1. Housing: Steel housing with vertical-limit stops to prevent spring extension due to weight being removed.

    a. Base with holes for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig.
    b. Top plate with threaded mounting holes or elastomeric pad.
    c. Internal leveling bolt that acts as blocking during installation.

2. Restraint: Limit stop as required for equipment and authorities having jurisdiction.
3. Outside Spring Diameter: Not less than 80-percent of the compressed height of the spring at rated load.
4. Minimum Additional Travel: 50-percent of the required deflection at rated load.
5. Lateral Stiffness: More than 80-percent of rated vertical stiffness.
6. Overload Capacity: Support 200-percent of rated load, fully compressed, without deformation or failure.

2.9. HOUSED-RESTRAINED-SPRING ISOLATORS

A. Description: Freestanding, Steel, Open-Spring Isolators with Vertical-Limit Stop Restraint in Two-Part Telescoping Housing.

1. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators. Housings are equipped with adjustable snubbers to limit vertical movement.

    a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig.
    b. Threaded top housing with adjustment bolt and cap screw to fasten and level equipment.

2. Outside Spring Diameter: Not less than 80-percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50-percent of the required deflection at rated load.

4. Lateral Stiffness: More than 80-percent of rated vertical stiffness.
5. Overload Capacity: Support 200-percent of rated load, fully compressed, without deformation or failure.

2.10. PIPE-RISER RESILIENT SUPPORT

A. Description: All-directional, acoustical pipe anchor consisting of two steel tubes separated by a minimum 1/2-inch-thick neoprene.

1. Vertical-Limit Stops: Steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions.
2. Maximum Load Per Support: 500 psig on isolation material providing equal isolation in all directions.

2.11. RESILIENT PIPE GUIDES

A. Description: Telescopic arrangement of two steel tubes or post and sleeve arrangement separated by a minimum 1/2-inch-thick neoprene.

1. Factory-Set Height Guide with Shear Pin: Shear pin shall be removable and re-insertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

2.12. ELASTOMERIC HANGERS

A. Description: Elastomeric Mount in a Steel Frame with Upper and Lower Steel Hanger Rods.

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

2.13. SPRING HANGERS

A. Description: Combination Coil-Spring and Elastomeric-Insert Hanger with Spring and Insert in Compression.

1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
2. Outside Spring Diameter: Not less than 80-percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50-percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80-percent of rated vertical stiffness.
5. Overload Capacity: Support 200-percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced

cup to support spring and bushing projecting through bottom of frame.
7. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
8. Self-centering hanger-rod cap to ensure concentricity between hanger rod and support spring coil.

2.14. SNUBBERS

A. Description: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.

1. Anchor bolts for attaching to concrete shall be seismic-rated, drill-in, and stud-wedge or female-wedge type.
2. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
3. Maximum 1/4-inch air gap, and minimum 1/4-inch-thick resilient cushion.

2.15. RESTRAINT CHANNEL BRACINGS

A. Description: MFMA-4, shop- or field-fabricated bracing assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

2.16. RESTRAINT CABLES

A. Restraint Cables: ASTM A 492 stainless-steel cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; with a minimum of two clamping bolts for cable engagement.

2.17. SEISMIC-RESTRAINT ACCESSORIES

A. Hanger-Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod.

B. Hinged and Swivel Brace Attachments: Multifunctional steel connectors for attaching hangers to rigid channel bracings and restraint cables.

C. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.

D. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices used.

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

2.18. MECHANICAL ANCHOR BOLTS

A. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

2.19. ADHESIVE ANCHOR BOLTS

A. Adhesive Anchor Bolts: Drilled-in and capsule anchor system containing PVC or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

2.20. VIBRATION ISOLATION EQUIPMENT BASES

A. Steel Rails: Factory-fabricated, welded, structural-steel rails.

1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide rails.
2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Rails shall have shape to accommodate supported equipment.
3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.

B. Steel Bases: Factory-fabricated, welded, structural-steel bases and rails.

1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.
2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.
3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.

C. Concrete Inertia Base: Factory-fabricated or field-fabricated, welded, structural-steel bases and rails ready for placement of cast-in-place concrete.

1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.

    a. Include supports for suction and discharge elbows for pumps.

2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.
3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.

4. Fabrication: Fabricate steel templates to hold equipment anchor-bolt sleeves and anchors in place during placement of concrete. Obtain anchor-bolt templates from supported equipment manufacturer.

2.21. RESTRAINED ISOLATION ROOF-CURB RAILS

A. Description: Factory-assembled, fully enclosed, insulated, air- and watertight curb rail designed to resiliently support equipment and to withstand seismic and wind forces.

B. Upper Frame: The upper frame shall provide continuous support for equipment and shall be captive to resiliently resist seismic and wind forces.

C. Lower Support Assembly: The lower support assembly shall be formed sheet metal section containing adjustable and removable steel springs that support the upper frame. The lower support assembly shall have a means for attaching to building structure and a wood nailer for attaching roof materials, and shall be insulated with a minimum of 2 inches of rigid, glass-fiber insulation on inside of assembly. Adjustable, restrained-spring isolators shall be mounted on elastomeric vibration isolation pads and shall have access ports, for level adjustment, with removable waterproof covers at all isolator locations. Isolators shall be located so they are accessible for adjustment at any time during the life of the installation without interfering with the integrity of the roof.

D. Snubber Bushings: All-directional, elastomeric snubber bushings at least 1/4 inch thick.

E. Water Seal: Galvanized sheet metal with EPDM seals at corners, attached to upper support frame, extending down past wood nailer of lower support assembly, and counterflashed over roof materials.

PART 3 – EXECUTION

3.1. EXAMINATION

A. Examine areas and equipment to receive vibration isolation and seismic and wind control devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2. APPLICATIONS

A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application.

B. Hanger-Rod Stiffeners: Install hanger-rod stiffeners where indicated or scheduled on

Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.

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

D. Vibration Isolation: In addition to vibration isolation devices indicated within the project documents, provide isolators per ASHRAE Handbook – "HVAC Applications", Chapter 48, Table 47 "Selection Guide for Vibration Isolation".

1. Suspended Piping: Install vibration isolation hangers in all mechanical equipment rooms and on all piping within 50 feet of vibrating equipment connections and steam PRV stations.

    a. Three hangers closest to each equipment connection shall be rated for deflection equal to the equipment isolator deflection.
    b. The remaining hangers shall have a deflection of 3/4-inch.
    c. Exceptions: Not required at terminal equipment connections where the equipment is isolated, such as terminal units, blower coil units, fan coil units and heaters.

2. Noise Sensitive Spaces: All piping 2-inches and larger and ductwork within 50-feet of spaces designated as noise sensitive shall have vibration isolation hangers.

3.3. CONTROL AND RESTRAINT DEVICE INSTALLATION

A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork.

B. Installation of vibration isolators must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.

C. Equipment Restraints:

1. Install seismic snubbers on HVAC equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
2. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
3. Install seismic-restraint devices.

D. Piping Restraints:

1. Comply with requirements in MSS SP-127.
2. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.
3. Brace a change of direction longer than 12 feet.

E. Install cables so they do not bend across edges of adjacent equipment or building structure.

F. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.

G. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

H. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

I. Drilled-in Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid pre-stressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
5. Set anchors to manufacturer's recommended torque, using a torque wrench.
6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.4. ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

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

3.5. FIELD QUALITY CONTROL

A. Perform tests and inspections:

1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless post-connection testing has been approved), and with at least seven days' advance notice.
3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
4. Test at least four of each type and size of installed anchors and fasteners selected by

Engineer.

5. Test to 90-percent of rated proof load of device.
6. Measure isolator restraint clearance.
7. Measure isolator deflection.
8. Verify snubber minimum clearances.

B. Remove and replace malfunctioning units and retest as specified above.

C. Prepare test and inspection reports.

3.6. ADJUSTING

A. Adjust isolators after piping system is at operating weight.

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

3.7. VIBRATION ISOLATION EQUIPMENT BASES INSTALLATION

A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork.

END OF SECTION 230548

SECTION 230553 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:

1. Nameplates.
2. Tags.
3. Stencils.
4. Pipe markers.
5. Ceiling tacks.
6. Labels.
7. Lockout devices.

1.02 SUBMITTALS

A. Submittal Procedures: Refer to Division 01 for Submittal procedures.

B. Product Data: Submit manufacturers catalog literature for each product required.

C. Shop Drawings: Submit list of wording, symbols, letter size, and color coding for mechanical identification and valve chart and schedule, including valve tag number, location, function, and valve manufacturer's name and model number.

D. Manufacturer's Installation Instructions: Indicate installation instructions, special procedures, and installation.

E. Manufacturer's Certificate: Certify products meet or exceed specified requirements.

1.03 CLOSEOUT SUBMITTALS

A. Execution and Closeout Requirements: Refer to Division 01 for Closeout procedures.

B. Project Record Documents: Record actual locations of tagged valves; include valve tag numbers.

1.04 QUALITY ASSURANCE

A. Conform to ASME A13.1 for color scheme for identification of piping systems and accessories.

B. Maintain one copy of each document on site.

1.05 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years' experience.

B. Installer: Company specializing in performing Work of this section with minimum three years' experience approved by manufacturer.

1.06 PRE-INSTALLATION MEETINGS

A. Administrative Requirements: Refer to Division 01 for Pre-installation meeting.

1.07 FIELD MEASUREMENTS

A. Verify field measurements prior to fabrication.

1.08 EXTRA MATERIALS

A. Execution and Closeout Requirements: Refer to Division 01 for Spare parts and maintenance products.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers:

1. Craftmark Identification Systems
2. Safety Sign Co.
3. Seton Identification Products
4. Brady Co
5. Thomas Betts Inc.

2.02 NAMEPLATES

A. Product Description: Laminated three-layer plastic with engraved black letters on light contrasting background color.

2.03 TAGS

A. Plastic Tags:

1. Laminated three-layer plastic with engraved black letters on light contrasting background color. Tag size minimum 1-1/2 inches diameter.

B. Metal Tags:

1. Brass Aluminum or Stainless Steel with stamped letters; tag size minimum 1-1/2 inches diameter with finished edges.

C. Information Tags:

1. Clear plastic with printed "Danger," "Caution," or "Warning" and message; size 3- 1/4 x 5-5/8 inches with grommet and self-locking nylon ties.

D. Valve Tag Chart: Typewritten letter size list of applied tags and location in anodized aluminum frame.

2.04 STENCILS

A. Stencils: With clean cut symbols and letters of following size:

1. Up to 2 inches Outside Diameter of Insulation or Pipe: 1/2-inch-high letters.
2. 2-1/2 to 6 inches Outside Diameter of Insulation or Pipe: 1-inch-high letters.
3. Over 6 inches Outside Diameter of Insulation or Pipe: 1-3/4 inches high letters.
4. Ductwork and Equipment: 1-3/4 inches high letters.

B. Stencil Paint: As specified in Section 09 90 00, semi-gloss enamel.

2.05 PIPE MARKERS

A. Plastic Pipe Markers:

1. Factory fabricated, flexible, semi-rigid plastic, preformed to fit around pipe or pipe covering. Larger sizes may have maximum sheet size with spring fastener.

B. Plastic Tape Pipe Markers:

1. Flexible, vinyl film tape with pressure sensitive adhesive backing and printed markings.

C. Plastic Underground Pipe Markers:

1. Bright colored continuously printed plastic ribbon tape, minimum 6 inches wide by 4 mil thick, manufactured for direct burial service.

2.06 CEILING TACKS

A. Description: Steel with 3/4-inch diameter color-coded head.

B. Color code as follows:

1. HVAC equipment: Yellow.
2. Fire dampers/smoke dampers: Red.
3. Heating/cooling valves: Blue.

2.07 LABELS

A. Description: Laminated Mylar, size 1.9 x 0.75 inches, adhesive backed with printed

identification and bar code.

2.08 LOCKOUT DEVICES

A. Lockout Hasps:

1. Anodized aluminum hasp with erasable label surface; size minimum 7-1/4 x 3 inches.

B. Valve Lockout Devices:

1. Steel device preventing access to valve operator, accepting lock shackle.

PART 3 EXECUTION

3.01 PREPARATION

A. Degrease and clean surfaces to receive adhesive for identification materials.

B. Prepare surfaces in accordance with Section 09 91 23 for stencil painting.

3.02 INSTALLATION

A. Apply stencil painting in accordance with Section 09 91 23.

B. Install identifying devices after completion of coverings and painting.

C. Install plastic nameplates with corrosive-resistant mechanical fasteners, or adhesive.

D. Install labels with sufficient adhesive for permanent adhesion and seal with clear lacquer. For unfinished canvas covering, apply paint primer before applying labels.

E. Install tags using corrosion resistant chain. Number tags consecutively by location.

F. Install underground plastic pipe markers 6 to 8 inches below finished grade, directly above buried pipe.

G. Identify air handling units, pumps, heat transfer equipment, tanks, and water treatment devices with plastic nameplates. Identify in-line pumps and other small devices with tags.

H. Identify control panels and major control components outside panels with plastic nameplates.

I. Identify valves in main and branch piping with tags.

J. Identify air terminal units with numbered tags.

K. Tag automatic controls, instruments, and relays. Key to control schematic.

L. Identify piping, concealed or exposed, with stenciled painting. Use tags on piping 3/4-inch diameter and smaller. Identify service, flow direction, and pressure. Install in clear view and align with axis of piping. Locate identification not to exceed 20 feet on straight runs including risers and drops, adjacent to each valve and tee, at each side of penetration of structure or enclosure, and at each obstruction.

M. Identify ductwork with plastic nameplates. Identify supply air, return air, exhaust air, and flow direction. Identify with air handling unit identification number and area served. Locate identification at air handling unit, at each side of penetration of structure or enclosure, and at each obstruction.

N. Provide ceiling tacks to locate valves or dampers above T-bar type panel ceilings. Locate in corner of panel closest to equipment.

3.03 Piping Label Color Schedule Naming Convention

A. Paint/Jacket Color all piping completely, concealed and exposed, with two coats (If Painted to a uniform finish. Use the hospital standard color system as follows:

1. Refrigerant Piping

    a. Background Color: Yellow
    b. Letter Color: Black

2. Condensate Drain
    a. Background Color: Yellow
    b. Letter Color: Black

END OF SECTION 230553

SECTION 230593 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:

1. Testing, adjusting, and balancing of air systems.
2. Testing, adjusting, and balancing of hydronic systems.
3. Measurement of final operating condition of HVAC systems.

1.02 SUBMITTALS

A. Submittal Procedures: Refer to Division 01 for Submittal procedures.

B. Prior to commencing Work, submit proof of latest calibration date of each instrument.

C. Test Reports: Indicate data on AABC or NEBB forms.

D. Field Reports: Indicate deficiencies preventing proper testing, adjusting, and balancing of systems and equipment to achieve specified performance.

E. Prior to commencing Work, submit report forms or outlines indicating adjusting, balancing, and equipment data required. Include detailed procedures, agenda, sample report forms and copy of AABC National Project Performance Guaranty or Copy of NEBB Certificate of Conformance Certification.

F. Submit draft copies of report for review prior to final acceptance of Project.

G. Furnish reports in soft cover, letter size, 3-ring binder manuals, complete with table of contents page and indexing tabs, with cover identification at front and side. Include set of reduced drawings with air outlets and equipment identified to correspond with data sheets, and indicating thermostat locations.

1.03 CLOSEOUT SUBMITTALS

A. Execution and Closeout Requirements: Refer to Division 01 for Closeout procedures.

B. Project Record Documents: Record actual locations of flow measuring stations.

C. Operation and Maintenance Data: Furnish final copy of testing, adjusting, and balancing report inclusion in operating and maintenance manuals.

1.04 QUALITY ASSURANCE

A. Maintain one copy of each document on site.

B. Prior to commencing Work, calibrate each instrument to be used. Upon completing Work, recalibrate each instrument to assure reliability.

1.05 QUALIFICATIONS

A. Agency: Company specializing in testing, adjusting, and balancing of systems specified in this section with minimum five years documented experience certified by AABC or NEBB.

B. Perform Work under supervision of AABC Certified Test and Balance Engineer or NEBB Certified Testing, Balancing and Adjusting Supervisor.

1.06 PRE-INSTALLATION MEETINGS

A. Administrative Requirements: Refer to Division 01 for Pre-installation meeting.

B. Convene minimum one week prior to commencing work of this section.

1.07 SEQUENCING

A. Summary: Refer to Division 01 for Work sequence.

B. Sequence balancing between completion of systems tested and Date of Substantial Completion.

1.08 SCHEDULING

A. Administrative Requirements: Refer to Division 01 for Coordination and project conditions.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.01 EXAMINATION

A. Administrative Requirements: Refer to Division 01 for Coordination and project conditions.

B. Verify systems are complete and operable before commencing work. Verify the following:

1. Systems are started and operating in safe and normal condition.

2. Temperature control systems are installed complete and operable.
3. Duct systems are clean of debris.
4. Fire and volume dampers are in place and open.
5. Air coil fins are cleaned and combed.
6. Access doors are closed and duct end caps are in place.
7. Air outlets are installed and connected.
8. Duct system leakage is minimized.
9. Hydronic systems are flushed, filled, and vented.
10. Proper strainer baskets are clean and in place or in normal position.
11. Service and balancing valves are open.

3.02 PREPARATION

A. Furnish instruments required for testing, adjusting, and balancing operations.

B. Make instruments available to Architect/Engineer to facilitate spot checks during testing.

3.03 INSTALLATION TOLERANCES

A. Air inlets and outlets for air change requirements for all operating, procedure, treatment, exam and other patient areas:

1. Positive pressure room: Adjust supply inlets in space to within plus 0 to plus 10 percent (+0 to10%) and outlets to minus 0 to minus 10 (-0 to 10%) percent of design.
2. Negative pressure room: Adjust supply inlets in space to within minus 0 to minus 10 percent (-0 to10%) and outlets to plus 0 to plus 10 (+0 to 10%) percent of design
3. Neutral pressure room: Adjust supply inlets and outlets in space to within plus or minus 10 percent of design, but as close to equal airflow as possible, within 5% of each other.

B. Other Air Outlets and Inlets in general and public areas: Adjust outlets and inlets in space to within plus or minus 10 percent of design.

C. Hydronic Systems: Adjust to within plus or minus 10 percent of design.

3.04 ADJUSTING

A. Execution and Closeout Requirements: Refer to Division 01 for Testing, adjusting, and balancing.

B. Verify recorded data represents actual measured or observed conditions.

C. Permanently mark settings of valves, dampers, and other adjustment devices allowing settings to be restored. Set and lock memory stops.

D. After adjustment, take measurements to verify balance has not been disrupted. If

disrupted, verify correcting adjustments have been made.

E. Report defects and deficiencies noted during performance of services, preventing system balance.

F. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.

G. At final inspection, recheck random selections of data recorded in report. Recheck points or areas as selected and witnessed by Owner.

H. Check and adjust systems approximately six months after final acceptance and submit report.

3.05 AIR SYSTEM PROCEDURE

A. Adjust air handling and distribution systems to obtain required or design supply, return, and exhaust air quantities at site altitude.

B. Make air quantity measurements in main ducts by Pitot tube traverse of entire cross-sectional area of duct.

C. Measure air quantities at air inlets and outlets.

D. Adjust distribution system to obtain uniform space temperatures free from objectionable drafts.

E. Use volume control devices to regulate air quantities only to extent adjustments do not create objectionable air motion or sound levels. Effect volume control by using volume dampers located in ducts.

F. Vary total system air quantities by adjustment of fan speeds. Provide sheave drive changes to vary fan speed. Vary branch air quantities by damper regulation.

G. Provide system schematic with required and actual air quantities recorded at each outlet or inlet.

H. Measure static air pressure conditions on air supply units, including filter and coil pressure drops, and total pressure across fan. Make allowances for 50 percent loading of filters.

I. Adjust outside air automatic dampers, outside air, return air, and exhaust dampers for design conditions.

J. Measure temperature conditions across outside air, return air, and exhaust dampers to check leakage.

K. At modulating damper locations, take measurements and balance at extreme conditions. Balance variable volume systems at maximum airflow rate, full cooling, and at minimum airflow rate, full heating.

L. Measure building static pressure and adjust supply, return, and exhaust air systems to obtain required relationship between each to maintain approximately 0.05 inches positive static pressure near building entries.

3.06 WATER SYSTEM PROCEDURE

A. Adjust water systems, after air balancing, to obtain design quantities.

B. Use calibrated Venturi tubes, orifices, or other metered fittings and pressure gauges to determine flow rates for system balance. Where flow-metering devices are not installed, base flow balance on temperature difference across various heat transfer elements in system.

C. Adjust systems to obtain specified pressure drops and flows through heat transfer elements prior to thermal testing. Perform balancing by measurement of temperature differential in conjunction with air balancing.

D. Effect system balance with automatic control valves fully open or in normal position to heat transfer elements.

E. Effect adjustment of water distribution systems by means of balancing cocks, valves, and fittings. Do not use service or shut-off valves for balancing unless indexed for balance point.

F. Where available pump capacity is less than total flow requirements or individual system parts, simulate full flow in one part by temporary restriction of flow to other parts.

3.07 SCHEDULES

1.1 FINAL REPORT

A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.

1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
2. Include a list of instruments used for procedures, along with proof of calibration.
3. Certify validity and accuracy of field data.

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 data:

1. Title page.
2. Name and address of the TAB specialist.
3. Project name.
4. Project location.
5. Architect's name and address.
6. Engineer's name and address.
7. Contractor's name and address.
8. Report date.
9. Signature of TAB supervisor who certifies the report.
10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
11. Summary of contents including the following:

    a. Indicated versus final performance.
    b. Notable characteristics of systems.
    c. Description of system operation sequence if it varies from the Contract Documents.

12. Nomenclature sheets for each item of equipment.
13. Data for terminal units, including manufacturer's name, type, size, and fittings.
14. Notes to explain why certain final data in the body of reports vary from indicated values.
15. Test conditions for fans and pump performance forms including the following:

    a. Settings for outdoor-, return-, and exhaust-air dampers.
    b. Conditions of filters.
    c. Cooling coil, wet- and dry-bulb conditions.
    d. Face and bypass damper settings at coils.
    e. Fan drive settings including settings and percentage of maximum pitch diameter.
    f. Inlet vane settings for variable-air-volume systems.
    g. Settings for supply-air, static-pressure controller.
    h. Other system operating conditions that affect performance.

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 airflow rate in cfm.
b. Total system static pressure in inches wg.
c. Fan rpm.
d. Discharge static pressure in inches wg.
e. Filter static-pressure differential in inches wg.
f. Preheat-coil static-pressure differential in inches wg.
g. Cooling-coil static-pressure differential in inches wg.
h. Heating-coil static-pressure differential in inches wg.
i. Outdoor airflow in cfm.
j. Return airflow in cfm.
k. Outdoor-air damper position.
l. Return-air damper position.
m. Vortex 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. Airflow rate in cfm.
    b. Average face velocity in fpm.
    c. Air pressure drop in inches wg.
    d. Outdoor-air, wet- and dry-bulb temperatures in deg F.
    e. Return-air, wet- and dry-bulb temperatures in deg F.
    f. Entering-air, wet- and dry-bulb temperatures in deg F.
    g. Leaving-air, wet- and dry-bulb temperatures in deg F.
    h. Water flow rate in gpm.
    i. Water pressure differential in feet of head or psig.
    j. Entering-water temperature in deg F.
    k. Leaving-water temperature in deg F.
    l. Refrigerant expansion valve and refrigerant types.
    m. Refrigerant suction pressure in psig.
    n. Refrigerant suction temperature in deg F.
    o. Inlet steam pressure in psig.

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 wg.
    c. Fan rpm.
    d. Discharge static pressure in inches wg.
    e. Suction static pressure in inches wg.

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

1. Report Data:

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

I. Air-Terminal-Device Reports:

1. Unit Data:

a. System and air-handling unit identification.
b. Location and zone.
c. Apparatus used for test.
d. Area served.
e. Make.
f. Number from system diagram.

END OF SECTION 230593

SECTION 230700 - HVAC INSULATION

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:

1. Equipment insulation.
2. Equipment insulation jackets.
3. Insulation accessories including vapor retarders and accessories.
4. Ductwork insulation.
5. Ductwork insulation jackets.

1.02 SUBMITTALS

A. Submittal Procedures: Refer to Division 01 for Submittal procedures.

B. Product Data: Submit product description, thermal characteristics and list of materials and thickness for each service, and location.

C. Manufacturer's Installation Instructions: Submit manufacturers published literature indicating proper installation procedures.

D. Manufacturer's Certificate: Certify products meet or exceed specified requirements.

1.03 QUALITY ASSURANCE

A. Maintain one copy of each document on site.

1.04 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years' documented experience.

B. Applicator: Company specializing in performing Work of this section with minimum three years documented experience approved by manufacturer.

1.05 PRE-INSTALLATION MEETINGS

A. Administrative Requirements: Refer to Division 01 Pre-installation meeting.

B. Convene minimum one week prior to commencing work of this section.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Product Requirements: Refer to Division 01 Requirements for transporting, handling, storaging, and protecting products.

B. Accept materials on site in original factory packaging, labeled with manufacturer's identification, including product density and thickness.

C. Protect insulation from weather and construction traffic, dirt, water, chemical, and damage, by storing in original wrapping.

1.07 ENVIRONMENTAL REQUIREMENTS

A. Product Requirements: Refer to Division 01 Environmental conditions affecting products on site.

B. Install insulation only when ambient temperature and humidity conditions are within range recommended by manufacturer.

C. Maintain temperature during and after installation for minimum period of 24 hours.

1.08 FIELD MEASUREMENTS

A. Verify field measurements prior to fabrication.

1.09 WARRANTY

A. Execution and Closeout Requirements: Refer to Division 01 Product warranties and product bonds.

PART 2 PRODUCTS

2.01 FIBERGLASS DUCT INSULATION

A. Insulation: ASTM C1290; Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications.

1. Operating Temperatures: 250 degrees F.
2. Density: 0.75 lb/cu ft.
3. ‘K’ factor: ASTM C518, 0.27 at 75 degrees F.

B. Vapor Retarder Jacket: ASTM 1136, Type II Flexible and Low Permeance Vapor Retarders for Thermal Insulation.

1. For systems operating at temperatures below ambient, close and secure seams and joints. When outward clinching staples are used, seal

penetrations.

C. Vapor Retarder Lap Adhesive:

1. Compatible with insulation.

D. Insulating Cement/Mastic:

1. ASTM C195; hydraulic setting on mineral wool.

2.02 POLYISOCYNAURATE BOARD: Unfaced, preformed, rigid cellular polyisocyanurate material intended for use as thermal insulation.

A. Johns Manville – Xspect Isofoam APF Board

B. Comply with ASTM C 518, except thermal conductivity (k-value) shall not exceed 0.16 Btu x in./h x sq. ft. x deg F at 75 deg F after 180 days of aging.

C. Flame-spread index shall be 25 or less, and smoke-developed index shall be 50 or less for thickness up to 1 inch as tested by ASTM E 84.

D. Factory-Applied Jacket: Requirements are specified in "Factory-Applied Jackets" Article.

2.03 FIBERGLASS BOARD INSULATION

A. Insulation: ASTM C612 or ASTM C592; rigid, noncombustible.

1. ‘K’ factor: ASTM C177 or ASTM C518, 0.24 at 75 degrees F.
2. Maximum Service Temperature: 450 degrees F.
3. Maximum Moisture Absorption: 0.1 percent by volume.
4. Density: 3.0 lb/cu ft.

B. Vapor Retarder Jacket: ASTM C1136 Flexible, Low Permeance Vapor Retarders for Thermal Insulation, Type II.

C. Facing: 1 inch galvanized steel hexagonal wire mesh stitched on one face of insulation.

D. Vapor Retarder Lap Adhesive:

1. Compatible with insulation.

E. Insulating Cement/Mastic:

1. ASTM C195; hydraulic setting on mineral wool.

2.04 FACTORY APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following.

1. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II

2.05 EXTERIOR FIELD APPLIED DUCT JACKET

A. Polyguard – Alumaguard

1. Self-Adhesive Outdoor Jacket: 60-mil- thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a crosslaminated polyethylene film covered with white aluminum-foil facing

PART 3 EXECUTION

3.01 EXAMINATION

A. Administrative Requirements: Refer to Division 01 Coordination and project conditions.

B. Verify equipment and ductwork has been tested before applying insulation materials.

C. Verify surfaces are clean and dry, with foreign material removed.

3.02 INSTALLATION

A. Factory Insulated Equipment: Do not insulate.

B. Exposed Equipment: Locate insulation and cover seams in least visible locations.

C. Apply insulation close to equipment by grooving, scoring, and beveling insulation. Fasten insulation to equipment with studs, pins, clips, adhesive, wires, or bands.

D. Fill joints, cracks, seams, and depressions with bedding compound to form smooth surface. On cold equipment, use vapor retarder cement.

E. Mineral fiber insulated equipment containing fluids below ambient temperature: Provide vapor retarder jackets, factory-applied or field-applied. Finish with glass-cloth and vapor barrier adhesive.

F. Mineral fiber insulated equipment containing fluids above ambient temperature: Provide standard jackets, with or without vapor retarder, factory-applied or field-applied. Finish with glass cloth and adhesive.

G. Finish insulation at supports, protrusions, and interruptions.

H. Equipment in Mechanical Equipment Rooms or Finished Spaces: Finish with canvas jacket sized for finish painting.

I. Nameplates and ASME Stamps: Bevel and seal insulation around; do not insulate over.

J. Equipment Requiring Access for Maintenance, Repair, or Cleaning: Install insulation for easy removal and replacement without damage.

K. Insulated ductwork conveying air below ambient temperature:

1. Provide insulation with vapor retarder jackets.
2. Finish with tape and vapor retarder jacket.
3. Continue insulation through walls, sleeves, hangers, and other duct penetrations.
4. Insulate entire system including fittings, joints, flanges, fire dampers, flexible connections, and expansion joints.

L. Insulated ductwork conveying air above ambient temperature:

1. Provide with or without standard vapor retarder jacket.
2. Insulate fittings and joints. Where service access is required, bevel and seal ends of insulation.

M. Ductwork Exposed in Mechanical Equipment Rooms or Finished Spaces: Finish with canvas jacket sized for finish painting.

3.03 SCHEDULES

A. See table on following pages.

Mechanical Insulation Schedule				
Service or Services	**Location**	**Insulation Type**	**Duct Size**	**Insulation Thickness**
Supply Ductwork	Concealed, Indoors	Fiberglass, flexible (ductwrap)	All Sizes	2"
	Exposed, Indoors	Fiberglass Board	All Sizes	2"
	Mech. Equipment Rooms	Fiberglass Board	All Sizes	2"

Mechanical Insulation Schedule				
Service or Services	**Location**	**Insulation Type**	**Duct Size**	**Insulation Thickness**
Return Ductwork	Concealed, Indoors below roof and in shafts	Fiberglass Flexible (Ductwrap)	All Sizes	2”
	Exposed, Non-Conditioned Space, Indoors	Fiberglass Flexible (Ductwrap)	All Sizes	2"
	Exposed in a Conditioned Space, Indoors	None	All Sizes	N/A
	Mechanical Rooms	Fiberglass Board	All Sizes	2"
Outside Air	Concealed Indoors	Mineral Fiber flexible (Ductwrap)	All Sizes	2"
	Exposed, Indoors	Fiberglass Board	All Sizes	2"
	Mechanical Equipment Rooms	Fiberglass Board	All Sizes	2"
Exterior Supply/Return Ductwork	**Outdoors**	**Polyisocyanurate Board (Alumaguard) -Slope boards for top surface to allow water to naturally run off duct.**	**All Sizes**	**2” (R-13 Minimum)**

SECTION 230719 - HVAC PIPING INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes insulating the following HVAC piping systems:

1. Condensate drain piping, indoors and outdoors.
2. Refrigerant suction and hot-gas piping, indoors and outdoors.

1.2 SUBMITTALS

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

B. Qualification Data: For qualified Installer.

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

D. Field quality-control reports.

1.3 QUALITY ASSURANCE

A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to 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 agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.4 DELIVERY, STORAGE, AND HANDLING

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

1.5 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."

B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," and "Outdoor, Aboveground Piping Insulation Schedule," articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials.

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

   a. Aeroflex USA, Inc.; Aerocel.
   b. Armacell LLC; AP Armaflex.
   c. K-Flex USA; Insul-Lock, Insul-Tube, and K-FLEX LS.

2.2 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

B. Flexible Elastomeric Adhesive: Comply with MIL-A-24179A, Type II, Class I.

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

   a. Aeroflex USA, Inc.; Aeroseal.
   b. Armacell LLC; Armaflex 520 Adhesive.
   c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-75.
   d. K-Flex USA; R-373 Contact Adhesive.

2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

3. Use adhesive that complies with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers," including 2004 Addenda.

2.3 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.

1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below-ambient services.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-80/30-90.
b. Vimasco Corporation; 749.

2. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm at 43-mil dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F.
4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
5. Color: White.

C. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below-ambient services.

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

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Encacel.
b. Eagle Bridges - Marathon Industries; 570.
c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 60-95/60-96.

2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 30-mil dry film thickness.
3. Service Temperature Range: Minus 50 to plus 220 deg F.
4. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
5. Color: White.

2.4 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C, Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.

1. For indoor applications, use lagging adhesives that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

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

   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-50 AHV2.
   b. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-36.
   c. Vimasco Corporation; 713 and 714.

3. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over pipe insulation.
4. Service Temperature Range: 0 to plus 180 deg F.
5. Color: White.

2.5 SEALANTS

A. Joint Sealants:

1. Joint Sealants for Cellular-Glass, Products: Subject to compliance with requirements, provide one of the following:

   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
   b. Eagle Bridges - Marathon Industries; 405.
   c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-45.
   d. Mon-Eco Industries, Inc.; 44-05.
   e. Pittsburgh Corning Corporation; Pittseal 444.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.

1. Verify that systems to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.
3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Surface Preparation: Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:

1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils thick and an epoxy finish 5 mils thick if operating in a temperature range between 140 and 300 deg F. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
2. Carbon Steel: Coat carbon steel operating at a service temperature between 32 and 300 deg F with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

C. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

D. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping including fittings, valves, and specialties.

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

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

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

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

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

G. Keep insulation materials dry during application and finishing.

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

I. Install insulation with least number of joints practical.

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

1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.

4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

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

L. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.

    a. For below-ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.

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

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

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

P. For above-ambient services, do not install insulation to the following:

1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.
4. Manholes.
5. Handholes.
6. Cleanouts.

3.4 PENETRATIONS

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

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation,

install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.

3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
4. Seal jacket to wall flashing with flashing sealant.

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

C. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.

3.5 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:

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

above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.

8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
9. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

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

D. Install removable insulation covers at locations indicated. Installation shall conform to the following:

1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.
4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.6 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:

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

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:

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

3.7 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, two locations of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.

C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.8 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.

3.9 INDOOR PIPING INSULATION SCHEDULE

A. Condensate and Equipment Drain Water, below 60 Deg F:

1. All Pipe Sizes: Insulation shall be the following:

a. Flexible Elastomeric: 3/4 inch thick.

B. Refrigerant Suction and Hot-Gas Piping:

1. All Pipe Sizes: Insulation shall be the following:

a. Flexible Elastomeric: 1 ½ inch thick.

3.10 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

A. Condensate and Equipment Drain Water, below 60 Deg F:

1. All Pipe Sizes: Insulation shall be the following:

a. Flexible Elastomeric: 3/4 inch thick.

B. Refrigerant Suction and Hot-Gas Piping:

1. All Pipe Sizes: Insulation shall be the following:

a. Flexible Elastomeric: 2 inches thick.

3.11 INDOOR, FIELD APPLIED JACKET SCHEDULE

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

B. Piping, Exposed:
1. PVC: 20 mils thick

3.12 OUTDOOR, FIELD APPLIED JACKET SCHEDULE

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

B. Piping, Exposed:
1. Aluminum, Smooth with Z-Shaped Locking Seam : 0.040 inch thick

END OF SECTION 230719

SECTION 230911 – BUILDING CONTROL SYSTEM INTEGRATION

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 GENERAL

A. Work of this section is affected by Owner Preferred-Brand Alternate M1. Refer to section 01 23 00 – Alternates.

1.3 RELATED WORK

A. Division 01 Section Commissioning

1. The owner has hired an independent Cx Authority to commission the MEP systems serving this facility and the controls contractor shall be responsible for demonstrating (via performance verification) to the CxA that the controls point-to-point checkout has been completed, that the BAS controls have been properly furnished and installed, and that the sequences of operation (SOO) operate in accordance with the project documents. The requirements of the commissioning process and all related commissioning support and the duties of all members of the Cx Team are further detailed and explained in Division 1. The controls contractor shall become familiar with the requirements and coordination obligations of this specification, as well as this section, the Cx Plan and the project Cx Schedule issued by the CxA, so that they will be knowledgeable of all tasks, and prepared to carry out, all Cx Process support requirements that apply to the BAS controls.

B. Project Alternates

1. If an Alternate is not accepted as part of the contact, this contractor shall provide control system hardware to allow for the installation of the Alternates in the future without any additional hardware outside of the Alternate areas of work.

1.4 DEFINITIONS

A. The following abbreviations, acronyms, and definitions are used in addition to those details found elsewhere in Contract Documents.

1. Actuator: Control device to provide motion of valve or damper in response to control signal.
2. ADJ. Adjustable
3. AI: Analog Input
4. AO: Analog Output

5.	Analog:	Continuously variable state over stated range of values
6.	Auto-Tune:	Software routine used to adjust tuning parameters based on historical data.
7.	BAS:	Building Automation System
8.	DDC:	Direct Digital Control
9.	DDCP:	Direct Digital Control Panel
10.	Discrete:	Binary or digital state
11.	DI:	Discrete Input
12.	DO:	Discrete Output
13.	EMCS:	Energy Management and Control System (Same as BAS)
14.	FA:	Field Adjustable
15.	FC:	Fail Closed position of control device or actuator. Device moves to closed position on loss of control signal or energy source.
16.	FMS:	Facility Management System linking two or more BAS
17.	FO:	Fail Open position of control device or actuator. Device moves to open position on loss of control signal or energy source.
18.	Instrument:	Device used for sensing input parameters or used for actuation
19.	Modulating:	Movement of a control device through an entire range of values proportional to an infinitely variable input value.
20.	Motorized:	Control device with actuator.
21.	NC:	Normally Closed position of switch after control signal is removed or normally closed position of manually operated valves or dampers.
22.	NO:	Normally Open position of switch after control signal is removed or normally open position of manually operated valves or dampers.
23.	Node:	DDCP, user workstation, or other control device connected to Communications Network.
24.	Operator:	Same as actuator.
25.	PC:	Personal Computer
26.	PLC:	Programmable Logic Controller
27.	Peer-to-Peer:	Mode of communication between controllers in which each device connected to network has equal status and each shares its database values with all other devices connected to network.
28.	P:	Proportional control, control mode with continuous linear relationship between observed input signal and final controlled output element.
29.	PI:	Proportional - Integral control, control mode with continuous proportional output plus additional change in output based on both mount and duration of change in controlled variable (Reset control).
30.	PID:	Proportional - Integral - Derivative control, control mode with continuous correction of final controlled output element versus input signal based on proportional error, its time history (reset), and rate at which its changing (derivative).
31.	Point:	Analog or discrete instrument with addressable database value.
32.	Self-Tune:	Same as Auto-Tune
33.	Solenoid:	Electric two position actuator.
34.	TCC:	Temperature Control Contractor (Same as Control Contractor)
35.	TCP:	Temperature Control Panel

1.5 ACCEPTABLE CONTROL CONTRACTORS

A. Control Contractor shall have full-service office within 100 miles of project site. Full-service office is defined to be a home office of applications engineers, supervisors and field technicians having all required test and diagnostic equipment.

B. Control Contractors shall be factory authorized agent or dealer of controllers and control hardware as manufactured by:

1. Trane Tracer.
2. Johnson Controls, Inc.
3. Siemens.

1.6 SYSTEMS DESCRIPTION

A. The control system shall be fully integrated, UL listed direct digital control (DDC).

B. Space thermostat controls and terminal box controls shall be DDC.

C. Valve and damper actuators shall be 24 VAC electronic type.

D. Provide modular designed stand-alone web-based control system capable of future expansion with peer-to-peer communication networks and Ethernet connectivity using TCP/IP technology. All energy use information (kw, BTUs, etc) shall be available by Modbus over IP protocol to the Enterprise Control System. Provide architecture consisting of communication network, modular designed controllers with all points addressable and modifiable from existing user workstations or from master control system user interface panels. The controls system shall be fully expandable with addition of hardware and/or software. Expansion shall not require removal of existing control system, sensors, actuators, or communication networks.

E. System shall support user workstations as specified and shall be capable of additional workstations, limited only by systems maximum node capacity.

F. System intelligence shall be such that user workstation(s) can be used for programming controls, performing analysis on filed data, generating maintenance and operation reports and providing permanent storage for programs and data.

G. Safety devices shall function in both auto and hand modes on starter.

H. Safety devices shall function in both VFD and bypass modes.

I. Dampers interlocked with fans shall operate in both VFD and bypass starter modes to prevent dead-head of fans.

J. Provide uninterruptible power supply (UPS) for the main building DDCP so not to lose building communication with web-interface. Coordinate with Electrical Contractor power to all BAS components as power should be from 120 V panel (provided by EC).

1.7 SCOPE OF WORK

A. Provide all labor and materials for complete fully functioning control systems in accordance with Contract Documents.

B. Provide all labor and materials to complete the following work:

1. Provide all new BacNet based DDC control panels. All panels shall be wall mounted and not located in ceiling.

C. Engineering services shall be performed by factory trained engineers. System shall be installed by trained mechanics either in direct employment of Control Contractor or by subcontractors who are under direct supervision of Control Contractor's representative and who have at least 10 years of experience for both installation and maintenance of units required for this project. Engineer reserves the right to exclude any project managers; engineers field supervisors, or technicians whose past experience is not sufficient to meet the needs of this project.

D. Control contractor’s project managers, engineers and digital system programmers shall have previously performed in capacity that qualifies them to successfully engineer system of scope and magnitude similar to this project.

E. Labor shall include, but is not limited to:

1. Engineering services to size all unscheduled valves and dampers based on criteria specified in section 230912 – Control Valves and Dampers and confirm sizing of scheduled valves and dampers.
2. Engineering services to produce all submittals requested and working construction drawings and record drawings as specified here within.
3. Engineering services for all software programming required.
4. Engineering services for all graphics programming specified.
5. Project management services as single point contact to coordinate all construction related activities.
6. Field mechanics for installation of control devices.
7. Field mechanics for installation of control wiring and related control devices.
8. Field technicians to startup, calibrate, adjust, and tune all control loops.
9. Field technicians to perform system checkout, testing, and complete required reports.
10. Field supervisor during controls installation and startup and commissioning of systems as specified elsewhere.
11. Field technicians to assist Testing and Balancing Contractor in adjusting controls and determining setpoints related to his scope of work.
12. Field representatives and/or classroom instructors to provide Owner training as specified.

F. Control contractor shall be responsible for complete installation of all control devices (except as noted) and wiring at control panel locations to accomplish control sequences specified in this project manual or on drawings. Control Contractor is also responsible for any additional instrumentation described in any point schedules found in these Contract Documents, which may not be directly related to any specified control sequences. Control Contractor is required to provide power for air terminal controllers and other field mounted devices that require 24VAC, 60 hertz, and shall be powered from 120 to 24VAC transformer panels provided by Control Contractor. Control circuits serving equipment noted to be on emergency power shall be fed from the emergency generator.

G. Mechanical Contractor will provide all wells, taps, and other mechanical interfaces required for control equipment mounting into piping systems. Mechanical Contractor will install all in-line mounted devices, such as valves, dampers, flow meters, etc., furnished by Control Contractor. Control Contractor is responsible for installation of all other control devices, such as actuators, linkages, sensors, remote mounted control devices, control panels, control transformers etc.

H. Electrical work required as integral part of work is responsibility of Control Contractor. Provide final power connections including conduit, wire, and/or disconnect switches to all control devices and panels from appropriate electrical distribution panels. Contractor will provide circuit breakers, within panels which are designated for use by Control Contractor. Control Contractor shall be responsible for wiring from panel to DDCFP and control devices including any step-down transformers required for low voltage systems.

I. Mount control transformer panels adjacent to DDCP panels and powered from dedicated electrical circuits fed from emergency generator.

J. Materials shall be as specified. Provide components not specifically indicated or specified, but necessary to make system function within the intent of specification.

K. Electrical products shall be listed and labeled by UL and comply with NEMA Standards. Refer to Division 26.

L. Provide weather protection cover or weatherproof control devices where required for control devices located outdoors.

1.8 DESIGN/CONSTRUCTION COORDINATION MEETING

A. Prior to Control System drawing submittals being sent to the design team for review, a meeting shall occur to review the contract documents. The intent of this meeting is to address the following items:

1. Review sequences of operations.
2. Address questions by the Controls Contractor.
3. Review locations DDC control panels.
4. Review screen/interface graphic components (visual, static, interactive).
5. Identify alarm functions of all system components.
6. Identify points Owner requires from Third Party equipment interfaces.
7. Review powering up and powering down of all system components.
8. Review historical logging and pre-set logging functions
9. Review remote access and security functions

B. This meeting shall be led by the Controls Contractor and shall be attended by the Owner, Engineer, Contractor, Mechanical Contractor, and Commissioning Agent. Meeting duration shall be 8 hours.

C. Contractor shall notify all parties (4) four weeks in advance of meeting date and time.

D. Contractor shall (3) weeks prior to the meeting send out all applicable logic and functional drawings for the project. These documents are not intended to be shop drawing quality but are intended to clearly identify the building system controls, alarms and graphics and to facilitate

the meeting discussions. If in the design teams opinion, the documents submitted are not fully developed, the meeting shall be postponed and the controls contractor shall re-schedule the meeting and re-submit noted documents.

1.9 ACTION SUBMITTALS

A. Shop Drawings:

1. Manufacturer's printed product data sheets for control devices and materials listed in bill of material in control drawings. Organize sheets in order of model number, alphabetically, then numerically. If more than 20 product data sheets are submitted, provide front index and tabs for logical groups of devices. Data sheets must include sufficient technical data to describe instrument parameters required as specified in Division 23 – Controls Instrumentation. Identify setpoint or adjustable control range for each control device.
2. Data concerning type of signal wiring and installation methods including raceway types and grounding methods.
3. Control drawings including, but not limited to, the following:

    a. Front sheet index for projects with more than 10 control drawing sheets.
    b. Overall system/network architecture drawings: Provide block diagram showing relationship of each controller, control panel, or other network devices relative to each other. Label room location of each device. Number and indicate model number of each device. Indicate network types.
    c. Control Drawings: Including graphic representation of systems with all major inline components to properly locate all control devices. Identify controlled devices with their software designation on drawings, including unique valve and damper tag numbers.
    d. Detailed wiring and piping diagrams showing point to point hookup details of all transducers, relays, outputs, inputs and subsystem components. Label all control wires with field ID numbers/colors. Differentiate between manufacturer installed and field installed wiring. Provide trunk cable schematic showing programmable control unit locations and trunk data conductors.
    e. Bill of material identifying actual product model number used for each control device for each schematic control drawing.
    f. System graphics indicating monitored systems, data (connected and calculated) point addresses and operator notations.
    g. Sequence of operation: Verbally describe each control sequence indicating method of control. Identify sensors, controllers, and actuators used with references to tag number of controlled device. Include setpoints of each control loop.
    h. Panel layout drawings including front panel display for firemen’s override panel.

4. Graphical User Interface (GUI) pages for the controls display along with in-person meeting for live review active graphic interface. Include M&V graphics summary pages noted in this specification.
5. Plan for normalizing data to common time stamp value and filling in missing data values.
6. Include time for submittal review meeting with owner to review BAS set up and sequences.

1.10 INFORMATION SUBMITTALS

A. Qualifications:

1. Qualification of Project Managers, Engineers, Programmers, Field Supervisors, and Technicians to be assigned to this project within 30 days after contract award. Use qualification form attached at end of this section.

B. Completion Checklist:

1. Submit with shop drawings a detailed completion checklist including written procedures for adjusting and calibrating each type of instrument and sensor. Engineer reserves the right to request modifications to any procedure, which is incomplete or not adequate to prove system performance.
2. Checklist shall include references to the following additional requirements:

    a. Instruments and sensors shall be calibrated by comparison to known device, which is traceable to National Institute of Standards and Testing. Calibration certificates for instrumentation from the manufacturer will be accepted as proof of calibration.
    b. Check each point for calibration, connection to correct control loop, and that limit and alarm values are properly set.
    c. Transducers and other output devices shall be properly zeroed and calibrated at both minimum and maximum output. Document settings for discrete instruments and setpoints for analog instruments shall include minimum and maximum positions for safe operating conditions where applicable (max. pump speed or max. frequency of fan drive, etc.).
    d. Tune control loops to maintain controlled process variable at setpoint through seasonal conditions without operator intervention. Provide multiple sets of tuning parameters if necessary. Controller shall automatically use tuning parameters appropriately to existing ambient conditions. Maintain record, on completion checklist, of control loops that require tuning at alternate time of year. Instruct technicians to supply default parameters that can approximate stable control until actual load conditions allow proper tuning of control loops.
    e. Performance tests of all analog control loops shall be performed by changing setpoint and verify that sequence can come into stable equilibrium within reasonable time period which is appropriate for that sequence. Simulate load changes for all pressure and flow control loops.
    f. Performance tests of discrete control loops shall be performed by adjusting setpoint and verifying sequence action.
    g. All alarms, including network failures, shall be tested for each controller and device connected to network, and ensure that alarms are properly acknowledged at operator's workstation.

1.11 CLOSEOUT SUBMITTALS

A. Operating and Maintenance Manuals:

1. Operating and maintenance manuals shall provide descriptions of maintenance on all system components, including sensors and controlled devices. These shall include:
2. Periodic preventative maintenance.

3. Troubleshooting guide.
4. Repair parts list.
5. Calibration instructions.
6. Control Contractor's completion checklist.
7. Manufacturer representative's name, address, and phone number.

B. Record Drawings:

1. Submit revised shop drawings indicating all changes made during project including any changes to operating sequences or setpoints.
2. Update control diagrams to include all tuning parameters and setpoints applicable to systems depicted as of date of system completion. This information shall be incorporated with sequence of operation of each system.
3. Record actual locations of control components including control units, thermostats, air terminals and any controlled devices on as-built ductwork/piping plans provided by Mechanical Contractor. Include 120 v circuit identification including panel ID and breaker served.
4. Record Drawings for controls shall be provided on minimum 11'x17" drawing format.

C. Extended Service Agreement:

1. Control manufacturer shall, upon completion of warranty period, make available to Owner annual service agreement covering all labor and material required to effectively maintain control system after warranty period. Owner reserves the rights to accept or reject any such offers and to cancel on-going agreements with 30 day written notice.

1.12 GUARANTEE AND SERVICE

A. Control system vendor shall guarantee all equipment, materials and workmanship to be free from defect per Article 42 of the General Conditions. Additionally, control vendor shall provide a 2 year warranty against patent defects and defects in material and workmanship following final acceptance of control vendors work by Owner and shall replace defective materials or workmanship without cost to Owner.

B. Controls Contractor shall provide one (1) year of maintenance service for the HVAC controls system to begin concurrently with the first year of warranty. Service shall include inspection of all operating controls and components and adjustment of operating controls and components as noted by Owner and as observed through inspections. The service shall be performed every three months and documentation of service shall be provided to Facilities Operation.

C. Controls Contractor shall perform a complete Building Automation System Performance Verification performed in the 11th month of the first year of warranty. The Performance Verification shall include:

1. A complete and current Building Automation System site inventory including the following information at a minimum: a listing of all field and supervisory controllers with the following key attribute data; corresponding model numbers, firmware versions, available security updates, CPU and memory performance data, battery conditions, integrations, controlled equipment, and device and point counts.

2. A complete, written evaluation of system configuration and performance report to include: listing of any simultaneous heating and cooling instances, identify discharge air temperature variation from set point, pressure variation from set point and carbon dioxide variation from set point, identify overridden control points, identify control points creating excessive alarms, identify any unbound references, identify any duplicate BACnet Instance numbers.

PART 2 - PRODUCTS

2.1 CONTROL / POWER WIRING

A. Control / Power wiring shall be in accordance with National Electric Code. Final connection points at devices and panels shall be made at terminal blocks either integral to device or separate terminal blocks mounted inside of control panel enclosures. Use of wire nuts and crimped connections are not allowed for terminating control wiring.

B. Install communication and signal wiring in conduit or use plenum rated cable according to requirements specified in Part 3 of this section.

C. Refer to Division 26 for conduits and conductors, except as noted.

D. Signal Conductors (24 Volts and Under):

1. Wire smaller than #18 AWG shall not be used, except for manufacturer supplied instrument specific wire, or unless otherwise specified. Use 2 wire twisted pair 24 VDC for analog and/or discrete devices. For RTD signal wiring, use #18 AWG stranded, tinned copper twisted/shielded 3 conductor.
2. Communication Cable: Minimum #18 AWG twisted, shielded pairs, coaxial cable, or fiber optics for communications between remote control devices. Provide 250 ohm, 5 watt, 0.1% tolerance dropping resistors as required to get 1 to 5 volt signals in 24 VDC powered loops. Provide isolated instrument grounding system as per manufacturer's recommendations.
3. 24 VAC Power Conductors shall be #18 AWG 2 wire twisted pair or larger. Provide Metal Oxide Varistors (MOVs) on 24 VAC/VDC discrete outputs connected to inductive loads to reduce noise levels (i.e., solenoid valves, motor contactors, relays, damper/valve electric actuators, etc.).
4. Stranded twisted/shielded control conductors are required with shields to be terminated within variable frequency Drive enclosures to reduce effects of noise from VFD. Follow VFD manufacturer's installation instructions for wiring control conductors to VFD.

E. Transient Voltage Surge Suppression Devices:

1. Devices shall be designed for 120-volt power conditioning devices for electronic equipment. Devices shall be designed, manufactured, tested, and installed in compliance with ANSI/IEEE C62.41 and C62.45, Federal Information Processing Standards Publication 94 (FIPS PUB 94), NEMA, NFPA 70, 75, and 78, and UL 1449 and 1283. Devices must labeled for UL 1449.
2. Clamping voltage for 120-volt power systems to be 400-volts.
3. Provide visual indicator of when surge device has been used.

2.2 LOCAL CONTROL PANELS

A. Local control panels shall be constructed of steel or extruded aluminum with hinged door and keyed lock, with baked enamel finish of manufacturer's standard color. Construction shall comply with NEMA 1 standards for interior panels, NEMA 4 for exterior panels.

B. Provide control panels of adequate size to accommodate instruments for future expansion of approximately of approximately 10% beyond space required for this scope of work. See Section 23 09 23 – Building Control Systems and Networks for spare point capacity.

C. Controlling instruments, temperature indicators, relays, switches, and gauges shall be factory installed and permanently labeled. Devices shall be located inside or mounted on face of panel.

D. Unless otherwise indicated, mount control and adjusting switches, temperature indicators, and other indicating or manually operated devices, on front face of panel with white phenolic engraved nameplates with block letters. Provide document holder located on inside of door.

E. All control panels housing controllers shall have a key lock. All control panels shall utilize one master key. Provide two spare key sets to the owner.

F. All heat generating devices shall be located at top of panel and proper ventilation of cabinets shall be provided to limit heat buildup within cabinets.

PART 3 - EXECUTION

3.1 GENERAL

A. Install all control equipment, wiring and air piping in neat and workmanlike manner to satisfaction of Architect and/or Engineer.

B. Coordinate timely delivery of materials and supervise activities of other trade contractors to install devices such as immersion wells, pressure tappings, any associated shut-off valves, flow switches, level switches, flow meters, air flow stations, valves, dampers and other such items furnished by Control Contractor which are to be installed by Contractor.

1. The controls contractor shall work in close coordination with the TAB contractor in calibrating all airflow and water flow stations and all duct and pipe mounted differential pressure sensor / transmitters. The tests shall be documented and included in the final TAB report.
2. The BAS controls contractor shall provide Tee type connections (and associated stop cocks or caps) in the pressure sensor tubing at all differential pressure sensors, including ductwork high static pressure and airflow measuring devices, and HW & CHW pump control ΔP sensors, etc. that will allow field test measurements to be taken without interrupting the BAS reading.

C. Install control devices in accessible location with visual displays oriented to be readable from floor level.

D. Coordinate mounting height and location of control devices so that NEC workspace clearances are maintained.

E. Devices containing mercury shall not be allowed.

F. Install control panels with lockable device and at same height as adjacent/room electrical panels.

3.2 CONTROL / POWER WIRING

A. Provide all electrical wiring required for complete functional control systems, including power circuit to control panels, both line and low voltage, in accordance with all applicable local codes, and the latest version of National Electric Code.

B. Control panels serving equipment fed by standby power shall also be served by standby power. Equipment fed by standby power is so indicated on mechanical equipment schedules and electrical motor schedules.

C. Communication and signal wiring installation:

1. Communication and signal wiring shall be installed in conduit as specified in Division 26 of this specification except where noted below.
2. Communication and signal wiring installed in the following locations is not required to be installed in conduit providing installation meets requirements specified below:

    a. Communication and signal wiring installed above accessible areas of the building (excluding mechanical equipment rooms, exposed areas without ceilings).
    b. Accessible areas are defined as areas with lay-in tile ceilings as shown on architectural reflected ceiling plans. Hard ceiling areas with access panels in ceilings do not qualify as accessible areas.
    c. Communications and signal wiring in exposed areas and concealed within walls or chases shall be installed in conduit.
    d. Signal wiring associated with Fire Alarm System shall be installed in conduit.
    e. Where communications and signal wiring is installed in areas not requiring conduits, plenum rated cables shall be routed along building structure lines using manufactured J-hooks. Use of plastic cable ties, metal wire, or other contractor fabricated hanging devices is prohibited. J-hook shall be broad saddle type with minimum of 1-1/4” support for cabling, radiused to provide proper support with no kinking.
    f. Segregate controls wiring and equipment alarm wiring using independent J-hooks.
    g. Route communication and signal wiring parallel to or at right angles to the structure and install in a neat workmanlike manner. J-hooks shall be installed on a 5’-0” minimum spacing. Diagonal routing of wiring is not permitted.
    h. Label each cable which is not installed in conduit with unique wire ID number every 50’ and on each side of opening where cables are routed through walls.
    i. Where communications and signal wiring is not required to be installed in conduit, but is routed through fire rated openings, provide conduit enclosure through rated assembly with firestopping as specified in Section 07 84 00 – Firestopping.
    j. All cable not installed in conduit shall be plenum rated. Splicing of wire shall not be permitted.

D. Color code each junction box cover plate as to signal type using 1/2” self- adhesive color dots. Use green for emergency signal wiring, and orange for line voltage wiring used for signal wiring or dedicated power wiring.

E. Tag each wire termination at control panels, junction boxes, and remote-control devices with unique wire ID number using mechanically prepared labels.

F. Run direct current instrument conductors separately from alternating current conductors. Where allowed by NEC wiring classification, all required AC-DC route crossing shall be at 90 degrees. Install special sensor to converter cables in accordance with drawings or in compliance with manufacturer's instructions. Extra precautions should be taken when pulling and shortening these "vendor furnished" cables. Any extra length on these cables shall be neatly coiled into 3" diameter minimum coils and installed into junction box.

G. Route intrinsic safe wiring separately from other conductors. These conductors shall not be run with, nor cross, conductors of other NEC classifications and shall require barrier if run in the same path with wiring of other classifications.

H. Instrument and control conductor color codes shall be as follows:

Type	Color
120 VAC Control Signal	Red
120 VAC Instrument Line Power	Black
120 VAC Instrument Line Neutral	White
Grounds	Green
24 VAC 24 + VDC Instrument Signal	Red Black
24 – VDC Instrument Signal	White or Clear
24 VAC Neutral RTD V+	White Black
RTD V-	White
RTD Compensation	Red

I. Electric signal cables from electronic transmitters to receivers and from controllers to final control elements shall be continuously shielded. Shields shall be grounded at power source end only and floated at the other end. Pay particular attention to floating shields through termination points, maintaining only one single grounding point, and insulating from ground at all other points. Provide 250 ohm, 5 watt, 0.1 % tolerance, dropping resistors as required to generate 1-5 VDC signals from 4-20 mA control 100 P powered by 24 VDC power supply.

J. Network Communication Cable:

1. Route communication cable in separate conduit with proper clearances.
2. Install special cable connectors in accordance with manufacturer's recommendations.
3. Network communication cable shall not be spliced.
4. Bundle and harness multi-conductor instrument cable in place of single cables where a number of cables follow a common path.
5. Provide isolated instrument grounding system as per manufacturer’s recommendations.

K. Provide control wiring to electrical and plumbing meters as required.

3.3 LOCAL CONTROL PANELS

A. Provide local control panel for each system where more than one control device requires field mounting, (air handling units, miscellaneous control system including pump controls, etc.). Single devices may be exposed mounted on piping wall or ductwork. Install local control panel where indicated on drawings or suitable location adjacent to system served.

B. Mount panel on wall with suitable brackets or on self-supporting stand. Mount top of panel no higher than 6 feet above floor. Install panels so front cover door can swing full open without interference. All control panels in penthouse shall be mounted on self-supporting stand.

C. Label local control panels with its respective unique ID per Section 23 05 53 - Mechanical Systems Identification.

D. Control panel locations are indicated on the drawings as a reference only for coordination. Exact location and quantity shall be coordinated during the construction coordination effort.

3.4 ADJUSTMENT AND COMPLETION CHECKLIST

A. After completion of installation, follow checklist procedure defined in checklist submittal to adjust and calibrate all control valves, control actuators, controllers, sensors, and other equipment provided in this contract. Include signed and dated completed checklist in operating and maintenance manuals.

B. Provide a control system technician to assist during system performance verification and functional performance testing (FPT). The controls contractor shall make one (1) technician available to the CxA throughout the Acceptance Phase of the commissioning process. The controls technician shall be familiar with both the controls software and BAS programming and be capable of making controls system hardware repairs during Cx / FPT. The controls contractor shall also submit a copy of his controls point-to-point (PTP) checkout sheets to the CxA, prior to the start of the mechanical system FPTs. Functional testing of the control system may be conducted in phases or by systems (only complete systems can be properly commissioned), as defined by the requirements of the Final Cx Plan, or as approved by the CxA. The BAS controls contractor shall facilitate the Cx effort by implementing trend logs from the BAS, etc. on the various systems undergoing Cx / FPT and Performance Verification, as requested by the CxA.

C. Upon completion of work but before final acceptance of the systems, Controls Contractor shall demonstrate that controls are installed, adjusted, and operate as required by the drawings and specifications. This demonstration shall be documented and may be conducted in conjunction with the training of Owner personnel and commissioning. The documentation shall identify the item, the person performing the demonstration, date, and the signature of the Owners representative. The Owner representative will select the items to be demonstrated. Items shall be demonstrated as follows:

1. Disconnect one DDC from the building network to demonstrate that a single device failure will not disrupt peer-to-peer communication.
2. Manually generate alarms at all of points and demonstrate that the workstation(s) receive the alarms.

3. Calibration has been performed on at least 10% of all temperature sensors as selected by Owner.
4. Point-to-point verification of all points. Include labeling of points.
5. Sequence of operation for the air handling.
6. Sequence of operation for all terminal units including min/max air, reset.
7. Sequence of operation of the HVAC controls system during a fire alarm and emergency power mode.
8. Graphics system is functional and that the layout is consistent with field conditions.
9. Response to upset conditions and change of setpoint for selected systems.
10. Refer to commissioning requirements for additional testing requirements.

D. Documentation of results shall be provided to the Owner and included in O&M Manuals prior to Final Acceptance.

E. Control Contractor shall immediately remedy any deficiencies found. Corrective measures may include modification or addition of equipment and devices, control strategies and/or software program. All corrective modifications made by Control Contractor during warranty periods shall be incorporated and updated in operating and maintenance manuals.

F. If more than 1% of total loops are found defective, Engineer may request that the entire check list procedure be repeated.

G. Any subsequent performance check list reviews performed by Engineer to verify performance shall be done at Contractor's expense.

3.5 COORDINATION

A. Coordination with TAB Contractor:

1. Control Contractor shall allow sufficient time to provide assistance and instruction to TAB Contractor in proper use and setting of control components such as, computers, static pressure controllers, “k” factors for VAV boxes, or any other devices that may need set points changes so that TAB work can be performed.
2. For those times when the controls contractor is unavailable to provide “live” TAB support, the controls contractor shall provide the TAB contractor with either appropriate control system software or the controls contractor's handheld device, for setting up HVAC equipment, and placing said equipment in the correct mode for testing. This software and / or equipment shall be provided to the TAB contractor free of charge for the duration of the project and shall be returnable to the controls contractor upon completion of the project.

3.6 LABELING

A. Control contractor shall provide labels for all field devices including sensors, meters, transmitters, and relays. Labels shall be plastic laminate and shall be located adjacent to device served. Label all field devices (both locally and software ID’s) with reference to associated equipment served (i.e. Air handler, pump, etc.). In instances where there is no mounting surface near device, Contractor shall use brass chain for mounting plastic laminate labels. The controls contractor shall collaborate closely with the owner, the EOR, the mechanical contractor and the

TAB agency to ensure that unique naming and numbering of rooms, equipment, valves, instrumentation, and any other item programmed into the BAS software follows the agreed upon numbering / naming convention established for the project. If no such convention is in place for an item or piece of equipment requiring one, the controls contractor shall take the lead in coordinating with the appropriate parties (i.e. owner, EOR, MC, TAB agency, etc.) to ensure that all references to that item are unique, suitable for the application and utilized in all project submittals.

3.7 OWNER TRAINING

A. Provide full time BAS operator to operate systems after systems have been started and are regularly used until Owner has completed on-site training specified and commissioning is complete.

B. On-Site Training:

1. The manufacturer and the Controls Contractor shall provide factory trained and certified instructor(s) to provide on-site training in the maintenance and operation of the installed system for up to six (6) personnel.

    a. The factory trained instructor(s) shall not be the installing contractor.
    b. The training shall be documented and a syllabus and O&M manuals shall be submitted and approved by Owner 2 weeks prior to training.
    c. The instruction time periods shall be approved by the Owner and conducted during normal working hours 8:00 AM to 4:30 PM, Monday through Friday, at times convenient to the Owner at the job site.
    d. Training and classes shall be offered in multiple sessions at Owner's preference to accommodate Owner's work scheduling.
    e. These instructions shall consist of both classroom and hands-on training.
    f. Provide 40 hours of on-site training.

C. Off-site Training:

1. The manufacturer and the Controls Contractor shall provide additional 24 hours of training for two University employees at the manufacturer's offsite training facility after on-site training is completed.
2. Offsite training shall be "local" (within 50 miles of jobsite) and manufacturer shall include all travel, lodging, and expenses for the trainer and the university personnel in Bid.
3. The offsite training shall include follow-up to previous training based on current operation of systems and shall address any new concerns.
4. Training shall be documented and a syllabus must be submitted and approved by Owner prior to the training.

D. Owner training on control sequences of operation (SOO) shall not begin until the completion of the fieldwork portion of the Cx / FPT, when all final SOOs have been established, so that owner's personnel are only trained on the final SOOs utilized. Proposed training schedules, training plans / lesson plans, course syllabi, and materials included shall be submitted to the Architect, Owner and Cx Authority for review of course content and adequacy of information provided for training of Owner's personnel. Videotape instructional sessions and provide two

copies to Owner on USB drive. The contractor shall provide all students with a binder containing product specific training modules for the systems installed.

E. The Owner reserves the right to request replacement of any instructor who, in their opinion, does not demonstrate sufficient qualifications as an instructor.

F. The Owner reserves the right to additional training at contractor's expense other than specified above to familiarize technicians with any control systems which are not adequately explained or differ from instruction given in class.

G. Owner training is of critical importance and all onsite training shall be complete before beneficial occupancy. All training (on-site and offsite) shall be completed before Final Acceptance.

H. Course content for training shall include, but not limited to, the following topics:

1. Explain control sequences. Include which sensors are used and how output device operates.
2. Explain control drawings and manuals, including symbols, abbreviations, and overall organization. This will include a walk-thru at the building.
3. Walk-through project to identify all controller locations, and general routing of network cabling.
4. Review operating and maintenance of all hardware devices including air compressor, air dryers, controllers, instruments, and sensors. Include schedule for routine maintenance and adjustment, calibration, and replacement procedures.
5. Review accessing control system including logon procedure and use of graphic and DDC pages and password requirements.
6. Review operation of operator's workstation including hardware (PC's, printers, etc.)
7. Review operator's workstation software using specific examples of operating hardware.
8. Review of web services, data management, functions, and tool kit.
9. Review portable operator's workstation software using specific examples of operating hardware
10. Review operation and troubleshooting including;

    a. Modification of setpoints, schedules, and programming logic changes.
    b. Overview of graphics and text pages.
    c. Trending of points.
    d. Calibration and adjustment.
    e. Hands on training in troubleshooting and replacement of components including sensors, transmitters, control valves and actuators. Contractor shall have examples of each component and demonstrate measurement of input and output signals, and any operator adjustment available.
    f. DDC controller functions and operation.
    g. Expansion of control system including hardware and software additions.

11. In addition to requirements listed above, factory training shall include:

    a. Programming logic changes both locally and at the system (BCU).
    b. Expansion of the control system including hardware and software additions.
    c. Graphics generation and modification.
    d. HVAC control system principles.

I. The Controls Contractor shall provide an additional on-site training session nine (9) months after project completion. The purpose of the session will be to review any operational problems that have developed. In addition, the contractor will lead Owner personnel through a comprehensive annual preventative maintenance of the controls system. This shall be scheduled through Owner at least one (1) month in advance. Provide a minimum of 16 hours for this follow-up training.

END OF SECTION 230911

SECTION 23 09 13 – CONTROLS INSTRUMENTATION

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 INFORMATION SUBMITTALS

A. Devices shall be indexed by bill of material for each system as detailed in Section 23 09 11 – Building Control System Integration.

1.3 FCC COMPLIANCE

A. Digital equipment furnished under this contract shall have been tested and made to comply with the limits for a Class A computing devices pursuant to Subpart J of part 15 of FCC Rules, which are designed to provide reasonable protection against interference when operated in commercial environment. Literature shall so note and all equipment shall be so labeled.

PART 2 - PRODUCTS

2.1 GENERAL

A. Pressure and temperature ratings of devices indicated in Part 2 - Products are minimum required. All devices shall be designed to withstand maximum pressure and temperature encountered in the respective system.

B. Devices containing mercury shall not be allowed under this specification.

2.2 GENERAL INSTRUMENTATION

A. Pressure gauges shall be provided by Division 23 Contractor.

B. Thermometers shall be provided by Division 23 Contractor.

C. Analog Electronic Instrument Indicators:

1. Electronic indicators, used for displaying sensor and/or output values as measured by current or voltage, shall be panel mount type and at least 2” square. Output may be analog needle type or digital with ½” high LED or backlit LCD displays.
2. Electronic indicators shall be marked in appropriate units (Degrees, PSI, %RH, GPM, CFM, etc.) and with appropriate range of values. Panel mounted indicators shall have minimum accuracy of 1% of scale range. Digital units shall be scaled to show 3 digits plus 1 decimal point.

2.3 DISCRETE ELECTRIC INSTRUMENTATION

A. General:

1. Electrical devices, switches, and relays shall be UL listed and of type meeting current and voltage characteristics of the project. Terminal connections shall be made at terminal blocks inside of NEMA 12 enclosures unless otherwise specified. Outdoor units shall be NEMA 4 with concealed adjustment.
2. Ratings of normally open and closed contacts shall be adequate for applied load (Minimum 5 amps at 240 volts).
3. Accuracy of devices shall be ± 1% of scale with adjustable offset unless otherwise specified.

B. Relays:

1. Manufacturers: IDEC, Potter Brumfield, Square D, or Allen Bradley.
2. Equal to IDEC type RH2B-U, miniature 8 blade pilot relay with DPDT silver cadmium oxide contacts rated at 15A, 30 VDC, or 120 VAC. Coil shall match control circuit characteristics. DDC outputs shall be 24 VDC with maximum current burden of 50 milliamps. Rectangular base socket mount with blade type plug-in terminals and polycarbonate dust cover.
3. Provide DIN rail mountable (Snap type) mounting sockets equal to IDEC SH2B-05.
4. Enclosed Relay (Relay-in-a-box):

    a. Manufacturers: Veris Industries, Kele & Associates, Functional Devices, Inc. or approved equal.
    b. 1 or 2 SPDT relays in NEMA 1 or better enclosure. Coil shall be selected for control circuit characteristics.
    c. Contacts rated at 10A, 29 VDC or 120 VAC. Conduit nipple is ½” NPT. Maximum coil current burden of 50 milliamps.

C. Temperature Switches (Electric Thermostats):

1. Manufacturers: JCI, Kele, Penn
2. Line voltage or low voltage type suitable for application with adjustable setpoint and setpoint indication.
3. Low voltage type to have heat anticipation.

D. Pressure Differential Switches:

1. Manufacturers: Allen Bradley, Cleveland Controls, Ashcroft, Barber-Colman, Dwyer, Honeywell, Johnson Controls/Penn, Invensys, SOR, or United Electric.
2. Adjustable set point, differential pressure type. Select switches for accuracy, ranges (20 to 80% of operating range) and dead-band to match process conditions, electrical requirements and to implement intended functions.
3. Pressure differential switches for air systems shall have pressure rating of at least 10” wg.
4. Pressure indicating differential switches for air systems shall be equal to Dwyer Series 3000 photohelic gauge.
5. Pressure differential switches for water systems shall be rated for 150 psig unless otherwise noted. Chilled water pressure differential switches shall be provided with

totally sealed vapor tight switch enclosure on 300 psi body. Differential pressure switches to have 3- valve manifold for servicing.

a. Maximum Temperature Rating: 180°F
b. Repeatability: ± 1%

E. Position Switches (End Switches):

1. Manufacturers: Allen Bradley, GE, Johnson Controls/Penn, Honeywell, Square-D, Westinghouse, or Westlock.
2. Provide valve position switches, toggle switches, and wall switches as required to meet specified sequence. Rotary switches shall be cam action, lever, or proximity type.
3. Switches containing mercury shall not be used.

F. Current Switches – Variable Load, Variable Speed:

1. Manufacturers: Veris Industries, N-K Technologies, Absolute Process Instruments or approved equal
2. These shall be induction type sensors clamped over single-phase conductor of AC electrical power and shall consist of solid-state sensors with self –calibrating threshold and normally open contacts. Each current switch shall be selected for proper operating range of current.

a. Output: Solid state relay or relay contacts
b. Trip Setpoint: Adjustable by multi-turn

3. Potentiometer

a. Operating Temperature: 0 to 55°C (32 to 131°F)
b. Response Time: <0.5 seconds

G. Current Switches – Constant Load, Constant Speed:

1. Manufacturers: Veris Industries, N-K Technologies, Absolute Process Instruments, Kele & Associates, R-K Electronics or approved equal.
2. These shall be Induction type sensors clamped over single phase conductor of AC electrical power and shall be solid-state sensors with adjustable threshold and normally open contacts. Each current switch shall be selected for proper operating range of current.

a. Output: Solid state relay or relay contacts
b. Trip Setpoint: Self-calibrating through microprocessor
c. Operating Temperature: 0 to 55°C (32 to 131°F)
d. Response Time: <0.5 seconds

H. Mechanical Room and Local Control Panel Alarm Horns:

1. Manufacturers: Honeywell, Panalarm, Johnson Controls, Invensys or Federal Signal.
2. 24-volt alarm horn suitable for panel mounting.

I. On / Off Pushbutton Switch:

1. Switch enclosure shall be hermetically sealed, non-locking, NEMA 4 die cast enclosure. Switch station to contain the following elements:

    a. Red incandescent pilot light for “Fan OFF”.
    b. Green incandescent pilot light for “Fan ON”.
    c. A Start/Stop toggle switch.
    d. Legend plates for each function labeled Run, Off, Start/Stop.
    e. Provide protective plastic cover on switch.

2. Provide 2 NO / 2 NC contracts for switch with maintained type operator.
3. Switch to operate from 120 VAC or 24 VAC.
4. Push Buttons – Illuminated.

    a. Heavy-duty recessed illuminated maintained push buttons with NEMA 4 rating. Head shall be illuminated with switch in actuated position (depressed) and not illuminated after operator resets the switch (pulled out).
    b. Contact Type: Contractor shall select switches based on drawings or as required to meet intended control function.
    c. Voltage: 120 VAC/60 Hz or 24 VDC unless otherwise noted. (Contractor to match to required application.)
    d. Current: 5 amp continuous.
    e. Switch Actuation Life: 500,000 cycles minimum.
    f. Dielectric Strength: 2000 V for 1 minute.
    g. Shock: ½ cycle sine wave for 11 milliseconds without switch actuation.

5. Provide NEMA 4 rated junction box to mount switch assembly.
6. Provide laminated plastic nameplate above pushbutton labeled with equipment served.

J. Indicator Lights:

1. Manufacturers: Allen Bradley, GE, Square-D, or Westinghouse.
2. 1/4" minimum size, push-to-test type. Use green for normal, yellow for warning (low/high values), and red for alarm or fail (low-low or high-high conditions). AC or DC type with voltage matched to control circuit without transformers.

K. Temperature Low Limit Switches (Freezestats):

1. Manufacturers: JCI, Penn, Kele, Siemens
2. Electric 2 position type with temperature sensing element and manual reset. Controls shall be capable of opening circuit if any one-foot length of sensing element is subject to temperature below setting.
3. Sensing element shall not be less than one lineal foot per square foot of coil surface areas. Unless otherwise indicated, calibrate temperature switch setpoint to 38°F.

L. Temperature Switches (Aquastats):

1. Electric 2-position type with strap-on or immersion temperature sensing element. Switch contacts close on increasing temperature to provide start signal for unit heaters and open on high limit control for heating hot water heat exchangers.
2. Sensing element shall be set for 100°F (FA) for unit heater control. For setpoints to aquastats for hot water heat exchangers, refer to control sequences for each hot water

system. Provide screw-type materials in NEMA 12 switch enclosure for field mounting at unit heaters.

M. Moisture Detector:

1. Moisture detector is small, electronic control relay for detecting water within containment areas. Moisture detector shall alarm whenever water is detected.
2. Relay is normally energized upon powering up and no water is present. When water level reaches the trip point the relay de-energizes for alarming in BAS.
3. Moisture Detector Relay Module:

   a. Supply Voltage: 24 VAC, 60 Hz
   b. Power Consumption: 1 W
   c. Cable length: 18”
   d. Relays Contacts:

      1) Type: SPDT
      2) Rating:2.5A at 24 VDC; 5.0A at 120 VAC

   e. Enclosure Rating:Hermetically Sealed

2.4 ANALOG ELECTRONIC INSTRUMENTATION

A. Space Temperature Sensors:

1. Sensors shall be 1000-ohm platinum or nickel RTD Type, with the following minimum performance:

a.	Temperature Coefficient of Resistivity (TCR):	0.00385 ohm/ohm/°C
b.	Accuracy:	±.54°F + (0.005 X T) (Class B) T = Temperature of interest
c.	Conformance:	DIN-IEC 751
d.	Operating Range:	32 to 122°F, 0 to 99% RH

2. Thermistors are acceptable in lieu of RTD provided thermistor carries 5-year guarantee that device will maintain its accuracy within tolerance of ±0.36°F between 32°F and 150°F, and ±0.5°F between -20°F and 212°F.
3. Provide visible setpoint, setpoint adjustment, and space temperature indication for all spaces except circulation, classrooms, large seminar, lobby, rest rooms, and other public spaces.
4. Provide port on front of enclosure to allow for Portable Operator Terminal connection for troubleshooting.
5. Where temperature and humidity sensors are paired together for dewpoint sensors, a combo sensor can be provided that matches the requirements of each sensor.

B. Duct Mounted or Insertion Temperature Sensors:

1. 1000-ohm platinum RTD type, with the following minimum performance:

a.	Temperature Coefficient:	0.00385 ohm/ohm/°C

b.	Accuracy:	± 0.12% at 32°F (Class B)
c.	Conformance:	DIN-IEC 751
d.	Operating Range:	-50 to 170°F; 0 to 99% RH

2. Install sensors in stainless steel probes or wells. Outside air sensors shall be weatherproof of noncorrosive construction and protected with solar shield. Mount outside air sensors in outside air intake plenum serving air handling units to avoid thermal effects from direct sunlight.
3. Use of thermistors shall not be permitted.
4. Temperature sensors that are used for BTU measurement shall be calibrated together and be within 0.15°F at 45°F.

C. Direct Insertion Temperature Sensors:

1. Sensor assembly shall be direct insertion, suitable for use with water systems, 150-pound class, minimum rating.
2. Sensor shall be platinum wound RTD, minimum accuracy of ± 0.06% at 32°F.
3. Sheath diameter shall not exceed 5/16". Length shall be such that sheath, containing sensor, projects into process fluid from 2" to 2.5" beyond pipe wall when installed. Material to be 304 or 316 stainless steel. Process coupling to be 3/8" or 1/2" NPT.
4. Connection head to be NEMA 1. Provide internal termination for RTD and wire connection. Conduit connection shall be 1/2" NPT.
5. Provide hot tap assembly and extension. Material to be 304 or 316 stainless steel. Support hot tap at minimum of 2 points to eliminate vibration. Extension shall exceed insulation thickness by 1".

D. RTD Temperature Sensor/Transmitters:

1. Rosemount, Foxboro, MICO Products, Weed, Pyromation, Siemens, Automation Components Inc., or SMAR.
2. Transmitters shall provide 2 wire 4-20 mA current output signal proportional to specified temperature span of transmitter and compatible with DDC equipment. Sensor shall be 1000-ohm platinum RTD type.

a.	Power Supply Voltage:	13 to 35 VDC unregulated.
b.	Accuracy or Output Error:	0.1% of span of sensor and transmitter combination.
c.	Thermowells:	By same manufacturer as sensor.

3. Provide local temperature indicator with 3 LCD digital readout.

E. Dew Point Temperature Transmitter:

1. Manufacturers: General Eastern, Kele & Associates or Vaisala.
2. Microprocessor type primary dew point temperature measurement using platinum RTD, 4 wire, 100 ohm temperature sensing element with 4-20 mA transmitter.

a.	Accuracy:	± 1°F
b.	Repeatability:	± 0.1°F
c.	Hysteresis:	None
d.	Sensor Range:	-10°F to +140°F dew point

32°F to 140°F ambient

3. Unit shall be selected for wall application.

F. Space Oxygen Monitor:

1. Manufacturers: Toxalert, Vulcain, Honeywell, Texas Instruments, Vaisala, Kele and Associates, MDA Scientific, MSA.
2. Provide Oxygen Monitor as listed below for monitoring Oxygen levels in S202 Teaching Lab Biochem and S303 Lab Support.
3. Unit shall have adjustable setpoints and self-test diagnostics.

a.	Power Requirements:	18-28 VAC, 50/60 Hz or 18-40 VDC, 3W
b.	Signal Input:	Non-dispersive Infrared, Integral Senso
c.	Signal output:	Linearized 0 – 10 VDC or 4-20 mA DC
d.	Alarm Setpoint:	User defined, software adjustable in 100 ppm increments via LCD or Interface Keypad
e.	Ranges:	0-2000 ppm

G. Pressure/Differential Pressure Transmitter:

1. Manufacturers: Fischer & Porter, Moore Products, SMAR International, Honeywell, Johnson Yokogawa or Setra.
2. Pressure sensor and integral 4-20 mA VDC transmitter. Select instrument for intended usage (differential pressure, gauge pressure, level, etc.), range, maximum pressure/temperature. Sensor shall be capacitance or strain gauge type.
3. Differential pressure transmitters shall have 3-valve manifold for servicing.

a. Diaphragm Material: Stainless Steel or Hastelloy
b. Process Connection: 1/2" NPT Stainless Steel
c. Power Supply Voltage: 13 - 35 VDC unregulated
d. Over Pressure: 1000 psig or 2 times maximum operating pressure whichever is greater.
e. Performance:

1) Zero: Zero control shall be continuously adjustable between ± 50% of upper range limit. Total calibrated span and zero adjustment cannot exceed upper range limit. Zero span shall be independently field adjustable with no interaction.
2) Accuracy: ± 0.25% of calibrated span, including effects of linearity, hysteresis, repeatability dead band.
3) Drift: ± 0.1% of upper limit for 6 months.
4) Power Supply Effect: Less than 0.01% of output span per volt.
5) Static Pressure Effect: Zero Error: ± 0.1% of upper range limit per 1000 psi.
6) Span Error: ± 0.2% of reading per 1000 psi
7) Temperature Effect: ± (0.025% upper range limit plus 0.125% span) per 50°F.

4. Provide remote sensing element(s) whenever operating temperature exceeds transmitter maximum temperature.

H. Current Transformers:

1. Manufacturers: General Electric, Square D, Veris Industries, or Kele.
2. Alternating current transformers shall conform to the latest applicable standards including AEIC, EEI-NEMA, Standards for Instrument Transformers (MSJ-11) and ANSI Standard C57.13 for instrument transformers.

a.	Rated Voltage:	480 Volts
b.	Insulation Class:	600 Volts
c.	Basic Impulse Level:	60 Hz
d.	Short Time Current Rating:	100% (1 second)
e.	Accuracy Class:	0.3
f.	Continuous Current Rating:	150%

I. Pressure (E-P) Transducers:

1. Manufacturers: Brandt, Johnson Controls, Honeywell, Fairchild, Kele, Landis and Staefa, Moore Industries, or Siebe Environmental Controls (Robertshaw/Barber-Colman).
2. Provide pressure transducers integral to control panels or separate components to convert digital analog signal to variable pneumatic air pressure signal. Units to have following characteristics:

a.	Input:	4-20 mA or 0-5 VDC
b.	Linearity:	1% of span
c.	Hysteresis:	0.75% of span
d.	Maximum Air Consumption:	0.008 scfm @ 20 psi

J. Ducted Air System Static Pressure and Differential Pressure (Velocity) Transmitters:

1. Manufacturers: Modus, Setra, Ashcroft XLDP or approved equal.
2. Provide transducers/transmitters to convert velocity pressure differential or static duct pressure relative to sensor location into electronic signal.
3. Unit shall be capable of transmitting linear 4 to 20 mA DC output signal proportional to the differential (total minus static or static minus ambient) pressure input signals with the following minimum performance and application criteria:

a.	Span:	Not greater than twice the duct static or velocity pressure at maximum flow rate, nor more than 16 times velocity pressure at minimum flow rate.
b.	Accuracy:	± 1.0% of span or ± 1.0% of full scale
c.	Dead Band:	Less than 0.5% of output
d.	Hysteresis:	Within 0.5% of span or within 0.5% of full scale
e.	Linearity:	Within 1.0% of span or within 0.5% of full scale
f.	Repeatability:	Within 0.5% of output
g.	Response:	Less than 1 second for full span input

4. Return and exhaust air system static pressure transducers/transmitters shall be furnished with protective integral air filters on pressure sensing lines from the static pressure sensing stations, and static air probes to prevent migration of moisture or particulate matter into transducers. Supply air system sensors do not require integral air filters.

K. Very Low Differential Transducer (Building differential):

1. Bidirectional, very low differential pressure transducer shall be equal to Setra Model 269 with the following characteristics:

a.	Output Signal:	4-20 mA
b.	Accuracy Class:	V: +/-0.25%, E: +/-0.5%, G: +/-1.0%
c.	Hysterisis:	V: +/-0.5%, E: +/-0.5%, G: +/-0.1%
d.	Non-Repeatability:	V: +/-0.5%, E: +/-0.5%, G: +/-0.1%
e.	Operating Temp Range:	-20°F to 160°F
f.	Pressure Range:	-1.0 psi to 1.0 psi

L. Building and Space Pressure Differential Transmitter:

1. Provide differential pressure transmitter noted elsewhere in this section with shielded static pressure probe of aluminum or stainless-steel construction equal to Air Monitor Corp SOAP, or equivalent as manufactured by Tek-Air or Ultratech Industries.

M. Pressure (E-P) Transducers:

1. Manufacturers: Automation Components, Brandt, Johnson Controls, Honeywell, Fairchild, Kele, Siemens, Moore Industries, or Invensys Building Systems.
2. Units shall have following characteristics:

a.	Input:	4-20 mA or 0-5 VDC
b.	Linearity:	1% of span
c.	Hysteresis:	0.75% of span
d.	Maximum Air Consumption:	0.008 scfm @ 20psi

N. P-E Transducers (Pressure Transmitters):

1. Manufacturers: Ashcroft, Automation Components, Mamac, Setra, Kele or Modus.
2. Units shall have the following characteristics:

a.	Input:	Pressure 0-15 psig, minimum
b.	Output Signal:	4-20 mA, 0-5 VDC, 1-5 VDC, 1-10 VDC
c.	Accuracy:	1% of span
d.	Operating Temperature	32 to 125°F
e.	Power Requirements:	24 VDC (10-30 VDC)

PART 3 - EXECUTION

3.1 GENERAL

A. Install control equipment, wiring and air piping in neat and workmanlike manner to satisfaction of Architect and/or Engineer, and in accordance with manufacturer's recommendations. Maintain clearances, straight length distances, etc. required for proper operation of each device. Mark and detail exact location of inline devices, wells, and taps to be installed by the Mechanical Contractor on coordination drawings.

B. Coordinate timely delivery of materials and supervise activities of other trade contractors to install inline devices such as immersion wells, pressure tappings, any associated shut-off valves, flow switches, level switches, flow meters, air flow stations, and other such items furnished by Control Contractor which are to be installed by Mechanical Contractor.

C. Install control devices in accessible locations.

D. Mount motor control devices within 5 ft. of disconnect switch, or starting device furnished by Electrical Contractor unless noted otherwise. Maintain required NEC clearances.

E. Control Contractor and Mechanical Contractor shall review proposed static pressure sensor locations with Owner and Engineer for approval prior to installation.

3.2 GENERAL INSTRUMENTATION

A. Pressure Gauges (Pressure Indicators):

1. Install pressure gauge for indication of supply and control pressure in pneumatic systems at output of controllers, I/P transducers, electric air solenoid valves, pressure switches and other points where visible indication of air pressure is required for operating and maintenance purposes.
2. Provide test port for quick connection of test gauges at valve, damper motor and other actuator branch lines.
3. Pressure gauge tappings in piping will be provided by Mechanical Contractor.

B. Thermometers (Temperature Indicators):

1. Install thermometers at each point of temperature transmission and control, except for those that are indicated at local control panels. Install thermometers to permit easy reading from floor or operating platform (within 3 ft. of line of sight). Provide remote bulb thermometers with readout indicators mounted within 3 ft. of line of sight whenever sensing point is more than 3 ft. from line of sight.
2. Thermometer wells in piping will be installed by Mechanical Contractor.

C. Local Control Panels:

1. Install remote mounted devices, controllers, I/O terminal blocks, power supplies, etc. inside of local control panels.
2. Locate panels as shown on drawings.
3. Locate panels adjacent to equipment served with minimum of 3 ft. clearance in front of door. Provide sufficient clearances to allow full door swing and full access to internal components. Submit proposed panel locations with shop drawings.
4. Mount top of panel between 5 and 6 ft. above floor so that gauges and indicators are at eye level.

D. General Instrumentation at Local Control Panels:

1. Provide record control drawings of systems served by each local panel, in location adjacent to or inside of panel cover. Provide protective cover for drawing.

3.3 DISCRETE AND ANALOG INSTRUMENTATION

A. Wall Mounted Space Thermostats/Sensors:

1. Install space thermostats/sensors where indicated, as required to perform specified controls, or directed to meet job site conditions.
2. Mount space thermostats/sensors at 5 ft. above floor unless otherwise indicated.
3. Mount space thermostats/sensors with accessible setpoint adjustment or temperature reading (thermometer or digital temperature readout) at 46” above floor to meet ADA requirements.
4. Any space thermostats/sensors mounted on exterior walls shall be mounted on thermally insulated sub-base.
5. Relocate space thermostats/sensors if required due to draft, interferences with cabinets, chalkboards, etc., or improper sensing.
6. Coordinate all thermostat/sensor locations with Architect/Engineer prior to installation.

B. RTD Temperature Transmitters:

1. Provide RTD temperature transmitters whenever DDCPs cannot receive RTD type inputs.

C. Low Limit Temperature Switches (Freezestats):

1. Install low limit controls where indicated on drawings or as specified. Unless otherwise indicated, install sensing element at upstream side of cooling coils.
2. Distribute sensing element across entire area of medium being sensed. Install controls at accessible location on outside of air handling unit no higher than 6’-0” above finished floor with suitable mounting brackets and element duct collars where required.

D. Static Pressure and Air Flow Stations:

1. Furnish static pressure and air flow measuring stations to Mechanical Contractor for installation.
2. Stations shall be installed in strict accordance with manufacturer’s published requirements. These stations serve as primary signals for airflow control systems, therefore, it shall be responsibility of Control Contractor to verify location and installation to assure that accurate airflow signals are obtained.

E. Direct Insertion Temperature Sensors:

1. Install sensor so that sensor is pointed downstream.

F. Sensor Wells:

1. Mount sensor wells as shown on drawings and other gravity return as required by other contract documents. Wells mounted in pipe 3" and larger may be installed in horizontal or vertical lines provided element is always in the flow, (for condensate and other gravity return lines, install in bottom of pipe). Wells mounted in pipe 2-1/2" and smaller shall be installed at elbow tee fittings with well pointed upstream. Minimum of 2" pipe size for elbow tee installation.

G. Transmitters and Indicators:

1. Locate transmitters at sensing device or within 100 ft. for remote mounted transmitters. For hot systems (150°F and higher) mount electronics on side of pipe or remotely mount. For indicating type instruments, locate indicating element with 6 ft. of the floor with readout easily visible from floor level. Provide remote readouts if necessary.
2. Provide pressure transducers integral to DDC panels or separate components to convert digital analog signals to variable pneumatic air signals.
3. Provide P-E transducers to convert analog pressure signals to analog electronic signals for input to DDC panels.

END OF SECTION 230913

SECTION 23 09 23 – BUILDING CONTROL SYSTEMS AND NETWORKS

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 ACTION SUBMITTALS

A. Shop Drawings:

1. Refer to Section 23 09 11 – Building Control System Integration.

B. Operating and Maintenance Manuals:

1. Refer to Section 23 09 11 – Building Control System Integration.

1.3 CLOSEOUT SUBMITTALS

A. Software Manual:

1. As part of operating and maintenance manuals, submit one software manual per workstation plus one extra copy for archive use. Software manuals shall be divided into separate parts with tabs for each part.
2. Software manual parts shall include:

    a. Complete description of operating system including all commands, configuration programs, printouts, logs, database functions and passwords. Describe general operating procedures, starting with system overview and proceeding to detailed description of each software command feature with sample printed displays and system function description for each option. Include instructions on verifying errors, status, changing passwords and initiating or disabling control programs.
    b. Complete description of programming language including all commands, configuration programs, control loop functions and testing. Describe general programming procedures, starting with system overview and proceeding to detailed description of each software command feature. Include instructions on creating or modifying any control algorithm or parameter, debugging, etc. This shall include all control functions, algorithms, mathematic equations, variables, setpoints, time periods, messages, and other information necessary to load, alter, test and execute custom or pre-written programs.
    c. Software Backup: Upon successful completion of acceptance testing, submit to Owner 2 archive copies of all accepted versions of source code and compiled code for all application programs and data files. All control software must be readily accessible by Owner using workstation hardware and software.

d. Control Loop Documentation: Submit indexed summary of each control loop program. Summary shall list in tabular form, name of system, name of control loop, all I/O points used, and reference to sheet number in shop drawings to describe control sequence programmed. For each control loop submit complete printed listing of source code used, all setpoint points, high/low alarm points, time event schedules, proportional gains, integrals, derivative values, and other database values.

e. Points List Summary: Provide detailed summary for each point in the system. Summary shall be cross-index listing of all points in alpha/numerical order with list of control loops which use each point. For each point, include an abbreviated point name, expanded point description, detailed description of each input instrument or output device, and detailed description of exact location of all field hardware. Location descriptions shall include room names, column numbers, elevation (above ceiling, bottom of duct, etc.).

1.4 FCC COMPLIANCE

A. Digital equipment furnished under this contract shall have been tested and made to comply with limits for Class A computing device pursuant to Subpart J of Part 15 of FCC Rules, which are designed to provide reasonable protection against interference when operated in commercial environment. All literature shall so note and all equipment shall be so labeled to show this compliance.

PART 2 - PRODUCTS

2.1 DIRECT DIGITAL CONTROL PANEL (DDCP)

A. General:

1. Direct Digital Control Panels (DDCP) shall be microprocessor based, field programmable controllers, capable of performing control and energy management functions, and shall be UL listed as Signaling Systems. Each control panel shall include its own microprocessor, power supply, input/output modules, and termination modules as required to perform its intended function. Each DDCP controller shall have at least two RS-232 communication ports.
2. DDCP shall receive discrete electrical or analog electronic field input signals, convert signals for use by controller, perform control sequences, convert controller information into output signals, and provide control output signals to actuators and field control device. All inputs and outputs, including communication connections, shall be electrically or optically isolated from controller.
3. DDCP with analog input modules shall be capable of accepting any form of linear or non- linear voltage (0-5 VDC or 0-10 VDC), current (4-20 mA) or resistive input (0-1000 ohm).
4. DDCP with discrete input modules shall be capable of accepting discrete inputs from any device with isolated, dry-type contacts (no grounds or no voltage) of either normally open (NO) or normally closed (NC) configuration. Provide visible status lights (LEDs) to indicate input point status for digital output points.
5. Provide input modules capable of interfacing with pulsed output type sensors as required.

6. DDCP with discrete output modules shall have isolated, dry-type contacts (no grounds or no voltage) of either normally open (NO) or normally closed (NC) configuration. Contacts shall have a minimum rating of 2A continuous at 115VAC. Provide visible status lights (LEDs) to indicate output point status.
7. DDCP shall have capability to scale, offset, and display proper analog value without field hardware modification. Controller shall convert analog input signals to digital values (A/D conversion) and convert digital values to analog outputs (D/A conversion) for modulating control purposes.
8. Failsafe hardware shall be provided such that BAS failures result in immediate return to local control. If controller uses database values from other controller and communication network fails or malfunctions, control loop outputs shall continue to function using last value received.
9. Controllers shall have ability to interface and communicate with central controller through a dedicated network.
10. Master, Slave and Remote TCP/IP control panels are allowed.
11. Provide lockable panel.

B. Master DD Panels:

1. Master DDCP are defined as having capabilities of direct connection to Ethernet using TCP/IP technology, serve as communications hub for other controllers on slower speed LAN, and have sufficient processor capabilities and RAM to implement all types of custom software applications. Master controllers shall have serial type input/output (I/O) ports to directly support operator workstations (portable PCs), standard ASCII dumb terminals, modems, and all types of printers.
2. Master controllers shall have uninterrupted real time clocks capable of time of day, week, and year information to the system as needed to perform software functions. Clock shall be programmed to reset twice a year to allow for Daylight Savings Time. Clocks in multiple Master Controllers shall be synchronized automatically to match designated Master Controller or workstation. Accuracy shall be within 1 second per day minimum.
3. Batteries shall maintain all volatile memory and real time clocks for a period of at least 72 hours during power failure. Batteries shall be maintenance free and have minimum life of 2 years. When power has been restored, the following shall occur automatically:

    a. Orderly startup of all controlled equipment (user defined).
    b. Continuation of all control algorithms.
    c. Data base revision.
    d. Log times of power interruption and restoration.
    e. Battery recharging.

4. Provide local visual indication and system annunciation of low battery power for each battery.

C. Slave DDC Panels:

1. Slave Controllers are defined as being the same as Master Controllers but without high speed Ethernet capabilities and master clock capabilities. Slave Controllers shall communicate with Master Controllers via low/medium speed network or direct serial or parallel data bus interface.

D. Application Specific DDC Panels:

1. Application specific DDCP are defined as having capabilities of direct connection to Ethernet using TCP/IP Technology, and have sufficient processor capabilities and RAM to implement remote metering of energy, flow, temperature, etc.
2. Batteries shall maintain all volatile memory and real time clocks for a period of at least 72 hours during power failure. Batteries shall be maintenance free and have minimum life of 2 years. When power has been restored, the following shall occur automatically:

    a. Orderly startup of all controlled equipment (user defined).
    b. Continuation of all control algorithms.
    c. Data base revision.
    d. Log times of power interruption and restoration.
    e. Battery recharging.
    f. Provide local visual indication and system annunciation of low battery power for each battery.

E. Power Supplies:

1. Power supplies shall operate on nominal 120 volt, 60 hertz, single phase power. All control panels shall be provided with surge and noise protection. Power fluctuation shall not affect control system. Include surge protection on telephone line. Size power supply for 100% spare capacity with zero diversity.
2. Power sources shall be enclosed to isolate 120V power from low voltage power.

F. Building Level DDCP Operator's Interface:

1. Provide communications port to connect display device for operator access to information and operating system functions, except database reports and graphics functions.
2. Display keyboards shall be alphanumeric with special dedicated keys for functions such as manual-auto, test, function, value and enter.
3. Keyboard/display units shall be able to display analog variables, binary conditions, point values and conditions, and other information required for analysis and adjustment.
4. Provide permanent panel mounted keyboard and display at each DDCP. If manufacturer does not offer dedicated panel mounted keyboard and display unit, permanently mount industrial grade rack mounted PC unit with proper software and hardware to interface with local DDCP.

2.2 DIRECT DIGITAL CONTROL SOFTWARE

A. General:

1. DDCP control strategies shall be Owner definable from operator terminals or workstations.
2. Software functions and algorithms shall be sufficient to enable implementation of control sequences as specified and able to maintain continuous control as intended.
3. Control functions shall include both mathematical and logical operators. Control algorithms shall include proportional, integral and derivative control (PID). Adaptive (self- tuning) PID loop parameters.
4. Provide access control (user defined passwords) for system operation. There shall be minimum of 3 access levels. First level shall allow system monitoring only. Second level

shall allow monitoring and setpoint, and scheduling revision. Third level shall allow modification of control algorithms. System shall return to secured (monitoring only) mode after 5 minutes of inactive operation.

5. Each Controller shall contain self-diagnostics that continuously monitor proper operation of panel.
6. If microprocessor malfunctions, control loop outputs shall continue to function using last value received from microprocessor.

B. Building / Floor Level DDCP Software:

1. Provide all standard master DDCP's software application program modules for performing energy management control functions such as time of day change of database values (programmed start/stop, temperature setbacks, etc.), supply air temperature reset based on space load demand, economizer control, optimum start/stop based on current indoor and outdoor psychrometrics, duty cycling and client tailored programs required for special applications such as VAV fan matching and supply fan control, enthalpy control, intermediate season or "dead band" control, totalizing, and holiday programming.
2. Provide manufacturer's standard operating system for real time control of system interactions, including database information requests/transfers by system hardware or by operators. Operating system shall also have the following additional capabilities (given operator has appropriate security access level):

    a. Display any database (point) value including measured values, controlled variables, setpoints, gain factors, and any other adjustable parameter.
    b. Change or override any database value.
    c. Error detection, correction, re-transmission of database values, arithmetic or logical faults.
    d. Alarm reporting including sending alarms to remote workstations on network or by modem.
    e. Alarm buffer to retain all alarms in order of importance without losing any alarms.
    f. Creating and displaying historical trend logging any value limited only by available memory.
    g. Create new variable database values (soft points) based on arithmetic calculation (including summation or totalizing) on other database values.
    h. Add new hardware points without overall BAS shutdown.

C. Application Specific DDCP Software:

1. Manufacturer's standard software for application specific type DDCP may be used only if control sequences can be implemented without modification. If control sequence cannot be accomplished with standard software, provide battery backed RAM or EEPROM DDCP capable of being programmed for specified control sequence.
2. Provide software for portable PC units to communicate with terminal controllers at the room level network. Software shall allow access to modify, delete, or create control strategies at room sensor location.

2.3 OPERATOR’S WORKSTATION

A. Not required.

2.4 NETWORK HARDWARE

A. Provide network interface hardware for each device connected to network. Each device shall have sufficient performance as not to degrade specified processing speed.

B. Provide network cabling with sufficient performance as not to degrade specified communication speed. Cabling shall be compatible with proposed system and shall comply with requirements specified in Section 230901 - Control Systems Integration.

C. Provide other network support devices that are required for proper operation of network, such as file servers, signal repeaters, network hubs, etc. Include in base bid all costs associated with upgrades of existing server to accomplish control requirements specified herein including trending of energy data.

PART 3 - EXECUTION

3.1 GENERAL

A. Install all control equipment in neat and workmanlike manner to satisfaction of Architect and Engineer.

B. Coordinate timely delivery of materials and supervise installation of control system and network cabling and devices.

C. Install DDC panels and network control devices in accessible locations.

3.2 OVERALL ARCHITECTURE

A. Provide hardware/software to update database in less than 1 second for fast-acting control loops such as pressure control, air or water volume control, and air handling unit temperature control, or 10 seconds or less for all other control loops.

B. Control loop software algorithm for each analog control loop shall reside on the same controller as all inputs and outputs required for that specific control loop.

C. Networks, which operate via polled response or other types of protocols that rely on central processors, file servers, or other such devices to maintain or manage peer-to-peer communications, shall have redundant components to maintain network in the event of failure at central device. Provide automatic changeover to redundant device upon failure of any central type processor without operator intervention.

D. Network shall be multi-drop digital transmission network. Network shall provide communication link between operator's workstation and all remote DDCP and field panels.

E. Each multi-drop trunk shall be within manufacturer's allowable line lengths without signal degradation. All multi-drop trunks shall be interfaced to system via standard EIA or other industry recognized interfaces so that single failure does not disrupt or halt network.

F. Communications between DDCP's and operator's workstations shall be peer-to-peer, allowing multiple users to access and use system simultaneously with no loss of system performance.

G. Provide levels of connected networks to connect all DDCP, including terminal DDCP. Communications to terminal devices shall be similar to capabilities and functions of other DDCP and shall be transparent to operator.

H. Number of nodes (devices connected) on any one network shall not exceed 50% of maximum node capacity published by equipment manufacturer. Provide additional hardware, (master DDCP, network controllers, etc.) to meet this requirement.

I. Alarm reports from DDCP shall not be impeded by use of either remote, or local monitor, nor control stations on network either in access mode or programming mode.

J. Provide transient voltage surge suppression devices for controllers and other electronic devices requiring separate line voltage power source.

3.3 DIRECT DIGITAL CONTROL PANELS

A. DDC Panel Usage:

1. Select Controller to provide speed of response required for each control loop type. Pressure, flow rate, and air handling unit temperature control must be via Master DDCP.
2. Each Controller shall have sufficient I/O capacity to perform specified control sequences and/or included points listed in any point schedules.
3. Analog and critical safety discrete control loops shall have inputs and outputs into/from the same Controller. Analog control loops for major equipment (chilled water system, hot water system, steam and condensate systems, air handling units, exhaust fans, etc.) shall have PID control.

B. Point Capacity:

1. Provide point capacity required plus 10% spare I/O point capacity in each distribution control panel and 25% spare I/O point capacity in each main control panel. Spare I/O point capacity is defined as terminal connections, which are ready to accept digital or analog inputs, dry contacts for digital outputs, and variable voltage or current terminals for analog outputs. Universal type points are acceptable for both discrete and analog type points. Spare points do not include any input or output conversion devices. Spare point capacity to provide equal number of AI, AO, DI, DO points.

C. Cabinets:

1. Provide local control cabinets for DDCPs. DDCP cabinets may be used directly if enclosures are rated for NEMA 1. Lockable cabinets shall utilize single master key. Provide 2 spare key sets to Owner.
2. Mount panel on wall at same height as adjacent/room electrical panels.

3.4 SOFTWARE

A. Software from panels shall be permanently stored on CD ROM and on at least one hard disk at operator's workstation or Web Application Server. Provide auto re-boot feature on power up from system failure. System failures shall not necessitate manual reprogramming to restore normal system function.

B. Provide the latest version of all standard software, including, operating system and control software. Include any software updates for period of one year coinciding with warranty period. No beta released software shall be used.

C. Provide additional copies of software for existing portable PCs to use modem or Internet to connect to control system as if it were local operator workstations. Provide the same security software plus use automatic call back feature to confirm originating number is valid user.

3.5 INITIAL PROGRAMMING

A. Control Contractor shall provide all initial programming of all controllers to accomplish sequences specified.

B. Provide back-up documentation per software manual submittals for all programs in both written and electronic media formats.

C. Program historical file for run-times and number of start/stops of all motor driven equipment and filters.

D. Program maintenance alarms based on run-times and number of start/stops for all motor driven equipment.

E. Program alarms using the following levels:

1. Level 1 - Maintenance alarm, requiring attention within 1 to 2 days. (Examples; 2-3° temperature variance from setpoint, 15-25 percent relative humidity variance, etc.)
2. Level 2 - Low Level Alarm, requiring attention within 8 hours, preferably during the same shift. (Examples; 4°F or more variance from setpoint, 30 percent relative humidity or more variance from setpoints, etc., excess start/stops per day, etc.)
3. Level 3 - Critical Alarm, requiring immediate attention. (Examples: non-operation of primary equipment, H-O-A overrides.)
4. Level 1 and 2 alarms shall not interrupt current user operation, but shall be logged into alarm summary file, indicating status, acknowledgment, and by whom. Level 3 alarms shall interrupt user via audible and/or flashing warning until acknowledged without losing any work in progress. When alarms are acknowledged, the program shall display point group or appropriate graphic display. Level 3 alarms shall also be logged into alarm summary file similar to Level 1 and 2 alarms.

3.6 POINT LIST

A. Provide all points required to implement control sequences specified, whether or not they are listed in schedules. In addition to control points, provide additional listed in point schedules.

B. All outputs, whether sequenced or not, shall have separate programmable hardware output.

C. Work with Owner to develop point naming convention prior to start of programming.

3.7 GRAPHICS PROGRAMMING

A. Program color graphic displays for each system as described herein. Graphic displays shall consist of pictorial presentations on LCD, flat panel display with text description system schematic or picture, alarm fields, and database fields for all associated points, including all dynamic input values, output values, setpoints, gains, time schedules, etc. Provide single keystroke access to text file description of control sequence(s) in detail.

B. Make use of color to highlight system components. Components of similar type shall use the same color for all graphics (example; all valves shall be yellow, etc.). Alarm fields shall be flashing white letters on red background. Affected component shall also turn red whenever alarm status is indicated. Database fields shall be white letters on black background and shall be dynamically updated and re-displayed on screen by periodically polling all database points not less than once every minute.

C. Display time and date. Display command line with English prompt in the same location on each graphic. Provide command to direct specific displays without accessing main menu. Provide means of displaying directory of screens. Arrange displays by group and type.

D. Graphic displays, shall be designed to be easily understood. When display screen is too cluttered due to size, limit information to important monitoring data. Provide sub-graphic(s) to display data not displayed on main display.

E. Graphics to be generated shall include, but not be limited to:

1. Site Plans, including utility monitoring for buildings being served.
2. Overall building plan. Includes location of mechanical rooms, electrical rooms, pumps, fans, etc.
3. Schematic type graphics for:

    a. Each air handling and distribution.
    b. Water Heaters.
    c. Emergency Generator
    d. Exhaust fans.
    e. Air terminal units.
    f. Mini-split units.

F. Pre-Configured Trends (Multi-point trends):

1. Setup a pre-configured trend for each air handler that plots all of the following parameters together for each performance group listed below, so that associated points can be viewed together. Trends shall provide a combined graphical display for each trend group listed, and data shall also be easily extracted as a group.
2. Air Handler - General Performance:

    a. Outside air temperature (°F)

3. Air Handler - Cooling & Heating Performance:

    a. Supply air temperature and setpoint (°F)

4. Air Handler – Fan Performance:

    a. Supply air flow (CFM)
    b. Supply fan VFD speed (Hz)
    c. Supply fan(s) power (kW) – sum if there are multiple supply fans
    d. Static pressure and setpoint for ductwork (inches w.g.)

G. Graphics Review:

1. Controls contractor shall provide an in person review of graphics with Owner's Representative, Engineer and Commissioning Agent. Comments shall be documented and implemented by the controls contractor.

H. Measurement and Verification Data:

1. General: Graphic display shall include page(s) for summary of building energy performance using key performance indicators (KPIs) for a quick, intuitive understanding of building energy performance. Controls contractor shall work with Commissioning Agent and/or Engineer to validate that all points noted in this section are reporting correctly and shall update where miscalculations are found.
2. All points (real and virtual) listed in this Specification or in the Control Sequences shall have trends initiated to record data points in 15 minute increments and saved for five years. Timestamps on points shall be normalized so that all points can be compared versus a common time stamp value. For example: Time stamps for two points shall be 8:15:00 rather than 8:13:29 and 8:16:14. Submit logical plan for how to normalize trended points and fill in missing trend data. At a minimum, missing data shall have a time stamp value and a blank record for large periods of missing data. If the missing data does not exceed 4 hours, then linear interpolation shall be used between the last values on either side of the missing data to fill in estimates for missing values. Indicate in the BAS any point that has more than 1% of the data was missing for the most recent three months. Exclude extraneous information from the trends, and ensure that each trend has the exact same number of data point with the exact same time stamps when trends cover the same time range.

END OF SECTION 230923

SECTION 232300 - REFRIGERANT PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Refrigerant pipes and fittings.
2. Refrigerants.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of valve, refrigerant piping, and piping specialty.

B. Shop Drawings:

1. Show layout of refrigerant piping and specialties, including pipe, tube, and fitting sizes; flow capacities; valve arrangements and locations; slopes of horizontal runs; oil traps; double risers; wall and floor penetrations; and equipment connection details.
2. Show piping size and piping layout, including oil traps, double risers, specialties, and pipe and tube sizes to accommodate, as a minimum, equipment provided, elevation difference between compressor and evaporator, and length of piping to ensure proper operation and compliance with warranties of connected equipment.
3. Show interface and spatial relationships between piping and equipment.
4. Shop Drawing Scale: 1/4 inch equals 1 foot.

1.4 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals.

1.6 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to 2010 ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

B. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."

C. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

1.7 PRODUCT STORAGE AND HANDLING

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

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Line Test Pressure for Refrigerant R-410A:

1. Suction Lines for Air-Conditioning Applications: 300 psig.
2. Suction Lines for Heat-Pump Applications: 535 psig.
3. Hot-Gas and Liquid Lines: 535 psig.

2.2 COPPER TUBE AND FITTINGS

A. Copper Tube: ASTM B 280, Type ACR.

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

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

D. Solder Filler Metals: ASTM B 32. Use 95-5 tin antimony or alloy HB solder to join copper socket fittings on copper pipe.

E. Brazing Filler Metals: AWS A5.8/A5.8M.

F. Flexible Connectors:

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

2.3 REFRIGERANTS

A. ASHRAE 34, R-410A: Pentafluoroethane/Difluoromethane.

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

a. Atofina Chemicals, Inc.
b. DuPont Company; Fluorochemicals Div.
c. Honeywell, Inc.; Genetron Refrigerants.
d. INEOS Fluor Americas LLC.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS FOR REFRIGERANT R-410A

A. Hot-Gas and Liquid Lines**,** and Suction Lines for Heat-Pump Applications: Copper, Type ACR drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.

B. Safety-Relief-Valve Discharge Piping: Copper, Type ACR, annealed- or drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.

3.2 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems; indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings.

B. Install refrigerant piping according to ASHRAE 15.

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

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping adjacent to machines to allow service and maintenance.

G. Install piping free of sags and bends.

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

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

J. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

K. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels as specified in Section 083113 "Access Doors and Frames" if valves or equipment requiring maintenance is concealed behind finished surfaces.

L. Install refrigerant piping in protective conduit where installed belowground.

M. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.

N. Slope refrigerant piping as follows:

1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
2. Install horizontal suction lines with a uniform slope downward to compressor.
3. Install traps and double risers to entrain oil in vertical runs.
4. Liquid lines may be installed level.

O. When brazing or soldering, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.

P. Before installation of steel refrigerant piping, clean pipe and fittings using the following procedures:

1. Shot blast the interior of piping.
2. Remove coarse particles of dirt and dust by drawing a clean, lintless cloth through tubing by means of a wire or electrician's tape.
3. Draw a clean, lintless cloth saturated with trichloroethylene through the tube or pipe. Continue this procedure until cloth is not discolored by dirt.
4. Draw a clean, lintless cloth, saturated with compressor oil, squeezed dry, through the tube or pipe to remove remaining lint. Inspect tube or pipe visually for remaining dirt and lint.
5. Finally, draw a clean, dry, lintless cloth through the tube or pipe.
6. Safety-relief-valve discharge piping is not required to be cleaned but is required to be open to allow unrestricted flow.

Q. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

R. Identify refrigerant piping and valves according to Section 230553 "Identification for HVAC Piping and Equipment."

S. Install sleeves for piping penetrations of walls, ceilings, and floors.

T. Install sleeve seals for piping penetrations of concrete walls and slabs.

U. Install escutcheons for piping penetrations of walls, ceilings, and floors.

3.3 PIPE JOINT CONSTRUCTION

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

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

C. Fill pipe and fittings with an inert gas (nitrogen or carbon dioxide), during brazing or welding, to prevent scale formation.

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

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."

1. Use Type BCuP (copper-phosphorus) alloy for joining copper socket fittings with copper pipe.
2. Use Type BAg (cadmium-free silver) alloy for joining copper with bronze or steel.

F. Threaded Joints: Thread steel 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 to 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. Steel pipe can be threaded, but threaded joints must be seal brazed or seal welded.

H. Welded Joints: Construct joints according to AWS D10.12M/D10.12.

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

3.4 HANGERS AND SUPPORTS

A. Comply with requirements for pipe hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet long.
2. Roller hangers and spring hangers for individual horizontal runs 20 feet or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.
5. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

C. Install hangers for copper tubing with the following maximum spacing and minimum rod diameters:

1. NPS 1/2: Maximum span, 60 inches; minimum rod, 1/4 inch.
2. NPS 5/8: Maximum span, 60 inches; minimum rod, 1/4 inch.
3. NPS 1: Maximum span, 72 inches; minimum rod, 1/4 inch.
4. NPS 1-1/4: Maximum span, 96 inches; minimum rod, 3/8 inch.
5. NPS 1-1/2: Maximum span, 96 inches; minimum rod, 3/8 inch.
6. NPS 2: Maximum span, 96 inches; minimum rod, 3/8 inch.
7. NPS 2-1/2: Maximum span, 108 inches; minimum rod, 3/8 inch.
8. NPS 3: Maximum span, 10 feet; minimum rod, 3/8 inch.
9. NPS 4: Maximum span, 12 feet; minimum rod, 1/2 inch.

3.5 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Comply with ASME B31.5, Chapter VI.
2. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in "Performance Requirements" Article.

    a. Fill system with nitrogen to the required test pressure.
    b. System shall maintain test pressure at the manifold gage throughout duration of test.
    c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
    d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.

B. Prepare test and inspection reports.

3.6 SYSTEM CHARGING

A. Charge system using the following procedures:

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

3.7 ADJUSTING

A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.

B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.

C. Adjust set-point temperature of air-conditioning or chilled-water controllers to the system design temperature.

D. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:

1. Open shutoff valves in condenser water circuit.
2. Verify that compressor oil level is correct.
3. Open compressor suction and discharge valves.
4. Open refrigerant valves except bypass valves that are used for other purposes.
5. Check open compressor-motor alignment and verify lubrication for motors and bearings.

E. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

END OF SECTION 232300

SECTION 23 31 13 - METAL DUCTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Single-wall rectangular ducts and fittings.
2. Single-wall round ducts and fittings.
3. Sheet metal materials.
4. Duct liner.
5. Sealants and gaskets.
6. Hangers and supports.
7. Seismic-restraint devices.

1.3 ACTION SUBMITTALS

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

1. Liners and adhesives.
2. Sealants and gaskets.
3. Seismic-restraint devices.

B. Shop Drawings:

1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
2. Factory- and shop-fabricated ducts and fittings.
3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
4. Elevation of top and bottom of ducts.
5. Fittings.
6. Reinforcement and spacing.
7. Seam and joint construction.
8. Penetrations through fire-rated and other partitions.
9. Equipment installation based on equipment being used on Project.
10. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
11. Hangers and supports, including methods for duct and building attachment, seismic restraints, and vibration isolation.

C. Delegated-Design Submittal:

1. Sheet metal thicknesses.
2. Joint and seam construction and sealing.
3. Reinforcement details and spacing.
4. Materials, fabrication, assembly, and spacing of hangers and supports.
5. Design Calculations: Calculations, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation for selecting hangers and supports and seismic restraints.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: A single set of plans or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.

B. Welding certificates.

C. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel in accordance with the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
2. AWS D9.1/D9.1M, "Sheet Metal Welding Code," for duct joint and seam welding.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Duct Design: 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 with performance requirements and design criteria indicated in "Duct Schedule" Article.

B. Structural Performance: Duct hangers and supports and seismic restraints shall withstand the effects of gravity and seismic loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and ASCE/SEI 7. Seismically brace duct hangers and supports in accordance with SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems."

C. Airstream Surfaces: Surfaces in contact with airstream shall comply with requirements in ASHRAE 62.1.

D. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment," and Section 7 - "Construction and System Startup."

E. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

F. Duct Dimensions: Unless otherwise indicated, all duct dimensions indicated on Drawings are inside clear dimensions and do not include insulation or duct wall thickness.

2.2 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

1. Construct ducts of galvanized sheet steel unless otherwise indicated.

B. Transverse Joints: Fabricate joints in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. For ducts with longest side less than 36 inches, select joint types in accordance with Figure 2-1.
2. For ducts with longest side 36 inches or greater, use flange joint connector Type T-22, T-24, T-24A, T-25a, or T-25b. Factory-fabricated flanged duct connection system may be used if submitted and approved by engineer of record.

C. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

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

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.

1. Construct ducts of galvanized sheet steel 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).

C. Transverse Joints: Select joint types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.

D. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
2. Fabricate flat-oval ducts larger than 72 inches in width (major dimension) with butt-welded longitudinal seams.

E. Tees and Laterals: Select types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.4 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: G90.
2. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304 or 316, as indicated in "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in "Duct Schedule" Article.

D. Factory- or Shop-Applied Antimicrobial Coating:

1. Apply to the surface of sheet metal that will form the interior surface of the duct. An untreated clear coating shall be applied to the exterior surface.
2. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
3. Coating containing the antimicrobial compound shall have a hardness of 2H, minimum, when tested in accordance with ASTM D 3363.
4. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested in accordance with UL 723; certified by an NRTL.
5. Shop-Applied Coating Color: Black.
6. Antimicrobial coating on sheet metal is not required for duct containing liner treated with antimicrobial coating.

E. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.

F. Tie Rods: Galvanized steel, 1/4-inch- minimum diameter for lengths 36 inches or less; 3/8-inch-minimum diameter for lengths longer than 36 inches.

G. Insulation Pins and Washers:

1. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch- diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick galvanized steel; with beveled edge sized as required to hold insulation securely in place, but not less than 1-1/2 inches in diameter.

2.5 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 in accordance with UL 723; certified by an NRTL.

B. Two-Part Tape Sealing System:

1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
2. Tape Width: [3 inches] [4 inches] [6 inches].
3. Sealant: Modified styrene acrylic.
4. Water resistant.
5. Mold and mildew resistant.
6. Maximum Static-Pressure Class: 10-inch w.g., positive and negative.
7. Service: Indoor and outdoor.
8. Service Temperature: Minus 40 to plus 200 deg F.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.

C. Water-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Solids Content: Minimum 65 percent.
3. Shore A Hardness: Minimum 20.
4. Water resistant.
5. Mold and mildew resistant.
6. VOC: Maximum 75 g/L (less water).
7. Maximum Static-Pressure Class: 10-inch w.g., positive and negative.
8. Service: Indoor or outdoor.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

D. 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. Maximum Static-Pressure Class: 10-inch w.g., positive or negative.
9. Service: Indoor or outdoor.
10. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

E. 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.

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

G. Round Duct Joint O-Ring Seals:

1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch w.g. and shall be rated for 10-inch w.g. 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.

2.6 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Galvanized-steel rods and nuts.

B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.

E. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A 492.

F. Steel Cable End Connections: Galvanized-steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

G. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

H. Trapeze and Riser Supports:

1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
2. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.
3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

2.7 SEISMIC-RESTRAINT DEVICES

A. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an agency acceptable to authorities having jurisdiction.

1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least [four] <Insert number> times the maximum seismic forces to which they will be subjected.

B. Channel Support System: Shop- or field-fabricated support assembly made of slotted steel channels rated in tension, compression, and torsion forces and with accessories for attachment to braced component at one end and to building structure at the other end. Include matching components and corrosion-resistant coating.

C. Restraint Cables: ASTM A 603, galvanized steel cables with end connections made of galvanized-steel assemblies with brackets, swivel, and bolts designed for restraining cable service; and with an automatic-locking and clamping device or double-cable clips.

D. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod.

E. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type. Select anchor bolts with strength required for anchor and as tested in accordance with ASTM E 488/E 488M.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and coordination drawings.

B. Install ducts in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

C. Install ducts in maximum practical lengths with fewest possible joints.

D. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

E. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

F. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

G. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

H. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

I. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.

J. Install fire, combination fire/smoke, and smoke dampers where indicated on Drawings and as required by code, and by local authorities having jurisdiction. Comply with requirements in specifications for fire and smoke dampers and specific installation requirements of the damper UL listing.

K. Install heating coils, cooling coils, air filters, dampers, and all other duct-mounted accessories in air ducts where indicated on Drawings.

L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials both before and after installation. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."

1. All duct openings shall be sealed with plastic, end caps, or other approved protective coverings immediately after fabrication and shall remain sealed during storage, transport, and installation until final connection.
2. Ductwork shall be stored off the ground on dunnage, racks, or other approved supports to prevent contact with soil, standing water, or construction debris.
3. Duct interiors shall be protected from moisture, dust, and construction debris at all times.

M. At the time of installation, duct sections shall be visually inspected for cleanliness. Any duct section found to contain construction debris shall be cleaned by vacuum or wiping prior to installation. Ducts shall be maintained in visibly clean condition throughout construction.

N. Elbows: Use long-radius elbows wherever they fit.

1. Fabricate 90-degree rectangular mitered elbows to include turning vanes.
2. Fabricate 90-degree round elbows with a minimum of three segments for 12 inches and smaller and a minimum of five segments for 14 inches and larger.

O. Branch Connections: Use lateral or conical branch connections.

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 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 DUCTWORK EXPOSED TO WEATHER

A. All external joints are to have secure watertight mechanical connections. Seal all openings to provide weatherproof construction.

B. Construct ductwork to resist external loads of wind, snow, ice, and other effects of weather. Provide necessary supporting structures.

C. Single Wall:

1. Ductwork shall be galvanized steel with G90 minimum coating.

    a. Before insulating the exterior ductwork shall be painted with an exterior rated to help reduce corrosion. Paint materials and application requirements are specified in specification for "Exterior Painting."

2. Where ducts have external insulation, provide weatherproof aluminum jacket. See specification for "Duct Insulation."

3.4 DUCT SEALING

A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

B. Seal ducts at a minimum to the following seal classes in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":

1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
2. Outdoor, Supply-Air Ducts: Seal Class A.
3. Outdoor, Exhaust Ducts: Seal Class C.
4. Outdoor, Return-Air Ducts: Seal Class C.

5. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch w.g. and Lower: Seal Class B.
6. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch w.g.: Seal Class A.
7. Unconditioned Space, Exhaust Ducts: Seal Class C.
8. Unconditioned Space, Return-Air Ducts: Seal Class B.
9. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch w.g. and Lower: Seal Class C.
10. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch w.g.: Seal Class B.
11. Conditioned Space, Exhaust Ducts: Seal Class B.
12. Conditioned Space, Return-Air Ducts: Seal Class C.

3.5 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.
2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
3. Use powder-actuated concrete fasteners for standard-weight aggregate 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.
5. Do not use powder-actuated concrete fasteners for seismic restraints.

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum interval of 16 feet.

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.6 SEISMIC-RESTRAINT-DEVICE INSTALLATION

A. Install ducts with hangers and braces designed to support the duct and to restrain against seismic forces required by applicable building codes. Comply with SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems." ASCE/SEI 7.

1. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.

2. Brace a change of direction longer than 12 feet.

B. Select seismic-restraint devices with capacities adequate to carry present and future static and seismic loads.

C. Install cables so they do not bend across edges of adjacent equipment or building structure.

D. Install cable restraints on ducts that are suspended with vibration isolators.

E. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction.

F. Attachment to Structure: If specific attachment is not indicated, anchor bracing and restraints to structure, to flanges of beams, to upper truss chords of bar joists, or to concrete members.

G. Drilling for and Setting Anchors:

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

3.7 CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Section 233300 "Air Duct Accessories."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.8 PAINTING

A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."

3.9 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Leakage Tests:

1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
2. Test the following systems:

    a. Ducts with a Pressure Class Higher Than 2-Inch w.g.: Test representative duct sections totaling no less than 100 percent of total installed duct area for each designated pressure class.

3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
4. Testing of each duct section is to be performed with access doors, coils, filters, dampers, and other duct-mounted devices in place as designed. No devices are to be removed or blanked off so as to reduce or prevent additional leakage.
5. Test for leaks before applying external insulation.
6. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
7. Give seven days' advance notice for testing.

C. Duct System Cleanliness Tests:

1. Visually inspect duct system to ensure that no visible contaminants are present. Where visual inspection identifies unacceptable contamination, NADCA Method 3 testing and mechanical cleaning shall be required.
2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness in accordance with "Description of Method 3 - NADCA Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."

    a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.

D. Duct system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports and obtain witness’s signature. Tests shall be witnessed by Engineer, Commissioning Agent, or Owner’s Representative.

3.10 DUCT CLEANING

A. Clean new duct system(s) before testing, adjusting, and balancing only where visual inspection indicates the presence of debris, contamination, or foreign material. Where ductwork has been properly protected during construction and is verified to be visibly clean, mechanical duct cleaning is not required.

B. For cleaning of existing ductwork, see Section 230130.52 "Existing HVAC Air Distribution System Cleaning."

C. Use duct cleaning methodology as indicated in NADCA ACR.

D. Use service openings for entry and inspection.

1. Provide openings with access panels appropriate for duct static-pressure and leakage class at dampers, coils, and any other locations where required for inspection and cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Section 233300 "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.

E. 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.

F. 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.

G. Mechanical Cleaning Methodology:

1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.

5. Clean coils and coil drain pans in accordance with NADCA ACR. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
6. Provide drainage and cleanup for wash-down procedures.
7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents in accordance with manufacturer's written instructions after removal of surface deposits and debris.

3.11 STARTUP

A. Air Balance: Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.12 DUCT SCHEDULE

A. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:

1. Fabricate all ducts to achieve SMACNA pressure class, seal class, and leakage class as indicated below.

B. Supply Ducts:

1. Ducts Connected to Fan Coil Units and Terminal Units:

a. Pressure Class: Positive 2-inch w.g.
b. Minimum SMACNA Seal Class: C.
c. SMACNA Leakage Class for Rectangular: 8.
d. SMACNA Leakage Class for Round and Flat Oval: 8.

2. Ducts Connected to Variable-Air-Volume Air-Handling Units:

a. Pressure Class: Positive 4-inch w.g.
b. Minimum SMACNA Seal Class: A.
c. SMACNA Leakage Class for Rectangular: 4.
d. SMACNA Leakage Class for Round and Flat Oval: 2

3. Ducts Connected to Equipment Not Listed Above:

a. Pressure Class: Positive 3-inch w.g.
b. Minimum SMACNA Seal Class: A.
c. SMACNA Leakage Class for Rectangular: 4.
d. SMACNA Leakage Class for Round and Flat Oval: 2

C. Return Ducts:

1. Ducts Connected to Fan Coil Units and Terminal Units:

a. Pressure Class: Positive 2-inch w.g.
b. Minimum SMACNA Seal Class: C.
c. SMACNA Leakage Class for Rectangular: 8.

2. Ducts Connected to Air-Handling Units:

    a. Pressure Class: Positive 3-inch w.g.
    b. Minimum SMACNA Seal Class: A.
    c. SMACNA Leakage Class for Rectangular: 4.
    d. SMACNA Leakage Class for Round and Flat Oval: 2

3. Ducts Connected to Equipment Not Listed Above:

    a. Pressure Class: Positive 3-inch w.g.
    b. Minimum SMACNA Seal Class: A.
    c. SMACNA Leakage Class for Rectangular: 4.
    d. SMACNA Leakage Class for Round and Flat Oval: 2

D. Exhaust Ducts:

1. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:

    a. Pressure Class: Negative 3-inch w.g.
    b. Minimum SMACNA Seal Class: B if negative pressure, and A if positive pressure.
    c. SMACNA Leakage Class for Rectangular: 8.
    d. SMACNA Leakage Class for Round and Flat Oval: 4.

2. Ducts Connected to Fans Exhausting Fume Hood, Laboratory, and Process (ASHRAE 62.1, Class 3 and Class 4) Air:

    a. Type 316, stainless-steel sheet.
    b. Pressure Class: Positive or negative 3-inch w.g.
    c. Minimum SMACNA Seal Class A.
    d. SMACNA Leakage Class 2
    e. Airtight

E. Intermediate Reinforcement:

1. Galvanized-Steel Ducts: Galvanized steel.
2. Stainless-Steel Ducts:

    a. Exposed to Airstream: Match duct material.

F. Elbow Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

    a. Velocity 1000 fpm or Lower:

        1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
        2) Mitered Type RE 4 without vanes.

    b. Velocity 1000 to 1500 fpm:

1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

c. Velocity 1500 fpm or Higher:

1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

2. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

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) Velocity 1000 fpm or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
2) Velocity 1000 to 1500 fpm: 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
3) Velocity 1500 fpm or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
4) Radius-to Diameter Ratio: 1.5.

b. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.
c. Round Elbows, 14 < Inches and Larger in Diameter: Standing seam

G. Branch Configuration:

1. 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.
b. Rectangular Main to Round Branch: Conical spin in.

2. 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." Saddle taps are permitted in existing duct.

    a. Velocity 1000 fpm or Lower: 90-degree tap.
    b. Velocity 1000 to 1500 fpm: Conical tap.
    c. Velocity 1500 fpm or Higher: 45-degree lateral.

END OF SECTION 233113

SECTION 233300 - AIR DUCT ACCESSORIES

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:

1. Combination fire-and-smoke dampers.
2. Duct access doors.
3. Dynamic multiple blade fire dampers.
4. Static fire dampers.
5. Smoke dampers.
6. Volume control dampers.
7. Flexible duct connections.
8. Duct test holes.
9. Static pressure gauges.

1.02 SUBMITTALS

A. Submittal Procedures: Refer to Division 01 for Submittal procedures.

B. Shop Drawings: Indicate for shop fabricated assemblies including volume control dampers, duct access doors, and duct test holes.

C. Product Data: Submit data for shop fabricated assemblies and hardware used.

D. Product Data: Submit for the following. Include where applicable electrical characteristics and connection requirements.

1. Fire dampers including locations and ratings.
2. Smoke dampers including locations and ratings.
3. Backdraft dampers.
4. Flexible duct connections.
5. Volume control dampers.
6. Duct access doors.
7. Duct test holes.

E. Product Data: For fire dampers, smoke dampers, and combination fire and smoke dampers submit the following:

1. Complete schedule of all dampers.
2. Include UL ratings, dynamic ratings, leakage, pressure drop and maximum pressure data.
3. Indicate materials, construction, dimensions, and installation details.
4. Damper pressure drop ratings based on tests and procedures performed in accordance with AMCA 500.
5. Damper velocity rating.
6. Type of actuator, voltage, number of actuators, mounting position, running and

holding amperes, torque, and temperature rating.

F. Manufacturer's Installation Instructions: Submit for Fire and Combination Smoke and Fire Dampers.

G. Manufacturer's Certificate: Certify products meet or exceed specified requirements.

1.03 CLOSEOUT SUBMITTALS

A. Execution and Closeout Requirements: Refer to Division 01 for Closeout procedures.

B. Project Record Documents: Record actual locations of fire and smoke dampers, access doors, and test holes.

C. Operation and Maintenance Data: Submit for Combination Smoke and Fire Dampers.

1.04 QUALITY ASSURANCE

A. Dampers tested, rated and labeled in accordance with the latest UL requirements.

B. Damper pressure drop ratings based on tests and procedures performed in accordance with AMCA 500.

C. Maintain one copy of each document on site.

1.05 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years' experience.

1.06 PRE-INSTALLATION MEETINGS

A. Administrative Requirements: Refer to Division 01 for Pre-installation meeting.

B. Convene minimum one week prior to commencing work of this section.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Product Requirements: Refer to Division 01 for Product storage and handling requirements.

B. Protect dampers from damage to operating linkages and blades.

C. Delivery: Deliver materials to site in manufacturer's original, unopened containers and packaging, with labels clearly indicating manufacturer and material.

D. Storage: Store materials in a dry area indoor, protected from damage.

E. Handling: Handle and lift dampers in accordance with manufacturer's instructions. Protect materials and finishes during handling and installation to prevent damage.

1.08 FIELD MEASUREMENTS

A. Verify field measurements prior to fabrication.

1.09 COORDINATION

A. Administrative Requirements: Refer to Division 01 for Coordination and project conditions.

B. Coordinate Work where appropriate with building control Work.

1.10 WARRANTY

A. Execution and Closeout Requirements: Refer to Division 01 for Product warranties and product bonds.

1.11 TESTING

A. Provide testing of all fire, smoke and fire smoke dampers for initial test.

1.12 EXTRA MATERIALS

A. Execution and Closeout Requirements: Refer to Division 01 for Spare parts and maintenance products.

B. Furnish two of each size and type of fusible link.

PART 2 PRODUCTS

2.01 BACK-DRAFT DAMPERS

A. Product Description: Multi-Blade, back-draft dampers: Parallel-action, gravity-balanced, Galvanized 16-gauge thick steel, or extruded aluminum. Blades, maximum 6-inch width, center pivoted, with felt or flexible vinyl sealed edges. Blades linked together in rattle-free manner with 90-degree stop, steel ball bearings, and plated steel pivot pin. Furnish dampers with adjustment device to permit setting for varying differential static pressure.

2.02 COMBINATION FIRE AND SMOKE DAMPERS

A. Fabricate in accordance with NFPA 90A, UL 555, and UL 555S.

B. Dynamic Closure Rating: Dampers classified for dynamic closure to 2000 fpm and 4 inches wg static pressure, or as required for duct velocities above 2000 fpm.

C. Leakage Rating: Class II, maximum of 20 cfm at 4 inches wg differential pressure.

D. Damper Temperature Rating: 350 degrees F.

E. Frame: 16-gauge, galvanized steel.

F. Blades:

1. Style: Airfoil-shaped, single piece, double skin.
2. Action: Opposed.
3. Orientation: Horizontal.
4. Material: Minimum 14-gauge equivalent thickness, galvanized steel.
5. Width: Maximum 6 inches.

G. Bearings: Stainless steel pressed into frame.

H. Seals: Silicone blade edge seals and flexible stainless steel jamb seals.

I. Linkage: Concealed in frame.

J. Release Device: Close in controlled manner and allow damper to be automatically reset.

K. Actuator:

1. Type: Electric 120 volt, 60 hertz, two-position, fail close. For 120V actuators, maximum running current shall be 0.3 amps for 70 in–lb of torque. Provide label indicating voltage.
2. Mounting: External.
3. Provide one (1) actuator per damper. Any additional actuators must be approved by Engineer.
4. Temperature rating 350 degree F.

L. Fusible Link Release Temperature: 165 degrees F.

M. Finish: Mill galvanized.

N. Factory installed sleeve and mounting angles. Furnish silicone caulk factory applied to sleeve at damper frame to comply with leakage rating requirements.

2.03 DUCT ACCESS DOORS

A. Flexible, and as indicated on Drawings.

B. Fabrication: Rigid and close fitting of galvanized steel with sealing gaskets and quick fastening locking devices. For insulated ductwork, furnish minimum 1-inch-thick insulation with sheet metal cover.

1. Less than 12 inches square, secure with sash locks.
2. Up to 18 inches Square: Furnish two hinges and two sash locks.
3. Larger sizes: two compression latches with outside and inside handles.
4. Access panels with sheet metal screw fasteners are not acceptable.

2.04 DYNAMIC FIRE DAMPERS (MULTIPLE BLADE)

A. Fabricate in accordance with NFPA 90A and UL 555.

B. Dynamic Closure Rating: Dampers classified for dynamic closure to 2000 fpm and 4 inches wg static pressure, or as required for duct velocities above 2000 fpm.

C. Construction:

1. Frame: Minimum 16-gauge galvanized hat-shaped steel.
2. Blades:

   a. Style: Single piece airfoil-shaped construction with 14-gauge equivalent thickness, maximum 6" wide, with stainless steel flexible metal jamb seals and silicone blade edge seals, ½" plated steel hex axles.
   b. Action: Spring closure upon fusible link release.

3. Closure Springs: Type 301 stainless steel, constant force type, if required.
4. Minimum 20-gauge integral sleeve, 12 inches long.

D. Fusible Link Release Temperature: 165 degrees F.

E. Mounting: Vertical or horizontal as indicated on Drawings.

F. Finish: Mill galvanized.

2.05 STATIC FIRE DAMPERS

A. Fire Rating: UL 555 classified and labeled as a static fire damper.

B. Air Flow Rating: UL approved for dual directional air flow.

C. Integral Sleeve Frame: Minimum 20 gauge by 12 inches roll formed, galvanized steel.

1. Factory Sealant: Apply to dampers in HVAC systems with pressures to maximum 4 inches wg.

D. Blades:

1. Style: Curtain type, in airstream.
2. Action: Spring or gravity closure upon fusible link release.
3. Orientation: Horizontal.
4. Material: Minimum 24-gauge roll formed, galvanized steel.

E. Closure Springs: Type 301 stainless steel, constant force type, if required.

F. Temperature Release Device:

1. Fusible link, 165 degrees F.

G. Finish: Mill galvanized.

H. Picture Frame Mounting Angles:

1. One-piece, roll formed retaining angles 1-1/2 x 1-1/2 inches.
2. Factory matched and shipped attached to damper.

2.06 SMOKE DAMPERS

A. Fabricate in accordance with NFPA 90A and UL 555S.

B. Dynamic Closure Rating: Dampers classified for dynamic closure to 2000 fpm and 4 inches wg static pressure, or as required for duct velocities above 2000 fpm.

C. Leakage Rating: Class II, maximum of 20 cfm at 4 inches wg differential pressure.

D. Damper Temperature Rating: 350 degrees F.

E. Frame: 16-gauge, galvanized steel.

F. Blades:

1. Style: Airfoil-shaped, single piece, double skin.
2. Action: Opposed.
3. Orientation: Horizontal.
4. Material: Minimum 14-gauge equivalent thickness, galvanized steel.
5. Width: Maximum 6 inches.

G. Bearings: Stainless steel pressed into frame.

H. Seals: Silicone blade edge seals and flexible stainless steel jamb seals.

I. Linkage: Concealed in frame.

J. Actuator:

1. Type: Electric 120-volt, 60 hertz, two-position, fail close. Provide label indicating voltage.
2. Mounting: External.

K. Sleeve: Factory installed 20-gauge sleeve, minimum 12 inches long.

L. Finish: Mill galvanized.

2.07 VOLUME CONTROL DAMPERS

A. Manufacturers

1. Acceptable manufacturers are:

a. Nailor
b. Ruskin
c. Metal Form
d. Air Balance
e. Pottoroff
f. Louvers and Dampers

B. Fabricate in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible, and in accordance with specifications below.

C. Manual Dampers:

1. Material: Same gauge as duct to 24 inches size in both dimensions, and two gauges heavier for sizes over 24 inches.
2. Blade: Fabricate of double thickness sheet metal to streamline shape, secured with continuous hinge or rod.
3. Operator: Minimum 1/4-inch diameter rod in self-aligning, universal joint action, flanged bushing with set screw.
4. Single Blade Dampers area acceptable for duct sizes smaller than 12x12 inches.

D. Multi-Blade Damper: Fabricate of opposed blade pattern with maximum blade sizes 8 x 72 inches. Assemble center and edge crimped blades in prime coated or galvanized frame channel with suitable hardware.

E. End Bearings: Except in round ductwork 12 inches and smaller, furnish end bearings. On multiple blade dampers, furnish oil-impregnated nylon or sintered bronze bearings. Furnish closed end bearings on ducts having pressure classification over 2 inches wg.

F. Quadrants:

1. Furnish locking, indicating quadrant regulators on single and multi-blade dampers.
2. On insulated ducts mount quadrant regulators on standoff mounting brackets, bases, or adapters.
3. Where rod lengths exceed 30 inches furnish regulator at both ends.

2.08 FLEXIBLE DUCT CONNECTIONS

A. Fabricate in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible, and as indicated on Drawings.

B. Connector: Fabric crimped into metal edging strip.

1. Fabric: UL listed fire-retardant neoprene coated woven glass fiber fabric conforming to NFPA 90A, minimum density 30 oz per sq yd.
2. Net Fabric Width: Approximately 3inches wide.
3. Metal: 3-inch wide, 24-gauge galvanized steel.

2.09 DUCT TEST HOLES

A. Permanent Test Holes: Factory fabricated, airtight flanged fittings with screw cap. Furnish extended neck fittings to clear insulation.

2.10 STATIC PRESSURE GAUGES

A. Dial Gauges: 3-1/2-inch diameter dial in metal case, diaphragm actuated, black figures on white background, front calibration adjustment, 2 percent of full-scale accuracy.

B. Inclined Manometer: Plastic with red liquid on white background with black figures, front calibration adjustment, 3 percent of full-scale accuracy.

C. Accessories: Static pressure tips with compression fittings for bulkhead mounting, 1/4-inch diameter tubing.

2.11 BAROMETRIC RELIEF DAMPER AND ROOF VENTILATOR (STAIR)

A. RELIEF DAMPER: Greenheck EM-10 with adjustable pressure control (APC) accessory, or approved equal, 316 stainless steel frame, axles and blade, EPDM jamb seals heavy gauge 6063T5 extruded aluminum channel frame (0.125 in. thick) with 3-1/8 in. (79mm) depth; blades from 0.070 in. (1.8mm) 6063T5 extruded aluminum; 3/4 in. (19mm) dia. metallic axles turning in acetal bearings; damper shall be equipped with extruded vinyl blade seals; and internal 1Ú8 in. (3mm) plated steel blade-to-blade linkage with counterbalance weights. Damper manufacturer's printed application and performance data including pressure, velocity and temperature limitations shall be submitted for approval showing damper suitable for pressures to 10 in. wg (2491 Pa), velocities to 3500 fpm (18 m/s) and temperatures to 180°F (82ºC). Testing and ratings to be in accordance with AMCA Standard 500-D.

B. ROOF VENTILATOR: Greenheck FGR or approved equal, aluminum, 5 inch base, birdscreen, roof curb with two-inch insulation, 1 inch thick hood insulation liner, insect screen.

PART 3 EXECUTION

3.01 EXAMINATION

A. Administrative Requirements: Refer to Division 01 for Coordination and project conditions.

B. Put tape on damper heads.

C. Verify rated walls are ready for fire damper installation.

D. Verify ducts and equipment installations are ready for accessories.

E. Check location of air outlets and inlets and make necessary adjustments in position to conform to architectural features, symmetry, and lighting arrangement.

3.02 INSTALLATION.

A. Install in accordance with NFPA 90A, and follow SMACNA HVAC Duct Construction Standards - Metal and Flexible. Refer to Section 23 31 00 for duct construction and pressure class.

B. Install backdraft dampers on exhaust fans or exhaust ducts nearest to outside and where indicated on Drawings.

C. Provide a volume damper at all branch duct takeoffs from mains for all return and exhaust duct and all supply ducts for single zone systems or downstream of terminal boxes.

1. A volume damper is not required downstream of a terminal box with only one outlet.
2. Provide volume dampers on branch ducts for all diffusers downstream of terminal boxes where there is more than one diffuser.

D. Duct Access Doors: Install duct access doors at the following locations and as indicated on Drawings:

1. Upstream of each reheat coil.
2. At each automatic control damper.
3. At each fire damper and smoke damper.
4. Upstream of each duct smoke detector.
5. Install at locations for cleaning kitchen exhaust ductwork in accordance with NFPA 96.

E. Access Door Sizes: Install minimum 8 x 8 inch size for hand access, 18 x 18 inch size for shoulder access, and as indicated on Drawings. Review locations prior to fabrication.

F. Install temporary duct test holes and required for testing and balancing purposes. Cut or drill in ducts. Cap with neat patches, neoprene plugs, threaded plugs, or threaded or twist-on metal caps.

G. Install fire dampers, combination fire and smoke dampers and smoke dampers at locations as indicated on Drawings. Install with required perimeter mounting angles, sleeves, breakaway duct connections, corrosion resistant springs, bearings, bushings and hinges.

1. Install smoke dampers and combination smoke and fire dampers in accordance with NFPA 92A.
2. Install dampers square and free from racking with blades running horizontally.
3. Do not compress or stretch damper frame into duct or opening.
4. Handle damper using sleeve or frame. Do not lift damper using blades, actuator, or jack shaft.
5. Install bracing for multiple section assemblies to support assembly weight and to hold against system pressure. Install bracing as needed.
6. Install actuators externally. All actuators shall be accessible.

H. Access doors. Coordinate with other trades and provide access doors where necessary in

gypboard ceiling or walls to provide access to dampers and other duct accessories.

3.03 INSTALLATION - GAUGES

A. Install static pressure gauges to measure across filters and filter banks, (inlet to outlet). On multiple banks, provide manifold and single gauge.

B. Provide instruments with scale ranges selected according to service with largest appropriate scale.

3.04 DEMONSTRATION

A. Execution and Closeout Requirements: Refer to Division 01 for Requirements for demonstration and training.

B. Demonstrate re-setting of fire dampers to Owner's representative.

END OF SECTION 233300

SECTION 23 34 00 - HVAC FANS

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:

1. Sidewall mounted propeller fans.

1.2 PERFORMANCE REQUIREMENTS

A. Motors. Provide shaft grounding ring on all motors 5 hp and larger.

1.3 SUBMITTALS

A. Submittal Procedures: Refer to Division 1 for Submittal procedures.

B. Shop Drawings: Indicate size and configuration of fan assembly, mountings, weights, ductwork and accessory connections.

C. Product Data: Submit data on each type of fan and include accessories, fan curves with specified operating point plotted, power, RPM, sound power levels for both fan inlet and outlet at rated capacity, electrical characteristics and connection requirements.

D. Manufacturer's Installation Instructions: Submit fan manufacturer’s instructions.

E. Manufacturer's Certificate: Certify products meet or exceed specified requirements.

1.4 CLOSEOUT SUBMITTALS

A. Execution and Closeout Requirements: Refer to Division 1 for Closeout procedures.

B. Operation and Maintenance Data: Submit instructions for lubrication, motor and drive replacement, spare parts list, and wiring diagrams.

1.5 QUALITY ASSURANCE

A. Performance Ratings: Conform to AMCA 210 and bear AMCA Certified Rating Seal.

B. Sound Ratings: AMCA 301, tested to AMCA 300 and bear AMCA Certified Sound Rating Seal.

C. UL Compliance: UL listed and labeled, designed, manufactured, and tested in accordance with UL 705.

D. Balance Quality: Conform to AMCA 204.

E. Energy Recovery Unit Wheel Energy Transfer Rating: Meet ARI 1060.

F. Maintain one copy of each document on site.

1.6 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum five years experience.

B. Installer: Company specializing in performing Work of this section with minimum five years experience.

C. Product Requirements: Refer to Division 1 for Product storage and handling requirements.

D. Protect motors, shafts, and bearings from weather and construction dust.

1.7 FIELD MEASUREMENTS

A. Verify field measurements prior to fabrication.

1.8 WARRANTY

A. Execution and Closeout Requirements: Refer to Division 1 for Product warranties and product bonds.

1.9 EXTRA MATERIALS

A. Execution and Closeout Requirements: Refer to Division 1 for Spare parts and maintenance products.

B. Furnish two sets of belts for each fan.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Acceptable manufacturers are:

1. Greenheck Corp
2. Loren Cook Corp
3. Carnes
4. Penn Ventilator
5. ACME Fans
6. Aerovent Fans
7. Barry Blower
8. Twin City

2.2 DIRECT DRIVE SIDEWALL MOUNTED PROPELLER FANS

A. Fan Unit: Sidewall, mounted applications.

B. Propeller: constructed of cast aluminum. Securely attached to motor shaft with a standard square key, set screw and tapered bushing. Statically and dynamically balanced in accordance with AMCA Standard 204-05. The propeller and fan inlet will be aligned and shall have precise running tolerances for maximum performance and operating efficiency.

C. Motor:

1. Electronically Commutated Motor

   a. Motor Enclosure: Open Drip-Proof
   b. Electronic commutation type motor (ECM) specifically designed for fan applications. AC induction type motors are not acceptable. Examples of unacceptable motors are: Shaded Pole, Permanent Split Capacitor (PSC), Split Phase, Capacitor Start and 3 phase induction type motors.
   c. Motors are permanently lubricated, heavy duty ball bearing type to match with the fan load and pre-wired to the specific voltage and phase.
   d. Internal motor circuitry to convert AC power supplied to the fan to DC power to operate the motor or integrated variable frequency drive.
   e. Motor shall be speed controllable down to 20% of full speed (80% turndown). Speed shall be controlled by either a potentiometer dial mounted at the motor or by a 0-10 VDC signal.
   f. Motors can achieve up to 95% efficiency (model and horsepower dependent).

2. Drive Frame:
   a. Drive frames and fan panels shall be bolted construction.
   b. Drive frame assemblies and fan panels shall be galvanized steel or painted steel.
   c. Drive frame shall be formed steel and fan panels shall have pre-punched mounting holes, formed flanges, and a deep formed venturi.

3. Disconnect Switch:

   a. NEMA Rated: 1
   b. Positive electrical shut-off.
   c. Wired from fan motor to junction box.

D. Accessories:

1. Closure Angles: set of mounting flanges shall be available for field installation to close off the interior wall opening for a finished appearance.
2. Backdraft Damper: Gravity actuated, aluminum multiple blade construction, felt edged with offset hinge pin, nylon bearings, blades linked.
3. Damper Guard:
   a. Guard Frame Material: Aluminum
   b. Shall completely enclose the damper or wall opening on the discharge side of the fan.
4. Wall Housing.
5. Wall Collar.

6. Motor Side Guard.
7. Propeller Guard.
8. Weatherhood Kit: Birdscreen

PART 3 EXECUTION

3.1 EXAMINATION

A. Administrative Requirements: Refer to Division 1 for Coordination and project conditions.

B. Verify roof curbs are installed and dimensions are as instructed by manufacturer.

3.2 INSTALLATION

A. Secure fans and gravity ventilators with cadmium plated steel lag screws to roof curb.

B. Suspended Fans: Install flexible connections between fan and ductwork. Ensure metal bands of connectors are parallel with minimum one inch flex between ductwork and fan while running.

C. Install backdraft dampers on inlet to roof and wall exhaust fans and gravity ventilators used in relief air applications.

D. Install safety screen where inlet or outlet is exposed.

E. Pipe scroll drains to nearest floor or roof drain.

F. Install backdraft dampers on discharge of centrifugal fans and as indicated on Drawings.

G. Provide sheaves required for final air balance.

H. Provide gravity or motorized backdraft dampers on all exhaust or outside air supply fans as noted on plans.

3.3 MANUFACTURER'S FIELD SERVICES

A. Quality Requirements: Refer to Division 1 for Requirements for manufacturer’s field services.

B. Furnish services of factory trained representative for minimum of one day to start-up, calibrate controls, and instruct Owner on operation and maintenance. Furnish start-up report.

3.4 CLEANING

A. Execution and Closeout Requirements: Refer to Division 1 for Requirements for cleaning.

B. Vacuum clean inside of fan cabinet.

3.5 DEMONSTRATION

A. Execution and Closeout Requirements: Refer to Division 1 for Requirements for demonstration and training.

B. Demonstrate fan operation and maintenance procedures.

3.6 PROTECTION OF FINISHED WORK

A. Execution and Closeout Requirements: Refer to Division 1 for Requirements for protecting finished Work.

B. Do not operate fans until ductwork is clean, filters in place, bearings lubricated, and fan has been test run under observation.

END OF SECTION 233400

SECTION 23 36 00 - AIR TERMINAL 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 SUBMITTALS

A. Product Data: For each type of air terminal unit.

1. Manufacturer’s name and model number.
2. Identification as referenced in the drawings.
3. Capacities and ratings.
4. Materials of construction.
5. Sound data information.
6. Dimensions and clearance requirements.
7. Other appropriate information.

1.3 CLOSEOUT SUBMITTALS

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

1.4 DESIGN CRITERIA

A. Where any of the air terminal devices are indicated on drawings to control space conditions in conjunction with a reheat coil, that reheat coil may be furnished as an integral part of or standard accessory to the devices specified below.

B. When air terminal devices are furnished with reheat coils, either integrally or remotely, control panels shall be mounted on the same side of the air terminal unit as the reheat coil piping connections.

C. Unless otherwise specified, air terminal units shall be pressure independent and able to maintain air volumes within plus or minus 5% of required airflow, regardless of system pressure.

D. Unless otherwise specified, unit casings shall be constructed of galvanized steel or aluminum meeting SMACNA or ASHRAE Standards, but not lighter than 22 gauge.

E. Unless otherwise specified, air terminal casings shall be sealed with appropriate sealant to minimize casing air leakage. Seal joints and seams not factory sealed in the field as specified in Part 3.

F. Unit performance shall be certified in accordance with ARI Standard 880, including sound rating data certified for both casing discharge and radiated sound levels from 125-Hz through 4,000-Hz.

G. Unit manufacturer or manufacturer's representative shall be required to verify air terminal device performance and adjust or replace the device within the warranty period when it is determined that problems exist.

H. All air terminals and exhaust valves shall have actuators capable of striking from 100% open to 100% closed. This applies to but not limited to terminals and air valves balanced to constant volume airflow rates.

1.5 CONTROLS COORDINATION

A. Air terminal manufacturer shall provide inlet flow sensor, controls, and the controls enclosure for the Controls Subcontractor's use.

B. Furnish all actuators, linkages if required, differential pressure transmitters, controllers, and any other devices required for unit control that are not provided by the unit manufacturer for unit manufacturer's factory mounting. Coordinate for proper factory installation.

C. Unit manufacturer shall factory install devices to result in a complete and functioning unit. Unit manufacturer shall be responsible for reviewing compatibility of devices with units being provided.

D. Unit manufacturer shall perform preliminary calibration based on scheduled airflow rates.

E. Controls Subcontractor shall be responsible for calibrating actuators and controller through TAB work for scheduled airflows.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."

C. ASHRAE Compliance: Applicable requirements in ASHRAE/IES 90.1, "Section 6 - Heating, Ventilating, and Air Conditioning."

2.2 SINGLE-DUCT AIR TERMINAL UNITS – SUPPLY (BLADE DAMPER TYPE)

A. Manufacturers:

1. Price (Basis of Design).
2. Titus.

3. JCI.
4. Nailor.

B. Configuration: Volume-damper assembly inside unit casing with control components inside a protective metal shroud.

C. Units shall be suitable for the new direct digital controls (DDC) system. The Mechanical Contractor shall be responsible for wiring from control panels to each terminal unit.

D. Furnish units with reheat coils having capacities as indicated in the schedules.

E. Casing: Minimum 22-gauge, 0.032-inch-thick galvanized steel, single wall.

1. Casing Liner: Fiber free foam insulation complying with the requirements of UL 181 (erosion, mold growth, and humidity) and ASHRAE 62.1. Maximum flame/smoke spread of 25/50 for both the insulation and adhesive when tested in accordance with ASTM E84. Minimum 1" thick, R-value of 4.0.
2. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
3. Air Outlet: S-slip and drive connections.
4. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.
5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

F. Primary Damper Assembly:

1. Heavy gauge, galvanized steel with a solid shaft rotating in bearings.
2. The damper shaft shall incorporate a visual position indicator etched into the end of the damper shaft to clearly indicate damper position over the full range of 90 degrees.
3. 18-gauge galvanized steel with peripheral gasket and self-lubricating bearings.
4. Maximum Damper Leakage: AHRI 880 rated, 2 percent of nominal airflow at 3-inch wg inlet static pressure.
5. Damper Position: Normally open.

G. Airflow Sensor:

1. Differential pressure airflow device measuring total and static pressures, mounted within the inlet air connection.
2. Plastic parts shall be fire-resistant, in compliance with UL 94.
3. Airflow sensor shall be RoHS (Restriction of Hazardous Substances) compliant. Materials containing polybrominated compounds shall not be acceptable.
4. Control tubing shall be protected by grommets at the wall of the airflow sensor's housing.
5. The airflow sensor shall be furnished with twelve total pressure sensing ports and four static pressure sensing ports and shall include a center averaging chamber that amplifies the sensed airflow signal.

H. Hydronic Heating Coils:

1. Hot water coil casing shall be constructed from a minimum 22-gauge, 0.032-inch-thick galvanized steel, factory installed on the terminal unit discharge with S-slip and drive attachment to downstream ductwork.

2. Provide with gasketed access door, located on the bottom of the unit.
3. Water coil fins shall be 0.0045-inch aluminum fins, mechanically bonded to seamless 0.5 by 0.016-inch copper tubes. Fins shall be formed to facilitate high heat transfer with a maximum of 12 fins per inch spacing.
4. Coils shall be hydrostatically tested to a minimum of 390 psi, with a minimum burst pressure of 1,800 psi at ambient temperature. All water coils shall be rated for a maximum of 300 psi working pressure at 200°F.
5. The water coils shall be certified in accordance with AHRI 410 and shall bear the AHRI 410 label.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 5, "Hangers and Supports" and with Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.
2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes and for slabs more than 4 inches thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes and for slabs less than 4 inches thick.
5. Do not use powder-actuated concrete fasteners for seismic restraints.

C. Hangers Exposed to View: Threaded rod and angle or channel supports.

D. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.2 TERMINAL UNIT INSTALLATION

A. Install air terminal units according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."

B. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.

C. Install wall-mounted thermostats.

3.3 CONNECTIONS

A. Where installing piping adjacent to air terminal unit, allow space for service and maintenance.

B. Hot-Water Piping: Comply with requirements in Hydronic Piping and Hydronic Piping Specialties specifications, and connect heating coils to supply with shutoff valve, strainer, control valve, and union or flange; and to return with balancing valve and union or flange.

C. Comply with requirements in Metal Ducts specifications for connecting ducts to air terminal units.

3.4 IDENTIFICATION

A. Label each air terminal unit with plan number, nominal airflow, and maximum and minimum factory-set airflows. Comply with requirements in Identification for HVAC Piping and Equipment for equipment labels and warning signs and labels.

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.
2. Leak Test: After installation, fill water coils and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Air terminal unit will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.6 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Verify that inlet duct connections are as recommended by air terminal unit manufacturer to achieve proper performance.
3. Verify that controls and control enclosure are accessible.
4. Verify that control connections are complete.
5. Verify that nameplate and identification tag are visible.
6. Verify that controls respond to inputs as specified.

3.7 DEMONSTRATION

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

END OF SECTION 233600

SECTION 233713 - AIR DIFFUSERS 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. Supply air diffusers and grilles:

1. Type A – Square cone diffusers
2. Type I – Linear slot diffusers

B. Return/exhaust air diffusers and grilles:

1. Type T – Perforated face diffusers
2. Type V – Louvered face grilles

1.3 SUBMITTALS

A. Product Data including, but not limited to, the following:

1. Manufacturer’s name and model number.
2. Project specific designation (see drawing schedules).
3. Dimensions.
4. Capacities/ratings.
5. Sound ratings.
6. Materials of construction.
7. Finish.
8. Color selection charts (if applicable).
9. Manufacturer’s specific installation instructions.

B. Samples: For each exposed product and for each color and texture specified. Actual size of smallest diffuser indicated.

C. Samples for Initial Selection: For diffusers with factory-applied color finishes. Actual size of smallest diffuser indicated.

D. Samples for Verification: For diffusers, in manufacturer's standard sizes to verify color selected. Actual size of smallest diffuser indicated.

1.4 DESIGN CRITERIA

A. Performance data shall be tested in accordance with ASHRAE Standard 70, “Method of Testing and Rating the Performance of Air Outlets and Inlets.”

B. Submittal information shall clearly show testing methodology on performance data sheets.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable manufacturers shall be one of the following unless noted otherwise in the following section.

1. Price (Basis of Design).
2. Titus.
3. Nailor.
4. Krueger
5. Metalaire
6. Tuttle & Bailey

2.2 TYPE A – SQUARE CONE SUPPLY DIFFUSERS

A. Construction:

1. Diffusers shall be steel construction, and shall consist of a seamless, one-piece, precision formed backpan that incorporates a round inlet collar of sufficient length for connecting rigid or flexible duct.
2. The diffuser shall integrate with all duct sizes shown on the plans without affecting the face size and appearance of the unit.
3. An inner cone assembly shall consist of 4 cones which drop below the ceiling plane to assure optimal VAV air diffusion performance. The inner cone assembly shall be completely removable from the diffuser face to allow for full access to any dampers or other ductwork components located near the diffuser neck.
4. Diffusers shall be supplied with an insulated back pan, minimum R6 insulation.

B. Finish: White.

C. Mounting:

1. The diffuser mounting frame shall be suitable for lay-in or surface-mount applications.
2. Coordinate the required ceiling mounting frame with architectural reflected ceiling plan.
3. Support diffuser independently from structure.

2.3 TYPE I – LINEAR SLOT DIFFUSERS

A. Construction:

1. See air device schedule for quantity of discharge slots and slot width.

2. The supply diffusers shall have aerodynamically curved “ice tong” shaped pattern controllers for 180° air pattern control and airflow dampering.
3. The diffuser border shall be extruded aluminum construction with extruded aluminum spacers and mitered end flanges.
4. Continuous length units shall be provided with factory assembled corner modules to suit drawings and site conditions. Splice plates and alignment plates shall be provided to align continuous slot assemblies.
5. Straight shoulder plenum:

    a. Zinc-coated steel plenum with straight shoulders for enhanced throw characteristics.
    b. Side inlet configuration in sizes to fit specified slot diffuser.
    c. Shall be designed to suit both drywall and lay-in installations.
    d. Plenum shall be lined with 1/4” thick fiber-free insulation.

6. Blank off panel:

    a. The diffuser shall be supplied with metal blank off sections.
    b. The blank offs shall cover the inactive sections of the slot diffuser and shall be shipped loose for field cutting and installation.
    c. See drawings for blank off locations.

7. Alignment strips:

    a. Provide alignment strips when the diffuser is supplied in multiple sections to provide linear alignment to the continuous slot diffuser.

8. Plaster frame spacers:

    a. The diffuser shall be supplied with plaster frame spacers to provide the correct spacing of the plaster frame prior to installation of the diffuser.

B. Finish: Baked enamel, color selected by Architect.

C. Mounting:

1. The diffuser shall be suitable for surface mount or lay-in applications.
2. Coordinate the required ceiling mounting with architectural reflected ceiling plan.
3. Support diffuser independently from structure.

2.4 TYPE T – PERFORATED FACE GRILLES

A. Construction:

1. The return diffuser shall be steel construction, unless otherwise noted, and shall consist of a perforated face of no less than 51% free area, a heavy-gauge steel back pan with round or rectangular inlet collars as noted on the plans.
2. The back pan and perforated face shall be coated steel construction with snap-in mounting to the extruded aluminum border and mounting frame. The framed face panel subassembly shall connect to the back pan with spring clip latches for ease of removal.

3. The perforated face shall be removable from the diffuser face and shall be hinged for ease-of-removal of the face screen for cleaning purposes.
4. Diffusers shall be supplied with an insulated back pan, minimum R6 insulation.
5. The diffuser shall be supplied with a light shield to reduce visibility in the ceiling plenum from the room side.

B. Finish: Baked enamel, white.

C. Mounting:

1. The diffuser mounting frame shall be suitable for lay-in or surface mount applications.
2. Coordinate the required ceiling mounting frame with architectural reflected ceiling plan.
3. Support diffuser independently from structure.

2.5 TYPE V – LOUVERED FACE GRILLES

A. Construction:

1. The blades and border shall be **steel** construction. Stainless steel construction shall be provide where noted on plans.
2. Grilles shall have **one set of fixed blades with 45 degree deflection and 3/4 inch on center blade spacing**.
3. Grilles shall have the front blades parallel to the **long** dimension, unless otherwise noted on plans.
4. Provide with optional light shield to minimize the direct line of sight through the grille to the ceiling plenum.

B. Finish: Baked enamel, white

C. Mounting:

1. The diffuser mounting frame shall be suitable for lay-in, surface mount, or spiral duct mount applications.
2. Coordinate the required ceiling mounting frame with architectural reflected ceiling plan.
3. Support diffuser independently from structure for ceiling applications.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas where diffusers are 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 DELIVERY AND STORAGE

A. Protect diffusers and grilles from damage and construction dirt/debris. Clean or replace damaged or soiled air devices prior to final acceptance.

3.3 INSTALLATION

A. Install diffusers and grilles as shown on drawings according to the submitted manufacturer's specific installation instructions.

B. Unless otherwise indicated on drawings, size ductwork connections to diffusers and grilles to match the air device inlet collar.

C. Install diffusers level and plumb.

D. Install diffusers with airtight connections to ducts.

E. Allow service and maintenance of accessories such as balancing dampers and life-safety dampers.

F. Instances where ductwork is visible through diffuser or grille, paint the inside of the duct matte black to reduce visibility.

3.4 ADJUSTING

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

END OF SECTION 233713

SECTION 237416.13 – PACKAGED, LARGE-CAPACITY, ROOFTOP AIR-CONDITIONING UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes:

1. Packaged, large-capacity, rooftop air conditioning units.
2. Heat exchanger.
3. Refrigeration components.
4. Unit operating controls.
5. Roof curb.
6. Electrical power connections.

1.3 DEFINITIONS

A. RTU: Rooftop unit. As used in this Section, this abbreviation means packaged, large-capacity, rooftop air-conditioning units. This abbreviation is used regardless of whether the unit is mounted on the roof or on a concrete base on ground.

1.4 REFERENCES

A. ANSI/NFPA 90A - Installation of Air Conditioning and Ventilation Systems.

B. AHRI 340 / 360 - Unitary Air-Conditioning Equipment.

C. ANSI/ASHRAE/IESNA 90.1 - Energy Standard for New Buildings Except Low-Rise Residential

1.5 SUBMITTALS

A. Product Data:

1. For each type of product.

a. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.

b. Include rated capacities, dimensions, required clearances, characteristics, furnished specialties, and accessories.
c. Include unit dimensions and weight.
d. Include location and size of field connections.
e. Include cabinet material, metal thickness, finishes, insulation, and accessories.
f. Fans:

1) Include certified fan-performance curves with system operating conditions indicated.
2) Include certified fan-sound power ratings.
3) Include fan construction and accessories.
4) Include motor ratings, electrical characteristics, and motor accessories.

g. Include certified coil-performance ratings with system operating conditions indicated.
h. Include filters with performance characteristics.
i. Include factory selection calculations for each antimicrobial ultraviolet lamp installation.
j. Include dampers, including housings, linkages, and operators.
k. Submit manufacturer's installation instructions.

B. Shop Drawings: For each packaged, large-capacity, rooftop air-conditioning units.

1. Include plans, elevations, sections, and mounting attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

1.6 CLOSEOUT SUBMITTALS

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

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Submit operation and maintenance data.

B. Include manufacturer's descriptive literature, start-up and operating instructions, installation instructions, and maintenance procedures.

C. 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. Filters: One set(s) of filters for each unit.
2. Gaskets: One set(s) for each access door.

1.8 HANDLING

A. Comply with manufacturer's installation instructions for rigging, unloading, and transporting units.

B. Protect units from physical damage. Leave factory shipping covers in place until installation.

1.9 MAINTENANCE SERVICE

A. All work on units shall be accomplished by OEM factory trained and authorized servicing technicians.

1.10 WARRANTY

A. Warranty: Manufacturer agrees to repair or replace components of packaged, large-capacity, rooftop air-conditioning units that fail in materials or workmanship within specified warranty period.

1. Warranty Period: 1 year(s) from date of start-up
2. Warranty Period for compressors: Manufacturer’s standard, but not less than five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PACKAGED, LARGE-CAPACITY, ROOFTOP AIR-CONDITIONING UNITS

A. General:

1. Manufacturer of packaged unitary rooftop products shall have had a minimum of five years successful experience in the manufacture and service support of the rooftop packages specified herein. Manufacturers with less than five years’ experience in the production of rooftop units of the sizes and types specified shall not be acceptable.
2. Units shall be specifically designed for outdoor rooftop installation on a roof curb and be completely factory assembled and tested, piped, internally wired, fully charged with R-454B compressor oil, factory run tested and shipped in one piece. Units shall be available for direct expansion cooling only. Filters, outside air system, exhaust air system, optional non-fused disconnect switches and all operating and safety controls shall be furnished factory installed.
3. All units shall be UL listed to US and Canadian Safety Standards. Cooling capacity shall be rated in accordance with AHRI Standard 360. All units shall have decals and tags to aid in service and indicate caution areas. Electrical diagrams shall be printed on long life water resistant material and shall ship attached to control panel doors.

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

1. Trane.
2. Daikin Applied.
3. York.

C. Unit Casings:

1. General Fabrication Requirements for Casings: Formed and reinforced double-wall insulated panels, fabricated to allow removal for access to internal parts and components, with joints between sections sealed.
2. Exterior panels shall be zinc-coated, galvanized steel painted with a slate gray air-dry finish durable enough to withstand a minimum of 672 hours consecutive salt spray application in accordance with standard ASTM B117. Screws shall be zinc-plus-zinc chromate coated.
3. Heavy gauge steel hinged access panels with tiebacks to secure door in open position shall provide access to filters sections. Refrigeration components, supply air fan and compressor shall be accessible through removable panels as standard. Unit control panel and filter section shall be accessible through hinged access panels as standard. Optional double wall construction hinged access doors shall provide access to filters, return/ exhaust air, and supply fan section. All access doors and panels shall have neoprene gaskets. Interior surfaces or exterior casing members shall have 1/2-inch fiberglass insulation.
4. Unit base shall be watertight with heavy gauge formed load-bearing members, formed recess and curb overhang. Unit lifting lugs shall accept chains or cables for rigging. Lifting lugs shall also serve as unit tie down points.
5. Airstream Surfaces: Surfaces in contact with airstream are to comply with requirements in ASHRAE 62.1.

D. Refrigeration System

1. Variable speed compressors shall be capable of speed modulation from 25 Hz to a maximum of 100 Hz. The minimum unit capacity shall be 15% of full load or less. The compressor motor shall be a permanent magnet type. Each compressor shall have a crankcase heater installed, properly sized to minimize the amount of liquid refrigerant present in the oil sump during off cycles. Compressors shall be equipped with a bearing oil injection system that optimizes bearing and scroll set lubrication, sealing, and controls the oil circulation rate. Optimal bearing lubrication shall be provided by a gear oil pump.
2. Each variable speed compressor shall be matched with a specially designed variable frequency drive which modulates the speed of the compressor motor and provides several compressor protection functions. Control of the variable speed compressor and inverter shall be integrated with the unit controller to ensure optimal equipment reliability and efficiency.
3. Leak Detection Sensors: unit shall be furnished with a leak detection system from the factory when a circuit refrigerant charge exceeds 3.91 lbs. The leak detection system shall consist of one or more refrigerant detection sensors. When the system detects a leak, the unit controller shall initiate mitigation actions.

E. Corrosion Protected Condenser Coil

1. Protection on the all-aluminum, microchannel condenser coil shall consist of a corrosion resistant coating that shall withstand ASTM B117 Salt Spray test for 6,000 hours and ASTM G85 A2 Cyclic Acidified Salt Fog test for 2,400 hours. This coating shall be

added after coil construction covering all tubes, headers and fin edges, therefore providing optimum protection in more corrosive environments.

F. Evaporator Coil Drain Pan

1. Drain pan shall be double sloping galvanized steel and promote runoff of standing water from condensation inside the unit.
2. Two drain pipes shall be installed through the base channel on each side of the unit. Drain pipe connection shall be installed through the side of the unit and connector size is 1.25 NPTI. The stainless-steel option shall provide protection in corrosive environments.

G. Air-Cooled Condenser Coil

1. Condenser coils shall have all aluminum microchannel coils. All coils shall be leak tested at the factory to ensure pressure integrity. The condenser coil shall be pressure tested to 650 psig. Subcooling circuit(s) shall be provided as standard.

H. Air-Cooled Condenser Fans and Motors

1. All condenser fans shall be vertical discharge, direct drive fans, statically balanced, with aluminum blades and zinc plated steel hubs. Condenser fan motors shall be three-phase motors with permanently lubricated ball bearings, built-in current and thermal overload protection and weather-tight slingers over motor bearings. Modulating condenser fans shall be provided on all variable speed units.

I. Supply Fan

1. Supply fan motors shall be open drip-proof. All supply fans shall be dynamically balanced in factory. Supply fan shall be test run in unit and shall reach rated rpm. All 60 Hz supply fan motors shall meet the Energy Independence Security Act of 2007 (EISA).
2. Variable Air Volume Discharge Temperature Control with Variable Frequency Drives Option shall provide all necessary controls to operate a VAV rooftop from the discharge air temperature, including discharge air microprocessor controller and discharge air sensor.
3. The microprocessor controller shall coordinate the economizer control and the stages of cooling with discharge air temperature reset capabilities. Option shall include factory installed and tested VFDs to provide supply fan motor speed modulation.
4. VFD shall receive 0-10 VDC from the unit microprocessor based upon supply static pressure and causes the drive to accelerate or decelerate as required to maintain the supply static pressure setpoint. Optional bypass control shall provide full nominal airflow in the event of drive failure.
5. Bypass control shall provide full nominal airflow in the event of drive failure.

J. Electrical

1. Unit shall be completely factory wired with necessary control and contactor pressure lugs or terminal block for power wiring. Units shall provide an option for a non-fused disconnect with external handle for safety.
2. A high fault SCCR option is available that provides a 65,000A SCCR for 200V, 230V, and 460V units.

3. Motors shall have internal bearing protection for use with VFDs to provide a conductive discharge path away from the motor bearings to ground. Bearing Protection Rings shall be circumferential rings with conductive microfibers which provide the path of least resistance and dramatically extend motor life.
4. Phase monitor shall protect 3-phase equipment from phase loss, phase reversal and phase imbalance. Any fault condition shall produce a Failure Indicator LED and send the unit into an auto stop condition. cULus approved.
5. An external handle mounted on the control box door shall be provided to disconnect unit power with the control box door closed for safety.

K. Electronic Unit Controller

1. The electronic unit controller shall be an application-specific, programmable controller that is factory installed and designed to control packaged HVAC equipment. A 7" user interface features a touch-sensitive color screen that provides facility managers with at-a-glance operating status, performance monitoring, scheduling changes and operating adjustments. Other advanced features include automated controller backup and optional features such as secure remote connectivity, wireless building communications, mobile device connectivity and custom programming with expandable I/O.
2. The electronic unit controller shall support standard BACnet communication protocol through a RS485, two-wire communication link or BACnet/IP.
3. Factory installed expansion hardware shall have 19 inputs/outputs. Additional expansions may be added in the field.
4. Unit shall have rapid restart. This feature will provide immediate startup upon power failure. A backup generator shall be required on site before unit startup. Rapid Restart shall begin immediately after recovery from a power loss and work by restarting the compressors and supply fan quickly to provide full cooling within two to three minutes.

L. Filters

1. Filter options shall mount integral within unit and be accessible by hinged access panels.
2. Shall provide a complete set of two-inch thick filter racks, without the filter media to accommodate applications which require field supplied filters.
3. Shall provide a long-lasting galvanized steel frame without the filter media to accommodate applications which require field supplied filters.
4. Final filter section filter options shall mount integral within the blank section unit casing and be accessible by hinged access doors.
5. 90-95 Percent, Filter Option, MERV 14, available on cooling only units. 4-inch deep filters shall be mounted in a galvanized steel frame. Filters shall be Class 1 listed by Underwriters Laboratories and have a 90-95% dust spot efficiency per ASHRAE 52-76.

M. Relief Air

1. Relief air system shall include 100 percent modulating exhaust fan with direct space building pressurization control. Exhaust motors shall be open drip-proof fan cooled. All 60 Hz motors meet the Energy Independence and Security Act of 2007 (EISA). All 50 Hz exhaust motors meet the U.S. Energy Policy Act of 1992 (EPACT).
2. Two, single-width, single-inlet, 5-blade direct-drive plenum fans with backward inclined, high efficiency welded aluminum impeller that is dynamically balanced as an assembly. Fan shall be beltless and maintenance free throughout its operating life. Fan shall be balanced to G6.3 per ISO 21940. No external vibration shall be necessary. Motor shall be

electronically commutated (ECM) and contain power electronics for speed control. Motor modulation shall be managed by the equipment controller.

3. For VAV rooftops, the VFD shall be modulated in response to building pressure. A differential pressure control system, shall use a differential pressure transducer to compare indoor building pressure to outdoor ambient atmospheric pressure. The FC exhaust fan shall be turned on when required to lower building static pressure setpoint.
4. With the ventilation override option installed, the unit shall be programmed to transition to up to 5 different programmed sequences for Smoke Purge, Evacuation, Pressurization, Purge, Purge with duct control sequence and Unit off. The transition shall occur when a binary input on the VOM is closed (shorted); this would typically be a hard-wired relay output from a smoke detector or fire control panel.

N. Outside Air

1. Outside air: 0-100 percent fully modulating economizer.
2. Economizer option shall be operated through the primary temperature controls to automatically utilize outside air for “free” cooling. Automatically modulated return and outside air dampers shall maintain proper temperature in the conditioned space. Economizer shall be equipped with an automatic lockout when the outdoor high ambient temperature is too high for proper cooling.
3. Minimum position control shall be standard and adjustable at the user interface or through the building management system. A spring return motor shall ensure closure of OA dampers during unit shutdown or power interruption. Mechanical cooling shall be available to aid the economizer mode at any ambient. Standard economizer dampers leakage rate shall be 2.5 percent of nominal airflow (400 cfm/ton) at 1 inch wg. static pressure.
4. Low leak dampers shall be provided with gasketing added to the damper blades and rolled stainless steel jamb seals to the sides of the damper assembly. Low leak economizer dampers shall have a leakage rate of 1 percent based on testing data completed in accordance with AMCA Standard 500 at AMCA Laboratories.
5. Economizer return and outside air dampers shall be provided with horizontal airfoil blades and spring-return actuators. The economizer shall have a functional life of 60,000 opening and closing cycles. Dampers shall be AMCA 511 Class 1A certified with a maximum leakage rate of 3 CFM/sq-ft at 1.0 in WC pressure differential thus exceeding requirements of ASHRAE 90.1-2013, California Title 24-2013, and IECC-2012.
6. Two enthalpy sensors shall be provided to compare total heat content of the indoor air and outdoor air to determine the most efficient air source when economizing.
7. An outdoor enthalpy sensor shall be provided to compare the total heat content of outdoor air to a locally adjustable setpoint. The setpoint shall be programmed at the user interface to determine if the outdoor enthalpy condition is suitable for economizer operation.
8. An outdoor and return air temperature sensor is used to compare the dry bulb temperature of the outside air to the return air temperature to determine if it is suitable to economize.
9. A factory mounted airflow measurement station (TraqTM) shall be provided in the outside air opening to measure airflow. The airflow measurement station shall measure from 40 CFM/ton to maximum airflow. The airflow measurement station shall adjust for temperature variations. Measurement accuracy shall meet requirements of LEED IE Q Credit 1 as defined by ASHRAE 62.1-2007.
10. When equipped with a CO2 sensor, the outside air damper position shall modulate in response to a CO2 sensor in the conditioned space, in order to minimize the unit energy consumption and simultaneously meet the ventilation requirements of ASHRAE Std 62.1.

The Traq airflow monitoring solution shall augment the system, allowing for measurement and control of outside airflow.

O. Isolators

1. Supply and relief fan assemblies shall be isolated with two-inch nominal deflection to reduce transmission of vibrations.

P. Special Unit Paint Colors

1. Manufacturer shall allow matching of HVAC equipment to customer specified color, for an additional fee. This option shall be for standard paint compound in different colors only.

Q. Service

1. Hinged access doors shall provide easy access to supply fan, filters, exhaust/return fan, and the heating section. Double wall construction with dual density insulation sandwiched between heavy gauge galvanized steel panels for strength and durability can be selected.
2. A 15A, 115V Ground Fault Interrupter convenience outlet shall be factory installed. It shall be wired and powered from a factory mounted transformer. Unit-mounted, non-fused disconnect with external handle shall be furnished with factory powered outlet.

R. Roof curb.

1. Refer to Mechanical Schedules.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Contractor is to verify that roof is ready to receive work and opening dimensions are correct.

B. Verify the proper power supply is available.

3.2 INSTALLATION

A. Install in accordance with manufacturer’s instructions.

B. Equipment Mounting: mount units on factory-built roof mounting frame providing watertight enclosure to protect ductwork. Install roof mounting curb level.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where piping is installed adjacent to unit, allow space for service and maintenance of unit.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Tests and Inspections:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Remove and replace malfunctioning units and retest as specified above.

E. Prepare test and inspection reports.

3.5 STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

3.6 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain units.

END OF SECTION 237416.13

SECTION 238126 - SPLIT-SYSTEM AIR-CONDITIONERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes split-system air-conditioning and heat-pump units consisting of separate evaporator-fan and compressor-condenser components.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.

1.4 INFORMATIONAL SUBMITTALS

A. Warranty: Sample of special warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For split-system air-conditioning units to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Filters: One set(s) for each air-handling unit.

1.7 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASHRAE Compliance:

1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."

2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - " Procedures," and Section 7 - "Construction and System Start-up."

C. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1.

1.8 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork are specified in Section 033000 "Cast-in-Place Concrete."

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

1.9 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of split-system air-conditioning units that fail in materials or workmanship within specified warranty period.

1. Warranty Period:

a. For Compressor: Five year(s) from date of Substantial Completion.
b. For Parts: One year(s) from date of Substantial Completion.
c. For Labor: One year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 DUCTLESS SPLIT SYSTEMS

A. Manufacturers:

1. Mitsubishi.
2. Johnson Controls.
3. Fujitsu.
4. LG.
5. Daikin.

B. Indoor Unit:

1. General: The air conditioning unit shall be factory assembled, wired and run tested. Contained within the unit shall be all factory wiring, piping, control circuit board and fan motor. The unit shall have a self-diagnostic function, 3-minute time delay mechanism, an auto restart function, an emergency operation function and a test run switch. Indoor unit shall be charged with dry air before shipment from factory.

2. Unit Cabinet:

    a. The casing shall have a white finish.
    b. Multi directional drain and refrigerant piping, offering four (4) direction pipe alignment for all refrigerant piping and two (2) direction pipe alignment for condensate draining shall be standard.
    c. There shall be a separate back plate that secures the unit firmly to the wall.

3. Fan:

    a. The evaporator fan shall be manufacturer's standard.
    b. The fan shall be statically and dynamically balanced and run on a motor with permanently lubricated bearing.
    c. A manual adjustable guide vane shall be provided with the ability to change the airflow from side to side (left to right).
    d. An integral, motorized air sweep flow louver shall provide for uniform air distribution.
    e. The indoor fan shall consist of three (3) speeds: High, Medium and Low.

4. Filter:

    a. Return air shall be filtered by means of an easily removable washable filter.

5. Coil:

    a. The evaporator coil shall be of nonferrous construction with smooth plate fins on copper tubing.
    b. The tubing shall have inner groves for high efficiency heat exchange.
    c. All tube joints shall be brazed with phoscopper or silver alloy.
    d. The coils shall be pressure tested at the factory.
    e. A condensate pan and drain shall be provided under the coil.

6. Electrical:

    a. The system shall be equipped with a system allowing the air conditioning unit to be powered directly from the outdoor unit using a 3-wire connection plus ground.

7. Control:

    a. The air conditioning unit shall have a field installed hard-wired remote controller.
    b. The controller shall consist of a Power On/Off switch, Mode Selector, Temperature Setting, Timer Control, Fan Speed Select and Auto Vane selector.
    c. The air conditioning unit shall perform Self-diagnostic Function, Test Run switching and Check Mode switching.
    d. Temperature changes shall be by 1ºF increments with a range of 65-87ºF.
    e. The microprocessor located in the air conditioning unit shall have the capability of sensing return air temperature and air conditioning coil temperature, receiving and processing commands from the wireless or wired controller, providing emergency operation and controlling the outdoor unit.
    f. The system shall be capable of automatically restarting when the power is restored after power interruption.

g. Control system shall control the continued operation of the air sweep louvers, as well as provide On/Off, System/Mode function and Auto Changeover between heating and cooling.

C. Outdoor Unit:

1. General: The outdoor units are specifically designed to work the indoor units. The units must have a powder coated finish. The outdoor unit shall be completely factory assembled, piped and wired. Each unit shall be run tested at the factory.
2. Unit Cabinet:

   a. The casing shall be fabricated of galvanized steel, bonderized and finished with a powder coated baked enamel.

3. Fan:

   a. The unit shall be furnished with manufacturer's standard fan.
   b. The condenser fan motor shall have permanently lubricated bearings.
   c. The fan motor shall be mounted for quiet operation.
   d. The fan shall be provided with a raised guard to prevent contact with moving parts.
   e. The unit shall have horizontal discharge airflow.

4. Coil:

   a. The condenser coil shall be of nonferrous construction with lanced or corrugated plate fins on copper tubing.
   b. The coil shall be protected with an integral metal guard.
   c. Refrigerant flow from the condenser shall be controlled by means of individual electronic linear expansion valves for each air conditioning unit.

5. Compressor:

   a. The compressor shall be of a high performance hermetic; inverter driven, variable speed, rotary type.
   b. The outdoor unit shall be equipped with a suction side refrigerant accumulator.
   c. The compressor will be equipped with an internal thermal overload.
   d. The outdoor unit must have the ability to operate with a maximum height difference of 75 feet and have refrigerant tubing length of 125 feet between indoor and outdoor units without the need for line size changes, traps or additional oil.
   e. The compressor shall be mounted to avoid the transmission of vibration.

6. Refrigerant:

   a. R-410A.

7. Electrical:

   a. The unit electrical power shall be 208 volts, 1-phase, 60 hertz.
   b. The outdoor unit shall be controlled by the microprocessor located in the indoor unit and outdoor unit.

c. The outdoor unit shall be equipped with Pulse Amplitude Modulation (PAM) compressor inverter drive control for maximum efficiency with minimum power consumption.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install units level and plumb.

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

C. Equipment Mounting:

1. Comply with requirements for vibration isolation devices specified in Section 23 05 48.13 "Vibration Controls for HVAC."

D. Install and connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where piping is installed adjacent to unit, allow space for service and maintenance of unit.

3.3 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Tests and Inspections:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Remove and replace malfunctioning units and retest as specified above.

E. Prepare test and inspection reports.

3.4 STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

3.5 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain units.

END OF SECTION 238126

SECTION 238239.19 - WALL AND CEILING UNIT HEATERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Wall and ceiling unit heaters with propeller fans and electric-resistance heating coils.

PART 2 - PRODUCTS

2.1 WALL AND CEILING UNIT HEATERS

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

1. Trane
2. Markel Products Company; a subsidiary of TPI Corporation
3. QMark; Marley Engineered Products

B. Heaters: Assembly including chassis, electric heating coil, fan, motor, and controls. Comply with UL 2021.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

PART 3 - EXECUTION

END OF SECTION 238239.19