

**SECTION 23 00 00**  
**MECHANICAL ALTERNATES**

**PART 1 GENERAL**

**1.01 LIST OF ALTERNATES**

- A Refer to Division 01 Specification and Bid Form for Alternates.

**END OF SECTION 23 00 00 23 00 00**

**SECTION 23 01 00**  
**HVAC GENERAL PROVISIONS**

**PART 1 GENERAL**

**1.01 SCOPE OF WORK**

- A The Contractor shall provide all materials, equipment and labor necessary to install and set into operation the heating and air conditioning equipment as shown on the Engineering Drawings and as contained herein.
- B Intent of the drawings and specifications is to obtain complete systems, tested, adjusted, and ready for operation.
- C Include incidental details not usually indicated or specified, but necessary for proper installation and operation.

**1.02 QUALITY ASSURANCE**

- A Refer to the General and Supplementary General Conditions and Division 01.
- B Check, verify, and coordinate work with drawings and specifications of other trades. Include modifications, relocations, and adjustments necessary to complete work or to avoid interference with other trades.
- C All work shall be in accordance with local, state and federal regulations. Minimum requirements shall be the North Carolina State Building Code.
- D The Contractor shall be responsible for obtaining all permits and shall notify inspection departments as work progresses.
- E Whenever the words "Approval", "Approved", or "Approved Equal" appear, it is intended that items other than the model number specified shall be subject to the approval of the engineer.
- F Where a submitted product has electrical requirements that differ from the Basis of Design specified product, it is the Mechanical Contractor's responsibility to coordinate the electrical requirements of the equipment with the Electrical Engineer and Electrical Contractor at no additional cost to the project.
- G All material and equipment that the Contractor proposed to substitute in lieu of those specified in the Specifications, shall be submitted to the Engineer ten (10) days prior to the bid date for evaluation. The submittal shall include a full description of the material or equipment and all pertinent engineering data required to substantiate the equality of the proposed item to that specified. Items that are submitted for approval after this date will not be accepted.
- H "Provide" as used herein shall mean that the Contractor responsible shall furnish and install said item or equipment. "Furnish" as used herein shall mean that the Contractor responsible shall acquire and make available said item or equipment and that installation shall be by others. "Install" as used herein shall mean that the Contractor responsible shall make installation of items or equipment furnished by others.

**1.03 REQUIREMENT OF REGULATORY AGENCIES**

- A Rules and regulations of Federal, State, and local authorities having jurisdiction, and utility companies, in force at time of execution of contract shall become part of this specification.

**1.04 SUBSTITUTIONS**

- A Products are specified for use on this project by one of the following:
  - 1. Reference Standards and Description: Any products meeting the Reference Standards and Description will be acceptable (i.e., piping).
  - 2. Naming of a product as an example to denote the quality standard of the product desired, in which case three or more brands will be denoted (where applicable) to establish equivalent designs. Naming of a product does not restrict Bidders to a specific brand (i.e., fixtures, valves, etc.).
  - 3. Requests for approval of manufacturer's or substitutions which have not been preapproved shall be made by using the forms at the end of this section.
- B During bidding period: Submitted written requests from Bidders Only, using the forms herein, will be considered if received ten (10) calendar days prior to the date of receipt of bids to allow for proper evaluation. Requests from suppliers or subcontractors will not be considered. Substitutions will be considered when a product becomes unavailable through no fault of the Contractor. A request constitutes a representation that the Bidder/Contractor:
  - 1. Has investigated proposed product and determined that it meets or exceeds the quality level of the specified product and is suitable for use in the Work.

2. Will provide the same warranty for the substitution as for the specified product.
  3. Will coordinate installation and make changes to other work which may be required for the work to be complete with no additional cost to the Owner.
  4. Waives claims for additional cost or time extension which may subsequently become apparent.
  5. Has included a list of similar projects on which this product has been used with names and telephone numbers for verification.
  6. Has written verification from the product manufacturer that this product has been in use a minimum of two (2) years on a project similar to this work.
  7. Substitutions will not be considered when they are indicated or implied on shop drawing or product data submittals, without separate written request, or when acceptance will require revision to the Contract Documents.
- C Architect/Engineer Review
1. Review and approval will rely on manufacturer's literature and other data as outlined herein.
  2. Inadequacies in such submittals that fail to identify unsuitability are the responsibility of the parties making submittal.
- D Substitution Procedure
1. Submit three copies of request for substitution for consideration. Limit each request to one proposed substitution.
  2. Submit shop drawings, product data, and certified test results attesting to the proposed product equivalence.
  3. Submit listing of similar projects.
  4. Submit manufacturer's written verification that product has been in use a minimum of two (2) years at similar projects.
  5. The Architect/Engineer will notify Contractor, in writing, of decision to accept or reject request.
  6. Products bid or incorporated in the work that are not specified and without written approval of the Architect/Engineer may not be acceptable, and if not, the Contractor will be required to furnish and install the products specified.
  7. The Architect/Engineer will issue written approvals of product substitutions to all Bidders. Substitutions are not approved without written approval.

**1.05 SUBMITTALS**

- A Refer to General and Supplementary General Conditions and Division 01.
- B For satisfying submittal requirements for Division 23, "Product Data" is usually more appropriate than true "Shop Drawings" as defined in Division 01. However, the term "Shop Drawings" may be used throughout the specifications.
- C Within ten days after notification of the award of the Contract and written notice to begin work, the Contractor shall submit to the Architect/Engineer for approval a detailed list of equipment and material which he proposes to use. Items requiring submittal data for approval will be noted at this time.
- D Mark general catalog sheets and drawings to indicate specific items submitted and their correlation to specific tagged equipment on the drawings. Cross out all nonapplicable or extraneous information that does not apply to the submitted equipment. Circle or otherwise clearly indicate applicable options.
- E Contractor shall clearly indicate deviations (if any) from the project specifications on each submittal. Shop drawings accepted by the Engineer shall not relieve the Contractor of their responsibility to construct the work in accordance with the Contract Documents.
- F Include proper identification of equipment or item by name and/or number, as indicated on the Drawings.
- G Where manufacturer's reference numbers differ from those specified, clearly indicate such on the submittal.
- H Where equipment or items specified include accessories, parts, and additional items under one designation, submittals shall be complete and include all required components.
- I Equipment requiring electrical connections shall include composite wiring diagrams, motor efficiency, and power factor data. Wiring diagrams submitted shall be specific to project conditions.
- J Where submittals cover products containing non-metallic materials, include MSDS sheets from the manufacturer stating physical and chemical properties of components and precautionary steps to be taken.

- K The Contractor shall provide an electronic PDF copy of submittal data. The pdf shall contain complete submittal data on all products, methods, etc. proposed for use on the project.
- L Each submittal shall bear the approval of the Contractor indicating that he has reviewed the data and found it to meet the requirements of the specifications as well as space limitations and other project conditions. The submittals shall be clearly identified showing project name, manufacturer's catalog number, and all necessary performance and fabrication data.
- M The Contractor shall submit to the Engineer a set of accurately marked up plans indicating all changes encountered during the construction. Final payment will be contingent on receipt of these as-built plans.
- N The Contractor shall furnish an electronic PDF copy of maintenance and operating instructions as outlined in Paragraph C (Execution), of this specification section.
- O The Contractor shall submit to the Owner all certificates required for operating system in compliance with local, state and federal regulations.

**1.06 PRODUCT DELIVERY, STORAGE AND HANDLING**

- A All material and equipment shall be delivered and unloaded by the Contractor within the project site as noted herein or as directed by the Owner.
- B The Contractor shall protect all material and equipment from breakage, theft, or weather damage. No material or equipment shall be stored on the ground.
- C The material and equipment shall remain the property of the Contractor until the project has been completed and turned over to the Owner.

**1.07 WORK CONDITIONS AND COORDINATION**

- A The Contractor shall review the electrical plans to establish points of connection and the extent of electrical work to be provided in his Contract. All electrical work shall be performed by a licensed electrical contracting firm.
- B This Contractor shall be responsible for the final electrical connections to all equipment installed as part of his contract.
- C Electrical work shall be in accordance with all local, state and national codes and as specified in Division 26.
- D Where architectural features and elements govern location of work, refer to Architectural drawings prior to fabrication of materials or system components.
- E Refer to the Structural Drawings to become familiar with structural member sizes, framing type and configuration, opening sizes, and other details that could impact the work. Failure to coordinate with the Work of other trades, resulting in relocation of installed work to coordinate with architectural and/or structural elements, shall NOT be allowed as a basis for extra compensation by the contractor.
- F Where piping, ductwork, or other items are indicated to be routed in the webbing of joists or trusses, the mechanical contractor shall confirm with the General Contractor/Construction Manager and steel supplier the final joist/truss profile prior to fabricating or order materials. The actual final joist/truss profile shall be used in the BIM coordination effort.
- G Openings for insulated piping shall be based on the outside diameter of the insulation with continuous insulation through the opening.
- H Seal non-fire rated floor penetrations with non-shrink grout or urethane caulk, as appropriate.
- I Seal non-rated wall openings with urethane caulk.
- J Duct/pipe/conduit penetrations through floor slabs of mechanical platforms or slabs above the bottom floor shall have water stopped curb surrounding the pipe/duct/conduit opening. Coordinate with Construction Manager/General Contractor to confirm openings based on Coordination Drawings.
- K Pipe, conduit and duct chases required for installation of work shall be provided by the General Contractor unless otherwise noted. This Contractor shall be responsible for coordinating the location of all required chases.
- L All work shall be coordinated with other trades. Cutting of new work and subsequent patching shall be at the Contractor's expense at no extra cost to the Owner.
- M Contractor shall review the complete construction document package and determine, prior to the bid, which portions of the above grade structural slabs are hard rock concrete and/or light weight insulating concrete. Contractor shall review the Structural Engineer's requirements for attachment of loads to slabs, joists,

trusses, and other structural members. DO NOT exceed point loads on Structural Engineer's drawings and details. Unistrut and/or other support apparatus required to span multiple joists or beams shall be included in the Contractor's bid. No additional monies will be given for support steel or other components required to support Mechanical piping, duct, equipment, or other items.

**1.08 GUARANTEE**

- A See the General and Supplementary General Conditions
- B Where extended warranties or guarantees are available from the manufacturer, the Contractor shall prepare the necessary contract documents to validate these warranties as required by the manufacturer and present them to the Architect/Engineer.
- C The Contractor shall include in his bid a full warranty and guarantee for a five (5) year period on the compressors for the refrigeration equipment, including all chillers. This warranty does not include labor following the first year's Labor and Material Warranty.

**PART 2 PRODUCT**

**2.01 GENERAL REQUIREMENTS**

- A Materials and equipment shall be new, unless noted otherwise, of the highest grade and quality and free from defects or other imperfections. Materials and equipment found defective shall be removed and replaced at the contractor's expense.
- B The contractor shall provide name plates for identification of all equipment, switches, panels, etc.
- C The name plates shall be laminated phenolic plastic, black front and back with white core, white engraved letters (1/4" minimum) etched into the white core. Name plates shall be fastened with sheet metal screws.

**PART 3 EXECUTION**

**3.01 INSPECTION**

- A This Contractor shall examine the areas of completed work and shall insure that no defects or errors are present which would result in the poor application or installation of subsequent work.

**3.02 TEMPORARY SERVICES**

- A Refer to Division 01

**3.03 INSTALLATION**

- A All work shall be performed in a manner indicating proficiency in the trade.
- B Contractor may install additional piping, fittings, valves, etc., not indicated on the drawings, for testing purposes or for convenience to facilitate installation of the work. Where such materials are installed, they shall comply with the specifications and shall be sizes to be compatible with system design. Remove such materials when they interfere with design conditions or as directed by the Engineer.
- C Use of access panels in inaccessible ceilings for access to equipment, valves, dampers, etc., is not permitted, unless access panels are indicated on the Architectural reflected ceiling plans. Review any locations where additional access panels may be required with the Architect prior to incorporating into Work.
- D This Contractor shall be responsible for completely cleaning the fireproofing from ALL materials or equipment installed as part of this Contract. This includes, but is not limited to, ductwork, piping, conduit, equipment, faceplates, boxes, disconnects, control panels, and cabling.
- E All conduit, pipes, ducts, etc. shall be either parallel to building walls or plumb where installed in a vertical position and shall be concealed when located in architecturally finished areas.
- F Any cutting or patching required for installation of this Contractor's work shall be kept to a minimum. Written approval shall be required by the Architect/Engineer if cutting of primary structure is involved.
- G All patching shall be done in such a manner as to restore the areas or surfaces to match existing finishes.
- H The Contractor shall lay out and install his work in advance of pouring concrete floors or walls. He shall furnish all sleeves to the General Contractor for openings through poured masonry floors or walls, above grade, required for passage of all conduits, pipes, or ducts installed by him. The Contractor shall provide all inserts and hangers required to support his equipment.
- I The annular space around ALL wall and floor penetrations shall be properly sealed. For rated assemblies, a UL listed method shall be used. For non-rated wall and floors, the annular space shall be packed with mineral wool, or another suitable non-combustible material, and caulked air tight.
- J Installation of piping and ductwork shall not interfere with walkways or service access.

K All trapeze hanger rods shall be cut to within 1" of the bottom nut.

L Provide minimum 1/2" thick closed cell elastomeric foam insulation, applied with adhesive, on lower edges of equipment and mechanical duct and pipe supporting elements suspended less than 7 ft above finished floors, platforms, or roofs.

**3.04 PERFORMANCE**

A The Contractor shall perform all excavation and backfill operations necessary for installation of his work.

**3.05 ERECTION**

A All support steel, angles, channels, pipes or structural steel stands and anchoring devices that may be required to rigidly support or anchor material and equipment shall be provided by this Contractor.

**3.06 FIELD QUALITY CONTROL**

A The Contractor shall conform to the requirements of Division 3 for concrete testing.

B All testing required for compliance with the Contract shall be as stated in subsequent sections.

**3.07 ADJUST AND CLEAN**

A All equipment and installed materials shall be thoroughly clean and free of all dirt, oil, grit, grease, etc.

B Clean piping and ductwork both internally and externally to remove dirt, dust, debris, and other foreign matter. When external surfaces of piping are rusted, clean and restore surface to original condition.

C Clean all equipment as recommended by the manufacturer.

D Factory painted equipment shall not be repainted unless damaged areas exist. These areas shall be touched up with a material suitable for intended service. In no event shall name plates be painted.

E Dirt, dust, and other foreign matter shall be blown and/or cleaned from coils, terminal devices, diffusers, registers, and grilles. Inspect all coils and comb coil fins where damaged to as-new condition prior to test and balance work.

F If the Owner has doubts or concerns about the cleanliness of the ductwork or air handling systems, the Owner reserves the right to have a third-party assessment performed by a board certified indoor environmental consultant to determine if the installation meets requirements as stipulated in the National Air Duct Cleaners Association (NADCA) Assessment, Cleaning, and Restoration of HVAC Systems. If duct systems or air handling units are found to have accumulated dirt or foreign matter on interior surfaces in violation of NADCA guidelines, the Contractor shall be responsible for all costs required to restore the air distribution system to new condition to the satisfaction of the Owner. This shall include payment for all costs associated with third party testing of the systems.

G At a scheduled meeting, the Contractor shall instruct the Owner or the Owner's representative in the operation and maintenance of all equipment installed under his Contract (in the presence of the Engineer).

H Equipment with filter media shall be run for a period of two (2) weeks after completion of work at which time a new filter media shall be installed with one change of filter media provided the Owner for future replacement. (Provide a total of three (3) sets).

I The Contractor shall adjust the tension on all belts six months after the final inspection.

**3.08 TESTING AND BALANCING**

A Tests for equipment, ductwork, piping, and other systems shall be performed as specified in their respective sections in accordance with technical requirements indicated.

B Provide equipment and devices required for testing, including fittings for additional openings as required for the test apparatus.

C All ductwork and piping inspections and testing shall be successfully completed with test reports reviewed and approved by the Engineer before concealment or application of covering materials.

D Testing shall be witnessed by the Engineer, unless otherwise indicated. Notify Engineer, Owner, Commission Authority, and other parties at least 72 hours in advance of testing date. Engineer, at his discretion, may opt not to witness a given test. In this case, The Construction Manager/General Contractor and/or CxA shall witness the test and forward results to Engineer for review.

E Contractor shall be responsible for certifying in writing all equipment and system test results. Certification shall include identification of portion of system tested, date, time, weather conditions, test criteria, testing medium, and pressure used, duration of test, and name and title of person signing test certification document. Results shall be submitted to Engineer within three (3) days of test completion.

**3.09 MAINTENANCE AND OPERATING MANUAL**

- A The Contractor shall prepare a PDF version of the manual describing the proper maintenance and system operation. This manual shall not consist of standard factory printed data intended for dimension or design purposes (although these may be included), but shall be prepared to describe this particular job. This manual shall include the following:
  - 1. A check list for periodic maintenance of all equipment.
  - 2. Suggested setting of all controls and switches for normal operation, with description of control and its location.
  - 3. A check list for seasonal shutdown.
  - 4. Maintenance and spare parts data for each major piece of equipment.
  - 5. As-built wiring, interlock and control diagrams for equipment with color coding shown on wiring and interlock diagrams.
  - 6. Air and Water Balance Report.
- B The PDF shall be indexed, bookmarked, dated and signed by the Contractor when completed.
- C The operating and maintenance manuals shall be submitted to the Engineer for approval. When the manuals are considered complete by the Engineer, they will be turned over to the Owner for their permanent use.
- D For each major piece of equipment, the Contractor shall organize and record on video the on-site training sessions. A copy of the video shall be turned over to the Owner at the completion of the project.

**END OF SECTION 23 01 00**

**SECTION 23 05 12**  
**ELECTRICAL WORK**

**PART 1 GENERAL**

**1.01 DIVISION OF WORK**

- A This Contractor shall be responsible for the final electrical and the entire control connections and wiring to all equipment installed as part of his contract.
- B Contractor shall review the electrical plans, where applicable, to establish points of connection and the extent of his electrical work to be provided in his contract.
- C Unless otherwise noted, this Contractor shall wire from his equipment to disconnect switches, junction boxes, or panelboard circuit breakers as provided by the Electrical Contractor or as required by the existing conditions.
- D All power and control wiring shall be in conduits. Refer to electrical specifications for conduit and conduit fittings.
- E All electrical work shall be performed by a licensed electrician.
- F All electrical work shall be in accordance with the State Building Code and all its supplements, the latest edition of the National Electrical Code and the electrical specifications.

**PART 2 PRODUCT**

**2.01 GENERAL REQUIREMENTS**

- A All motor starters, disconnects, switches, relays, conduits, conductors, etc. that are required for a complete electrical power and/or control system shall conform to the requirements set forth by NEC.
- B Refer to the plans for the type, size and electrical characteristics of the starters, disconnects, switches, relays, conductor and conduits.
- C All conductors and conduits shall be sized as noted on the plans or As required per NEC.
- D All individual motor starters for mechanical equipment (i.e., fans, pumps, etc.) shall be furnished and installed under Division 23.
- E All relays, actuators, timers, seven-day clocks, alternators, pressure, vacuum, float, flow, pneumatic-electric, and electric-pneumatic switches, aquastats, freezestats, line and low voltage thermostats, thermals, remote selector switches, remote push-button stations, emergency break-glass stations, interlocking, disconnect switches beyond termination point, and other appurtenances associated with equipment under Division 23 shall be furnished, installed and wired under Division 23.

**PART 3 EXECUTION**

**3.01 GENERAL REQUIREMENTS**

- A All motor starters, disconnects, and switches shall be installed on or as close to the equipment they are serving as possible, or where shown on the plans.
- B Electrical connection to equipment subject to vibration which develops objectionable noises shall be made from the conduit system with short lengths of flexible "Liquid-Tite" conduit. Connection to other equipment shall be made with rigid conduit.
- C Conduits shall be run in a concealed space such as wall cavities, ceiling cavities, etc. except in the mechanical rooms where conduit may be run exposed.

**END OF SECTION 23 05 12 23 05 12**



**SECTION 23 05 17**  
**SLEEVES AND SLEEVE SEALS FOR HVAC PIPING**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A Pipe sleeves.
- B Pipe-sleeve seals.

**1.02 REFERENCE STANDARDS**

- A ASTM C592 - Standard Specification for Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered) (Industrial Type); 2022a.
- B ASTM E814 - Standard Test Method for Fire Tests of Penetration Firestop Systems; 2023a.

**1.03 SUBMITTALS**

- A Shop Drawings: Indicate pipe materials used, jointing methods, supports, floor and wall penetration seals. Indicate installation, layout, weights, mounting and support details, and piping connections.

**1.04 QUALITY ASSURANCE**

- A Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.
- B Clean equipment, pipes, valves, and fittings of grease, metal cuttings, and sludge that may have accumulated from the installation and testing of the system.

**1.05 DELIVERY, STORAGE, AND HANDLING**

- A Deliver and store sleeve and sleeve seals in shipping containers, with labeling in place.
- B Provide temporary protective coating on cast iron and steel sleeves if shipped loose.

**PART 2 PRODUCTS**

**2.01 PIPE SLEEVES**

- A Non-manufactured sleeves:
  - 1. Cast iron or Schedule 40 steel
- B Vertical Piping:
  - 1. Sleeve Length: 2 inch above finished floor.
  - 2. Provide sealant for watertight joint.
  - 3. Drilled Penetrations: Provide 1-1/2 inch angle ring or square set in silicone adhesive around penetration.
- C Pipe Passing Through Below Grade Foundation Walls or Exterior Walls:
  - 1. Manufactured sleeve-seal system
  - 2. Provide watertight space with link rubber or modular seal between sleeve and pipe on both pipe ends.
- D Non-rated interior stud wall Penetrations:
  - 1. Pack annular space with mineral wool and seal tight with caulk
- E Non-rated interior CMU wall Penetrations:
  - 1. Pack annual space with mineral wool and seal with non-shrink grout.
- F Clearances:
  - 1. Provide allowance for insulated piping.
  - 2. All Rated Openings: Caulked tight with fire stopping material in compliance with ASTM E814 to prevent the spread of fire, smoke, and gases.

**2.02 PIPE-SLEEVE SEALS**

- A Manufacturers:
  - 1. Advance Products & Systems, LLC
  - 2. Flexicraft Industries
  - 3. GPT Industries
  - 4. Or Approved Equal
- B Modular Mechanical Sleeve-Seal:
  - 1. Elastomer-based interlocking links continuously fill annular space between pipe and wall-sleeve, wall or casing opening.
  - 2. Watertight seal between pipe and wall-sleeve, wall or casing opening.

3. Size and select seal component materials in accordance with service requirements.
4. Service Requirements:
  - a. Corrosion resistant.
  - b. Oil, fuel, gas, and solvent resistant.
  - c. Underground, buried, and wet conditions.
  - d. High Temperature, up to 400 degrees F.
  - e. Low temperature, down to minus 67 degrees F.
5. Glass-reinforced plastic pressure end plates.

**C Sealing Compounds:**

1. Provide packing and sealing compound to fill pipe to sleeve thickness.
2. Combined packing and seal compound is to match partition fire-resistance hourly rating.

**PART 3 EXECUTION**

**3.01 PREPARATION**

- A Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
- B Remove scale and foreign material, from inside and outside, before assembly.

**3.02 INSTALLATION**

- A Route piping in orderly manner, plumb and parallel to building structure. Maintain gradient.
- B Install piping to conserve building space, to not interfere with use of space and other work.
- C Install piping and pipe sleeves to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
- D Inserts:
  1. Provide inserts for placement in concrete formwork.
  2. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
  3. Where concrete slabs form finished ceiling, locate inserts flush with slab surface.
  4. Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut above slab.
- E Structural Considerations:
  1. Do not penetrate building structural members unless approved by the Structural Engineer.
- F Provide sleeves when penetrating footings, floors, and walls. Seal pipe including sleeve penetrations to achieve fire resistance equivalent to fire separation required.
  1. Aboveground Piping:
    - a. Pack solid using mineral fiber in compliance with ASTM C592.
    - b. Fill space with an elastomer caulk to a depth of 0.50 inch where penetrations occur between conditioned and unconditioned spaces.
  2. Caulk exterior wall sleeves watertight with lead and oakum or mechanically expandable chloroprene inserts with mastic-sealed components.
- G Manufactured Sleeve-Seal Systems:
  1. Install manufactured sleeve-seal systems in sleeves located in grade slabs and exterior walls at piping entrances into building.
  2. Provide sealing elements of the size, quantity, and type required for the piping and sleeve inner diameter or penetration diameter.
  3. Locate piping in center of sleeve or penetration.
  4. Install field assembled sleeve-seal system components in annular space between sleeve and piping.
  5. Tighten bolting for a water-tight seal.
  6. Install in accordance with manufacturer's recommendations.
- H When installing more than one piping system material, ensure system components are compatible and joined to ensure the integrity of the system. Provide necessary joining fittings. Ensure flanges, union, and couplings for servicing are consistently provided.

**3.03 CLEANING**

- A Upon completion of work, clean all parts of the installation.

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- B Clean equipment, pipes, valves, and fittings of grease, metal cuttings, and sludge that may have accumulated from the installation and testing of the system.

**END OF SECTION 23 05 17**

**SECTION 23 05 29**

**HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A Support and attachment components.

**1.02 REFERENCE STANDARDS**

- A ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products; 2017.
- B ASTM A153/A153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware; 2023.
- C ASTM A181/A181M - Standard Specification for Carbon Steel Forgings, for General-Purpose Piping; 2023.
- D ASTM A36/A36M - Standard Specification for Carbon Structural Steel; 2019.
- E ASTM A47/A47M - Standard Specification for Ferritic Malleable Iron Castings; 1999, with Editorial Revision (2022).
- F ASTM A283/A283M - Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates; 2018.
- G ASTM A395/A395M - Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures; 1999 (Reapproved 2022).
- H ASTM A653/A653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process; 2023.
- I ASTM B633 - Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel; 2023.
- J ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2018b.
- K FM (AG) - FM Approval Guide; Current Edition.
- L MFMA-4 - Metal Framing Standards Publication; 2004.
- M MSS SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation; 2018, with Amendment (2019).
- N UL (DIR) - Online Certifications Directory; Current Edition.
- O UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials; Current Edition, Including All Revisions.

**1.03 ADMINISTRATIVE REQUIREMENTS**

- A Coordination:
  - 1. Coordinate sizes and arrangement of supports and bases with the actual equipment and components to be installed.
  - 2. Coordinate the work with other trades to provide additional framing and materials required for installation.
  - 3. Coordinate compatibility of support and attachment components with mounting surfaces at the installed locations.
  - 4. Coordinate the arrangement of supports with ductwork, piping, equipment and other potential conflicts installed under other sections or by others.
  - 5. Notify Architect of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.
- B Sequencing:
  - 1. Do not install products on or provide attachment to concrete surfaces until concrete has fully cured.

**1.04 SUBMITTALS**

- A Product Data: Provide manufacturer's standard catalog pages and data sheets for channel (strut) framing systems, nonpenetrating rooftop supports, post-installed concrete and masonry anchors, and thermal insulated pipe supports.
- B Shop Drawings: Include details for fabricated hangers and supports where materials or methods other than those indicated are proposed for substitution.

1. Application of protective inserts, saddles, and shields at pipe hangers for each type of insulation and hanger.

- C Evaluation Reports: For products specified as requiring evaluation and recognition by ICC Evaluation Service, LLC (ICC-ES), provide current ICC-ES evaluation reports upon request.
- D Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.

**1.05 QUALITY ASSURANCE**

- A Comply with applicable building code.
- B Review the Structural Drawings for limitations as to type of hangers to be used on various structural members.
- C Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

**1.06 DELIVERY, STORAGE, AND HANDLING**

- A Receive, inspect, handle, and store products in accordance with manufacturer's instructions.

**PART 2 PRODUCTS**

**2.01 SUPPORT AND ATTACHMENT COMPONENTS**

- A General Requirements:
  1. Provide all required hangers, supports, anchors, fasteners, fittings, accessories, and hardware as necessary for the complete installation of plumbing work.
  2. Provide products listed, classified, and labeled as suitable for the purpose intended, where applicable.
  3. Where support and attachment component types and sizes are not indicated, select in accordance with manufacturer's application criteria as required for the load to be supported with a minimum safety factor of 2. Include consideration for vibration, equipment operation, and shock loads where applicable.
  4. Do not use wire, chain, perforated pipe strap, or wood for permanent supports unless specifically indicated or permitted.
  5. Steel Components: Use corrosion resistant materials suitable for the environment where installed.
    - a. Zinc-Plated Steel: Electroplated in accordance with ASTM B633.
    - b. Galvanized Steel: Hot-dip galvanized after fabrication in accordance with ASTM A123/A123M or ASTM A153/A153M.
- B Prefabricated Trapeze-Framed Metal Strut Systems:
  1. Manufacturers:
    - a. Cooper B-Line, a division of Eaton Corporation
    - b. Elgen Manufacturing Company, Inc
    - c. Thomas & Betts Corporation
    - d. Unistrut, a brand of Atkore International Inc
    - e. Source Limitations: Furnish hardware, fittings, and accessories from single manufacturer.
  2. MFMA-4 compliant, pre-fabricated, MSS SP-58 type 59 continuous-slot metal strut channel with associated tracks, fittings, and related accessories.
  3. Strut Channel or Bracket Material:
    - a. Indoor Dry Locations: Use zinc-plated steel or galvanized steel.
    - b. Outdoor and Damp or Wet Indoor Locations: Use galvanized steel.
  4. Minimum Channel Thickness: Steel sheet, 12 gauge, 0.1046 inch.
  5. Accessories: Provide bracket covers, clamps, conduit clamps, fire-retarding brackets, j-hooks, protectors, and vibration dampeners.
- C Strut Channels:
  1. Manufacturers:
    - a. B-Line, a brand of Eaton Corporation
    - b. Gripple, Inc; Universal Bracket

- c. Unistrut, a brand of Atkore International Inc
    - d. Source Limitations: Furnish hardware, fittings, and accessories from single manufacturer.
  2. ASTM A653/A653M galvanized steel bracket with clamps for surface mounting of piping or equipment support.
  3. Channel or Bracket Kits: Include rods, brackets, end-fixed fittings, covers, clips, and other related hardware required to complete sectional trapeze section for piping or other support.
- D Channel Nuts:
  1. Provide carbon steel channel nut with galvanized steel, stainless steel, or zinc finish and regular spring.
- E Hanger Rods:
  1. Threaded zinc-plated or galvanized steel unless otherwise indicated.
- F Steel Cable:
  1. Manufacturers:
    - a. Ductmate Industries, Inc, a DMI Company; Clutcher Cable Hanging System
    - b. Elgen Manufacturing Company, Inc
    - c. Source Limitations: Furnish hardware, fittings, and accessories from single manufacturer.
- G Cable Hanging System Kits:
  1. Manufacturers:
    - a. B-Line, a brand of Eaton Corporation
    - b. Ductmate Industries, Inc
    - c. Gripple, Inc
    - d. Source Limitations: Furnish hardware, fittings, and accessories from single manufacturer.
  2. Provide cable-wire in bulk or precut lengths with respective cable hangers as required to hold minimum weight of 240 lb.
- H Thermal Insulated Pipe Supports:
  1. Manufacturers:
    - a. Buckaroos, Inc
    - b. KB Enterprises
  2. General Requirements:
    - a. Insulated pipe supports to be provided at hanger, support, and guide locations on pipe requiring insulation or additional support.
    - b. Surface Burning Characteristics: Flame spread index/smoke developed index of 5/30, maximum, when tested in accordance with ASTM E84 or UL 723.
    - c. Pipe supports to be provided for nominally sized, 1/2 to 30 inch iron pipes.
    - d. Insulation inserts to consist of calcium silicate insulation surrounded by a 360 degree, galvanized steel jacketing.
  3. Pipe insulation protection shields to be provided at the hanger points and guide locations on pipes requiring insulation as indicated on drawings.
- I Pipe Supports:
  1. Material: ASTM A395/A395M ductile iron, ASTM A36/A36M carbon steel, ASTM A47/A47M malleable iron, ASTM A181/A181M forged steel, or ASTM A283/A283M steel.
  2. Liquid Temperatures Up To 122 degrees F:
    - a. Overhead Support: MSS SP-58 Types 1, 3 through 12.
    - b. Support From Below: MSS SP-58 Types 35 through 38.
  3. Operating Temperatures from 122 to 446 degrees F:
    - a. Overhead Support: MSS SP-58 Type 1 or 3 through 12, with appropriate saddle of MSS SP-58 Type 40 for insulated pipe.
    - b. Roller Support: MSS SP-58 Types 41 or 43 through 46, with appropriate saddle of MSS SP-58 Type 39 for insulated pipe.
    - c. Sliding Support: MSS SP-58 Types 35 through 38.
- J Pipe Stanchions:

1. Material: Malleable iron, ASTM A47/A47M; or carbon steel, ASTM A36/A36M.
  2. Provide coated or plated saddles to isolate steel hangers from dissimilar metal tube or pipe.
  3. For pipe runs, use stanchions of same type and material where vertical adjustment is required for stationary pipe.
- K Beam Clamps:**
1. MSS SP-58 types 19 through 23, 25 or 27 through 30 based on required load.
  2. Beam C-Clamp: MSS SP-58 type 23, malleable iron and steel with zinc finish.
  3. Small or Junior Beam Clamp: MSS SP-58 type 19, malleable iron with zinc finish. For inverted usage provide manufacturer listed size(s).
  4. Wide Mouth Beam Clamp: MSS SP-58 type 19, malleable iron with zinc or galvanized finish.
  5. Centerload Beam Clamp with Extension Piece: MSS SP-58 type 30, malleable iron with galvanized finish.
  6. FM (AG) and UL (DIR) Approved Beam Clamp: MSS SP-58 type 19, plated finish,
  7. Provide clamps with hardened steel cup-point set screws and lock-nuts for anchoring in place.
  8. Material: ASTM A395/A395M ductile iron, ASTM A36/A36M carbon steel, ASTM A47/A47M malleable iron, ASTM A181/A181M forged steel, or ASTM A283/A283M steel.
- L Riser Clamps:**
1. For insulated pipe runs, provide two bolt-type clamps designed for installation under insulation.
  2. MSS SP-58 type 1 or 8, carbon steel with stainless steel or zinc plated finish.
  3. Medium Split Horizontal Pipe Clamp: MSS SP-58 type 4, carbon steel or stainless steel with stainless steel or zinc plated finish.
  4. Copper Tube Pipe Clamp: MSS SP-58 type 8, copper.
  5. UL (DIR) listed: Pipe sizes 1/2 to 8 inch.
- M Pipe Hangers:**
1. Split Ring Hangers:
    - a. Provide hinged split ring and yoke roller hanger with epoxy copper or plain finish.
    - b. Material: ASTM A47/A47M malleable iron or ASTM A36/A36M carbon steel.
    - c. Provide hanger rod and nuts of the same type and material for a given pipe run.
    - d. Provide coated or plated hangers to isolate steel hangers from dissimilar metal tube or pipe.
  2. Clevis Hangers, Adjustable:
    - a. Copper Tube: MSS SP-58 Type 1, epoxy-plated copper.
    - b. Standard-Duty: MSS SP-58 Type 1, zinc-plated.
    - c. UL (DIR) listed: Pipe sizes 2-1/2 to 8 inch.
    - d. FM (AG) listed: Pipe sizes 2-1/2 to 8 inch.
- N Intermediate Pipe Guides:**
1. Pipe Diameter 6 inch and Smaller: Provide minimum clearance of 0.16 inch.
  2. Pipe Sizes 8 inch: 0.625 inch U-bolt with double nuts providing minimum clearance of 0.28 inch.
  3. Pipe Size 10 inch: 0.75 inch U-bolt.
  4. Pipe Sizes 12 to 16 inch: 0.875 inch U-bolt.
  5. Pipe Sizes 18 to 30 inch: 1 inch U-bolt.
  6. Use pipe clamps with oversize pipe sleeve that provides clearance around pipe.
- O Pipe Alignment Guides: Galvanized steel.**
1. Pipe Sizes 8 inch and Smaller: Spider or sleeve type.
  2. Pipe Sizes 10 inch and Larger: Roller type.
- P Dielectric Barriers: Provide between metallic supports and metallic piping and associated items of dissimilar type; acceptable dielectric barriers include rubber or plastic sheets or coatings attached securely to pipe or item.**
- Q Nonpenetrating Rooftop Supports for Low-Slope Roofs:**
1. Manufacturers:
    - a. Anvil International; H-Block

- b. Cooper B-Line, a division of Eaton Corporation
  - c. Erico International Corporation, a brand of Pentair
  - d. PHP Systems/Design; \_\_\_\_\_
  - e. Unistrut, a brand of Atkore International Inc
2. Provide steel pedestals with thermoplastic or rubber base that rest on top of roofing membrane, not requiring any attachment to the roof structure and not penetrating the roofing assembly, with support fixtures as specified.
  3. Base Sizes: As required to distribute load sufficiently to prevent indentation of roofing assembly.
  4. Attachment/Support Fixtures: As recommended by manufacturer, same type as indicated for equivalent indoor hangers and supports.
  5. Mounting Height: Provide minimum clearance of 6 inches under supported component to top of roofing.
- R Anchors and Fasteners:
1. Manufacturers - Mechanical Anchors:
    - a. FNW; 7502
    - b. Hilti, Inc
    - c. ITW Red Head, a division of Illinois Tool Works, Inc
    - d. Powers Fasteners, Inc
  2. Unless otherwise indicated and where not otherwise restricted, use the anchor and fastener types indicated for the specified applications.
  3. Concrete: Use preset concrete inserts, expansion anchors, or screw anchors.
  4. Solid or Grout-Filled Masonry: Use expansion anchors or screw anchors.
  5. Hollow Stud Walls: Use toggle bolts.
  6. Steel: Use beam-ceiling clamps, beam clamps, machine bolts, or welded threaded studs.
  7. Sheet Metal: Use sheet metal screws.
  8. Plastic and lead anchors are not permitted.
  9. Hammer-driven anchors and fasteners are not permitted.
  10. Preset Concrete Inserts: Continuous metal channel (strut) and spot inserts specifically designed to be cast in concrete ceilings, walls, and floors.
    - a. Comply with MFMA-4.
    - b. Channel Material: Use galvanized steel.
    - c. Manufacturer: Same as manufacturer of metal channel (strut) framing system.

**PART 3 EXECUTION**

**3.01 INSTALLATION**

- A Install products in accordance with manufacturer's instructions.
- B Install anchors and fasteners in accordance with ICC Evaluation Services, LLC (ICC-ES) evaluation report conditions of use where applicable.
- C Provide independent support from building structure. Do not provide support from piping, ductwork, conduit, or other systems.
- D Unless specifically indicated or approved by Architect, do not provide support from suspended ceiling support system or ceiling grid.
- E Unless specifically indicated or approved by Architect, do not provide support from roof deck.
- F Do not penetrate or otherwise notch or cut structural members without approval of Structural Engineer.
- G Provide thermal insulated pipe supports complete with hangers and accessories. Install thermal insulated pipe supports during the installation of the piping system.
- H Equipment Support and Attachment:
  1. Use metal fabricated supports or supports assembled from metal channel (strut) to support equipment as required.
  2. Use metal channel (strut) secured to studs to support equipment surface-mounted on hollow stud walls when wall strength is not sufficient to resist pull-out.



3. Use metal channel (strut) to support surface-mounted equipment in wet or damp locations to provide space between equipment and mounting surface.
  4. Securely fasten floor-mounted equipment. Do not install equipment such that it relies on its own weight for support.
- I Preset Concrete Inserts: Use manufacturer-provided closure strips to inhibit concrete seepage during concrete pour.
- J Secure fasteners according to manufacturer's recommended torque settings.
- K Remove temporary supports.

**3.02 FIELD QUALITY CONTROL**

- A Inspect support and attachment components for damage and defects.
- B Repair cuts and abrasions in galvanized finishes using zinc-rich paint recommended by manufacturer. Replace components that exhibit signs of corrosion.
- C Correct deficiencies and replace damaged or defective support and attachment components.

**END OF SECTION 23 05 29**

**SECTION 23 05 48**  
**VIBRATION AND SEISMIC CONTROLS FOR HVAC**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A Vibration isolation requirements.
- B Vibration isolators.

**1.02 REFERENCE STANDARDS**

- A ASHRAE (HVACA) - ASHRAE Handbook - HVAC Applications; Most Recent Edition Cited by Referring Code or Reference Standard.

**1.03 ADMINISTRATIVE REQUIREMENTS**

- A Coordination:
  - 1. Coordinate selection and arrangement of vibration isolation and/or seismic control components with the actual equipment to be installed.
  - 2. Coordinate the work with other trades to provide additional framing and materials required for installation.
  - 3. Coordinate compatibility of support and attachment components with mounting surfaces at the installed locations.

**1.04 SUBMITTALS**

- A Product Data: Provide manufacturer's standard catalog pages and data sheets for products, including materials, fabrication details, dimensions, and finishes.
  - 1. Vibration Isolators: Include rated load capacities and deflections; include information on color coding or other identification methods for spring element load capacities.
- B Shop Drawings - Vibration Isolation Systems:
  - 1. Include dimensioned plan views and sections indicating proposed arrangement of vibration isolators; indicate equipment weights and static deflections.

**1.05 QUALITY ASSURANCE**

- A Comply with applicable building code.
- B Seismic Controls and High-Wind Designer Qualifications: Registered professional engineer licensed in the State in which the Project is located and with minimum five years experience designing seismic and wind restraints for nonstructural components.
- C Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.

**1.06 DELIVERY, STORAGE, AND HANDLING**

- A Receive, inspect, handle, and store products in accordance with manufacturer's instructions.

**PART 2 PRODUCTS**

**2.01 VIBRATION ISOLATION REQUIREMENTS**

- A Design and provide vibration isolation systems to reduce vibration transmission to supporting structure from vibration-producing HVAC equipment and/or HVAC connections to vibration-isolated equipment.
- B Comply with applicable general recommendations of ASHRAE (HVACA), where not in conflict with other specified requirements:
- C General Requirements:
  - 1. Select vibration isolators to provide required static deflection.
  - 2. Select vibration isolators for uniform deflection based on distributed operating weight of actual installed equipment.
  - 3. Select vibration isolators for outdoor equipment to comply with wind design requirements.
- D Equipment Isolation: Isolate all motor driven mechanical equipment, unless otherwise noted, from building structure, and from systems which they serve, to prevent equipment vibrations from being transmitted to structure. Unless specifically indicated, follow the latest edition of ASHRAE Application Handbook - Sound and Vibration Control, or manufacturer's recommendations for isolator selection, whichever is more stringent..

1. Select and locate isolators to produce uniform loading and deflection. Use a minimum of 4 isolators to support each piece of equipment.
  2. Select vibration isolation devices based on the lowest operating speed of equipment.
- E Piping Isolation:
1. Provide vibration isolators for piping supports:
    - a. Located in equipment rooms.
    - b. Located within 50 feet of connected vibration-isolated equipment and pressure-regulating valve (PRV) stations.
  2. Minimum Static Deflection:
    - a. First Three Supports Closest to Isolated Equipment: Same as static deflection of equipment; maximum of 2 inch deflection required.
    - b. Remainder of Supports: 0.75 inch deflection unless otherwise indicated.
  3. Suspended Piping, Nonseismic Applications: Use resilient material isolator hangers, spring isolator hangers, or combination resilient material/spring isolator hangers.
  4. Floor-Mounted Piping, Nonseismic Applications: Use open (unhoused) spring isolators.
- F Thrust Restraint Applications:
1. Use thrust restraints to resist horizontal motion due to thrust for fan heads, suspended fans, and base-mounted and suspended air handling equipment operating at 2.0 inches wg or greater total static pressure.
  2. Minimum Static Deflection: Same as static deflection of equipment.

**2.02 VIBRATION ISOLATORS**

- A Manufacturers:
1. Vibration Isolators:
    - a. Kinetics Noise Control, Inc
    - b. Mason Industries
    - c. Vibration Eliminator Company, Inc
    - d. The VMC Group/Amber Booth
    - e. Or Approved Equal
  2. Source Limitations: Furnish vibration-isolators and associated accessories produced by a single manufacturer and obtained from a single supplier.
- B General Requirements:
1. Resilient Materials for Vibration Isolators: Oil, ozone, and oxidant resistant.
  2. Spring Elements for Spring Isolators:
    - a. Color code or otherwise identify springs to indicate load capacity.
    - b. Lateral Stability: Minimum lateral stiffness to vertical stiffness ratio of 0.8.
    - c. Designed to operate in the linear portion of their load versus deflection curve over deflection range of not less than 50 percent above specified deflection.
    - d. Designed to provide additional travel to solid of not less than 50 percent of rated deflection at rated load.
    - e. Selected to provide designed deflection of not less than 75 percent of specified deflection.
    - f. Selected to function without undue stress or overloading.
- C Vibration Isolators for Nonseismic Applications:
1. Resilient Material Isolator Pads:
    - a. Description: Single or multiple layer pads utilizing elastomeric (e.g. neoprene, rubber) isolator material.
    - b. Pad Thickness: As required for specified minimum static deflection; minimum 0.25 inch thickness.
    - c. Multiple Layer Pads: Provide bonded, galvanized sheet metal separation plate between each layer.
  2. Resilient Material Isolator Mounts, Nonseismic:

- a. Description: Mounting assemblies for bolting equipment to supporting structure utilizing elastomeric (e.g. neoprene, rubber) isolator material; fail-safe type.
3. Open (Unhoused) Spring Isolators:
  - a. Description: Isolator assembly consisting of single or multiple free-standing, laterally stable steel spring(s) without a housing.
  - b. Bottom Load Plate: Nonskid, molded, elastomeric isolator material or steel with nonskid elastomeric isolator pad with provisions for bolting to supporting structure as required.
  - c. Furnished with integral leveling device for positioning and securing supported equipment.
4. Housed Spring Isolators:
  - a. Description: Isolator assembly consisting of single or multiple free-standing, laterally stable steel spring(s) within a metal housing.
  - b. Furnished with integral elastomeric snubbing elements, adjustable type, for limiting equipment movement and preventing metal-to-metal contact between housing elements.
  - c. Bottom Load Plate: Steel with nonskid, elastomeric isolator pad with provisions for bolting to supporting structure as required.
  - d. Furnished with integral leveling device for positioning and securing supported equipment.
5. Restrained Spring Isolators, Nonseismic:
  - a. Description: Isolator assembly consisting of single or multiple free-standing, laterally stable steel spring(s) within a metal housing designed to prevent movement of supported equipment above an adjustable vertical limit stop.
  - b. Bottom Load Plate: Steel with nonskid elastomeric isolator pad with provisions for bolting to supporting structure as required.
  - c. Furnished with integral leveling device for positioning and securing supported equipment.
  - d. Provides constant free and operating height.
6. Resilient Material Isolator Hangers, Nonseismic:
  - a. Description: Isolator assembly designed for installation in hanger rod suspension system utilizing elastomeric (e.g. neoprene, rubber) isolator material for the lower hanger rod connection.
7. Spring Isolator Hangers, Nonseismic:
  - a. Description: Isolator assembly designed for installation in hanger rod suspension system utilizing single or multiple free-standing, laterally stable steel spring(s) in series with an elastomeric element for the lower hanger rod connection.
  - b. Designed to accommodate misalignment of bottom hanger rod up to 30 degrees (plus/minus 15 degrees) without short-circuiting of isolation.
8. Combination Resilient Material/Spring Isolator Hangers, Nonseismic:
  - a. Description: Isolator assembly designed for installation in hanger rod suspension system utilizing single or multiple free-standing, laterally stable steel spring(s) for the lower hanger rod connection and elastomeric (e.g. neoprene, rubber) isolator material for the upper hanger rod connection.
  - b. Designed to accommodate misalignment of bottom hanger rod up to 30 degrees (plus/minus 15 degrees) without short-circuiting of isolation.

### **2.03 VIBRATION-ISOLATED AND/OR SEISMICALLY ENGINEERED ROOF CURBS**

#### **A Manufacturers:**

1. Vibration-Isolated and/or Seismically Engineered Roof Curbs:
  - a. Kinetics Noise Control, Inc
  - b. Mason Industries
  - c. CalDyn
  - d. Vibration Eliminator Company, Inc
  - e. The VMC Group/Amber Booth
  - f. BRD
  - g. Or Approved Equal

#### **B Vibration Isolation Curbs:**

1. Nonseismic Curb Rail:
  - a. Location: Between existing roof curb and rooftop equipment.
  - b. Construction: Aluminum.
  - c. Integral vibration isolation to comply with requirements of this section.
  - d. Weather exposed components consist of corrosion resistant materials.
2. Nonseismic Curb:
  - a. Location: Between structure and rooftop equipment.
  - b. Construction: Aluminum.
  - c. Integral vibration isolation to comply with requirements of this section.
  - d. Weather exposed components consist of corrosion resistant materials.

### **PART 3 EXECUTION**

#### **3.01 EXAMINATION**

- A Verify that field measurements are as shown on the drawings.
- B Verify that mounting surfaces are ready to receive vibration isolation and/or seismic control components and associated attachments.
- C Verify that conditions are satisfactory for installation prior to starting work.

#### **3.02 INSTALLATION**

- A Install products in accordance with manufacturer's instructions.
- B Install anchors and fasteners in accordance with ICC Evaluation Services, LLC (ICC-ES) evaluation report conditions of use where applicable.
- C Secure fasteners according to manufacturer's recommended torque settings.
- D Install flexible piping connections to provide sufficient slack for vibration isolation and/or seismic relative displacements as indicated or as required.
- E Vibration Isolation Systems:
  1. Spring Isolators:
    - a. Position equipment at operating height; provide temporary blocking as required.
    - b. Lift equipment free of isolators prior to lateral repositioning to avoid damage to isolators.
    - c. Level equipment by adjusting isolators gradually in sequence to raise equipment uniformly such that excessive weight or stress is not placed on any single isolator.
  2. Isolator Hangers:
    - a. Use precompressed isolator hangers where required to facilitate installation and prevent damage to equipment utility connection provisions.
    - b. Locate isolator hangers at top of hanger rods in accordance with manufacturer's instructions.
  3. Clean debris from beneath vibration-isolated equipment that could cause short-circuiting of isolation.
  4. Use elastomeric grommets for attachments where required to prevent short-circuiting of isolation.
  5. Adjust isolators to be free of isolation short circuits during normal operation.
  6. Do not overtighten fasteners such that resilient material isolator pads are compressed beyond manufacturer's maximum recommended deflection.

#### **3.03 FIELD QUALITY CONTROL**

- A Inspect vibration isolation and/or seismic control components for damage and defects.
- B Vibration Isolation Systems:
  1. Verify isolator static deflections.
  2. Verify vibration isolation performance during normal operation; investigate sources of isolation short circuits.
- C Correct deficiencies and replace damaged or defective vibration isolation and/or seismic control components.

**END OF SECTION 23 05 48**

**SECTION 23 05 49**  
**IN ROOF CURB ACOUSTICAL DECK TREATMENT**

**PART 1 – GENERAL**

**1.01 WORK INCLUDED**

- A The work consists of furnishing an Acoustical Deck System for rooftop HVAC units as described in this specification.
- B In-Curb Acoustical Treatment as shown on the contract drawings, schedule, or as tabulated shall be installed in each RTU curb to reduce the noise levels from Rooftop Air Handling Equipment radiating through the curb to the occupied spaces below.

**1.02 SUBMITTALS**

- A Include construction details, materials, dimensions of individual components and profiles and finishes.
- B Detail fabrication including anchorages and attachments to structure and to supported equipment.
- C Copy of ASTM E-90-10 test results from an independent lab shall be included in the submittal.

**1.03 QUALITY ASSURANCE**

- A Company specializing in the manufacture of acoustical and vibration systems and equipment/related accessories with not less than 10 years documented successful experience for work comparable to work of this project.
  - 1. All component products outlined in this specification shall be furnished by a single supplier.
- B The Acoustical Deck System shall be supplied with the packaged air handling unit equipment.

**PART 2 – PRODUCTS**

**2.01 MANUFACTURERS**

- A Acoustical Solutions
- B Acoustiblok
- C BRD Noise and Vibration Control, Inc.
- D Kinetics Noise Control

**2.02 IN-CURB COMPOSITE ACOUSTICAL TREATMENT**

- A Acoustical composite
  - 1. The overall installed composite shall have an installed thickness of 7” for the composite.
  - 2. Shall meet Class “A” per ASTM E84 for flammability
  - 3. The composite panels shall receive model HSAC-100 acoustical grade caulk at seams and all perimeter edges inside the curb
  - 4. Seams for each layer shall be staggered

**2.03 IN-CURB COMPOSITE ACOUSTICAL TREATMENT PERFORMANCE**

- A The combination of all layers shall be tested for Sound Transmission Loss in accordance with procedure ASTM E-90-10. The assembly shall be rated at not less than STC-38 with 1/3 octave performance values as listed below for sound radiation through the deck inside the curb.

Freq. (Hz)	80	100	125	160	200	250	315	400
TL (dB)	14	18	18	19	22	26	30	32
Freq. (Hz)	500	630	800	1000	1250	1600	2000	2500
TL (dB)	41	48	51	54	56	58	62	63
Freq. (Hz)	3150	4000	5000	6300	8000	10k	STC	
TL (dB)	66	70	72	72	75	73	38	

- B Copy of test report by an accredited lab shall be included in the submittals to document the above performance.

**PART 3 – EXECUTION**

**3.01 DECKING**

- A Decking shall be maintained inside the RTU roof curb to a clearance of 1/4” maximum around all duct drops but never contact the duct.
  - 1. Pack all air gaps around duct drops for return and supply with HUSH BATT™ and seal with HUSH SEALANT™ HSAC-100. Equivalent products by manufacturers listed above may be used.

**3.02 INSPECTIONS**

- A The manufacturer or their local authorized agent shall inspect the in-curb deck system work on site prior to lowering of the units and issue a letter of certification stating that the products have been properly installed and sealed around all ductwork and drops to eliminate air gaps which can compromise performance.

**END OF SECTION 23 05 49**

**SECTION 23 05 53**  
**IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A Nameplates.
- B Tags.
- C Stencils.
- D Pipe markers.

**1.02 REFERENCE STANDARDS**

- A ASTM D709 - Standard Specification for Laminated Thermosetting Materials; 2017.

**1.03 SUBMITTALS**

- A List: Submit list of wording, symbols, letter size, and color coding for mechanical identification.
- B Chart and Schedule: Submit valve chart and schedule, including valve tag number, location, function, and valve manufacturer's name and model number.
- C Product Data: Provide manufacturers catalog literature for each product required.
- D Manufacturer's Installation Instructions: Indicate special procedures, and installation.

**PART 2 PRODUCTS**

**2.01 IDENTIFICATION APPLICATIONS**

- A Air Handling Units: Nameplates.
- B Air Terminal Units: Nameplates.
- C Automatic Controls: Tags. Key to control schematic.
- D Control Panels: Nameplates.
- E Dampers: Ceiling tacks, where located above lay-in ceiling.
- F Ductwork: Stencilled painting.
- G Heat Transfer Equipment: Nameplates.
- H Instrumentation: Tags.
- I Major Control Components: Nameplates.
- J Piping: Stencilled painting.
- K Relays: Tags.
- L Small-sized Equipment: Tags.
- M Thermostats: Nameplates.

**2.02 NAMEPLATES**

- A Manufacturers:
  - 1. Advanced Graphic Engraving, LLC
  - 2. Brimar Industries, Inc
  - 3. Craftmark Pipe Markers
  - 4. Kolbi Pipe Marker Co
  - 5. Seton Identification Products, a Tricor Direct Company
  - 6. Or Approved Equal
- B Letter Color: Black.
- C Letter Height: 1/4 inch.
- D Background Color: White.
- E Phenolic: Conform to ASTM D709.

**2.03 TAGS**

- A Manufacturers:
  - 1. Advanced Graphic Engraving
  - 2. Brady Corporation
  - 3. Brimar Industries, Inc
  - 4. Craftmark Pipe Markers
  - 5. Kolbi Pipe Marker Co



- 6. Seton Identification Products, a Tricor Company
- 7. Or Approved Equal
- B Metal Tags: Aluminum with stamped letters; tag size minimum 1-1/2 inch diameter with smooth edges. Use metal tags in return air plenums.
- C Valve Tag Chart: Typewritten letter size list in anodized aluminum frame.

**2.04 STENCILS**

- A Manufacturers:
  - 1. Brady Corporation
  - 2. Craftmark Pipe Markers
  - 3. Kolbi Pipe Marker Co
  - 4. Seton Identification Products, a Tricor Company
  - 5. Or Approved Equal
- B Stencils: With clean cut symbols and letters of following size:
  - 1. 3/4 to 1-1/4 inch Outside Diameter of Insulation or Pipe: 8 inch long color field, 1/2 inch high letters.
  - 2. 1-1/2 to 2 inch Outside Diameter of Insulation or Pipe: 8 inch long color field, 3/4 inch high letters.
  - 3. 2-1/2 to 6 inch Outside Diameter of Insulation or Pipe: 12 inch long color field, 1-1/4 inch high letters.
  - 4. 8 to 10 inch Outside Diameter of Insulation or Pipe: 24 inch long color field, 2-1/2 inch high letters.
  - 5. Ductwork and Equipment: 2-1/2 inch high letters.
  - 6. Stencil Paint: Semi-gloss enamel, colors conforming to ASME A13.1.

**2.05 CEILING GRID LABELS**

- A Label each device or valve above the ceiling and label the ceiling grid below each. Indicate the type of device or valve and its associated service (e.g. “Shutoff Valve – HW”, “VAV-21”).
- B Provide custom printed labels for each device, either vinyl or polypropylene, suitable for indoor / outdoor applications. Use portable printer equal to Brady HandiMark Portable Industrial Labeling System.
- C Labels shall be no more than 1-inch in height. Lettering shall be minimum 18-point font. Lettering shall be black on white tape.
- D Provide a list of devices and valves labeled with the identical information in the O&M Manuals.
- E Submit samples of markings on three different devices for approval of the Owner and Engineer.
- F Ceiling grid markers shall be the color listed below:
  - 1. Electrical - Pull Box/Disconnects/Future - Neon Red
  - 2. Mechanical Equipment/Fan/Dampers, etc. - Neon Yellow
  - 3. Gas valves/regulators/etc. - Yellow
  - 4. Fire Alarm/Sprinklers/Life Safety - Red

**PART 3 EXECUTION**

**3.01 PREPARATION**

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

**3.02 INSTALLATION**

- A Install nameplates with corrosive-resistant mechanical fasteners, or adhesive. Apply with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer.
- B Install tags with corrosion resistant chain.
- C All piping and duct shall be labeled at least once in EVERY room. Piping and ductwork shall be labeled every 15 ft and at every change of direction.
- D All exposed mechanical piping in mechanical rooms, boiler rooms, on and above mezzanine levels, both insulated and uninsulated, shall be color coded per the following schedule:
  - 1. Fuel Gas Paint piping Yellow
  - 2. Refrigerant Gray
- E Install underground plastic pipe markers 6 to 8 inches below finished grade, directly above buried pipe.
- F Install ductwork with stencilled painting. Identify with air handling unit identification number and area served. Identify service (supply, return, exhaust, outside air, etc.) Locate identification at air handling unit, at each side of penetration of structure or enclosure, and at each obstruction.

- G Provide ceiling grid labels to locate valves or dampers above lay-in panel ceilings. Locate in corner of panel closest to equipment.
- H Identify control panels, manual motor starters, combination motor starters, disconnects, variable frequency drives, and major control components outside panels with plastic nameplates.
- I Identify thermostats or temperature sensors relating to air handling units or valves with labels.
- J Tag automatic controls, instruments, and relays. Key to control schematic.
- K Identify air handling units with plastic nameplates indicating unit number, area served, OEM and external static pressure, based on actual equipment submittal data, number and size of filters, and number and size of belts (where applicable).
- L Provide ceiling track markers to locate valves or dampers above T-bar type panel ceilings. Locate in corner of panel closest to equipment. Markers shall be installed prior to request for above ceiling inspection.

**3.03 SCHEDULE**

A Standard Color Identification for Mechanical Piping (all labels shall be provided with flow arrows):

- 1. Fuel Gas Piping                      GAS                      Black Lettering/Yellow Background
- 2. Condensate Drain                      COND                      Black Lettering
- 3. Refrigerant                              REF                      Black Lettering

B Standard Color Identification for Ductwork (all labels shall be provided with flow arrows):

- 1. Supply Air                              SUPPLY                      Black Lettering
- 2. Return                                      RETURN                      Black Lettering
- 3. Outside Air                              OUTSIDE AIR              Black Lettering
- 4. General Exhaust                      EXHAUST                      Black Lettering

**END OF SECTION 23 05 53**

**SECTION 23 05 70**  
**MECHANICAL COORDINATION DRAWINGS/MODEL**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A The Mechanical Contractor shall be responsible for providing ¼ scale coordination drawings for the entire project, format shall be as stated below.
- B The drawings shall cover above ceiling space, mechanical rooms, electrical rooms and service yards.

**PART 2 PRODUCTS - NOT USED**

**PART 3 EXECUTION**

**3.01 COORDINATION (REVIT)**

- A The Mechanical Contractor shall obtain the architectural, structural, and MEP REVIT models from the Architect. The models will be in REVIT 2022.
- B The Mechanical Contractor shall produce drawings that indicate all piping, equipment and ductwork on 1/4" scale drawings. All items shall be drawn to scale, dimensioned and be easily identified. The drawings shall indicate a bottom of duct or bottom of pipe.
- C The Mechanical Contractor shall obtain the Structural model containing the actual structural members being provided on the project from the General Contractor/Construction Manager and steel supplier.
- D Where piping, ductwork, or other items are indicated to be routed in the webbing of joists or trusses, the mechanical contractor shall confirm with the General Contractor/Construction Manager and steel supplier the final joist/truss profile prior to fabricating or order materials. The actual final joist/truss profile shall be used in the BIM coordination effort.
- E The Mechanical Contractor shall import a file compatible with Navisworks from the Plumbing Contractor that indicates all piping and plumbing equipment. This includes underground piping. The drawings shall be to scale, dimensioned and clearly identified. The drawings shall indicate bottom of pipe (or centerline) for all equipment or pipes.
- F The Mechanical Contractor shall import a file compatible with Navisworks from the Fire Protection Contractor that indicates all piping, heads, and equipment. The drawings shall be to scale, dimensioned and clearly identified. The drawings shall indicate bottom of pipe (or centerline) for all equipment or pipes.
- G The Mechanical Contractor shall import a file compatible with Navisworks from the Electrical Contractor that indicate all conduits over 2", lights, cable tray, underground duct banks and electrical equipment. The drawings shall be to scale, dimensioned and clearly identified. The drawings shall indicate mounting heights of all equipment.
- H The Mechanical Contractor shall incorporate the Plumbing Contractor's and the Electrical Contractor's model and drawings with his own model and drawings to make one overall set of coordination drawings for each area. The Mechanical Contractor shall adjust layers, colors, etc., to make the drawing readable.
- I Navisworks shall be used for clash detection. The Mechanical Contractor shall review the overall coordination model for conflicts. If a conflict is found, the Mechanical Contractor shall coordinate revisions to the plans with each sub contractor. There shall be as many iterations as required to produce a clash-free model
- J If any problems cannot be worked out between the Contractors, the Mechanical Contractor shall contact the Engineer. At that time, a meeting with the Engineer and the Architect will be arranged. The Mechanical Contractor shall make the overall coordination model available for the meeting.
- K Once all conflicts have been resolved, the Mechanical Contractor shall provide the Architect and Engineer with a complete set of Coordination Drawings.
- L In addition, the Mechanical Contractor shall send the completed overall coordination drawings to a printer so that the Plumbing, Fire Protection, and Electrical Contractors can order as many copies as they desire (at their expense). The Mechanical Contractor is responsible for providing the Engineer's set, the Architect's set, and the Mechanical Contractor's set(s).
- M The Mechanical Contractor and the General Contractor are responsible for setting the schedule for this process. The Plumbing Contractor, Fire Protection Contractor, Electrical Contractor and the Architect

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should approve the schedule.

- N The Coordination Drawings shall be used as the basis for the As-Built Drawings/Model. These shall be made available to the Design Team and Owner for this purpose.
- O The overall coordination drawings shall be completed prior to any plumbing, mechanical and electrical work beginning. Start of work, including underground work, without completed Coordination Drawings is at the Contractor's risk.

**END OF SECTION 23 05 70**

**SECTION 23 05 93**  
**TESTING, ADJUSTING, AND BALANCING FOR HVAC**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A Testing, adjustment, and balancing of air systems.
- B Measurement of final operating condition of HVAC systems.
- C Commissioning activities.

**1.02 REFERENCE STANDARDS**

- A AABC (NSTSB) - AABC National Standards for Total System Balance, 7th Edition; 2016.
- B ASHRAE Std 111 - Measurement, Testing, Adjusting, and Balancing of Building HVAC Systems; 2008.
- C NEBB (TAB) - Procedural Standards for Testing Adjusting and Balancing of Environmental Systems; 2015, with Errata (2017).

**1.03 SUBMITTALS**

- A TAB Plan: Submit a written plan indicating the testing, adjusting, and balancing standard to be followed and the specific approach for each system and component.
  - 1. Submit to Architect.
  - 2. Submit to the Commissioning Authority.
- B Include at least the following in the plan:
  - 1. Indicate standard to be followed (AABC or NEBB)
  - 2. List of all airflow and system capacity and efficiency measurements to be performed and a description of specific test procedures, parameters, formulas to be used.
  - 3. Copy of field checkout sheets and logs to be used, listing each piece of equipment to be tested, adjusted and balanced with the data cells to be gathered for each.
  - 4. Identification and types of measurement instruments to be used and their most recent calibration date.
  - 5. Discussion of what notations and markings will be made on the duct and piping drawings during the process.
  - 6. Final test report forms to be used.
  - 7. Detailed step-by-step procedures for TAB work for each system and issue, including:
    - a. Terminal flow calibration (for each terminal type).
    - b. Diffuser proportioning.
    - c. Branch/submain proportioning.
    - d. Total flow calculations.
    - e. Rechecking.
    - f. Diversity issues.
  - 8. Details of how TOTAL flow will be determined; for example:
    - a. Air: Sum of terminal flows via control system calibrated readings or via hood readings of all terminals, supply (SA) and return air (RA) pitot traverse, SA or RA flow stations.
  - 9. Specific procedures that will ensure that systems are operating at the lowest possible pressures and methods to verify this.
  - 10. Confirmation of understanding of the outside air ventilation criteria under all conditions.
  - 11. Method of verifying and setting minimum outside air flow rate will be verified and set and for what level (total building, zone, etc.).
  - 12. Methods for making coil or other system plant capacity measurements, if specified.
  - 13. Time schedule for TAB work to be done in phases (by floor, etc.).
  - 14. Description of TAB work for areas to be built out later, if any.
  - 15. Time schedule for deferred or seasonal TAB work, if specified.
  - 16. False loading of systems to complete TAB work, if specified.
  - 17. Exhaust fan balancing and capacity verifications, including any required room pressure differentials.
  - 18. Procedures for formal deficiency reports, including scope, frequency and distribution.

- C Control System Coordination Reports: Communicate in writing to the controls installer all setpoint and parameter changes made or problems and discrepancies identified during TAB that affect, or could affect, the control system setup and operation.
- D Final Report: Indicate deficiencies in systems that would prevent proper testing, adjusting, and balancing of systems and equipment to achieve specified performance.
  - 1. Revise TAB plan to reflect actual procedures and submit as part of final report.
  - 2. Submit draft copies of report for review prior to final acceptance of Project. Provide final copies for Architect and for inclusion in operating and maintenance manuals.
  - 3. Provide final reports in soft cover, letter size, 3-ring binder manuals, complete with index 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. The Final Report shall be placed in and become a part of the Maintenance and Operations Manuals (4 copies).
  - 4. Include actual instrument list, with manufacturer name, serial number, and date of calibration.
  - 5. Form of Test Reports: Where the TAB standard being followed recommends a report format use that; otherwise, follow ASHRAE Std 111.
  - 6. Units of Measure: Report data in I-P (inch-pound) units only.
  - 7. Include the following on the title page of each report:
    - a. Name of Testing, Adjusting, and Balancing Agency.
    - b. Address of Testing, Adjusting, and Balancing Agency.
    - c. Telephone number of Testing, Adjusting, and Balancing Agency.
    - d. Also include a certification sheet containing the seal and name, address, telephone number, and signature of the Certified Test and Balance Engineer. Include in this division a listing of the instruments used for the procedures along with proof of calibration.
- E Project Record Documents: Record actual locations of flow measuring stations and balancing valves and rough setting.

**1.04 QUALITY ASSURANCE**

- A The TAB agency shall be a subcontractor of the General Contractor (or Construction Manager) and shall report directly to and be paid by the General Contractor.
- B The TAB agency shall be either a certified member of AABC or NEBB to perform TAB service for HVAC, water balancing and vibrations and sound testing of equipment. The certification shall be maintained for the entire duration of duties specified herein.
- C Any agency that has been the subject of disciplinary action by either the AABC or NEBB within the five years preceding Contract Award shall not be eligible to perform any work related to the TAB. All work performed in this Section and in other related Sections by the TAB agency shall be considered invalid if the TAB agency loses its certification prior to Contract completion, and the successor agency's review shows unsatisfactory work performed by the predecessor agency.
- D TAB Specialist: The TAB specialist shall be either a member of AABC or an experienced technician of the Agency certified by NEBB. The certification shall be maintained for the entire duration of duties specified herein. If, for any reason, the Specialist loses subject certification during this period, the General Contractor shall immediately notify the Engineer and submit another TAB Specialist for approval. Any individual that has been the subject of disciplinary action by either the AABC or NEBB within the five years preceding Contract Award shall not be eligible to perform any duties related to the HVAC systems, including TAB. All work specified in this Section and in other related Sections performed by the TAB specialist shall be considered invalid if the TAB Specialist loses its certification prior to Contract completion and must be performed by an approved successor.
- E TAB Specialist shall be identified by the General Contractor within 60 days after the notice to proceed. The TAB specialist will be coordinating, scheduling and reporting all TAB work and related activities and will provide necessary information as required by the Resident Engineer. The responsibilities would specifically include:

1. Shall directly supervise all TAB work.
  2. Shall sign the TAB reports that bear the seal of the TAB standard. The reports shall be accompanied by report forms and schematic drawings required by the TAB standard, AABC, TABB or NEBB.
  3. Would follow all TAB work through its satisfactory completion.
  4. Shall provide final markings of settings of all HVAC adjustment devices.
  5. Permanently mark location of duct test ports.
  6. Shall document critical paths from the fan or pump. These critical paths are ones in which are 100% open from the fan or pump to the terminal device. This will show the least amount of restriction is being imposed on the system by the TAB firm.
- F All TAB technicians performing actual TAB work shall be experienced and must have done satisfactory work on a minimum of 3 projects comparable in size and complexity to this project. Qualifications must be certified by the TAB agency in writing. The lead technician shall be certified by AABC or NEBB

**1.05 WARRANTY**

- A National Project Performance Guarantee: Provide a guarantee AABC or NEBB will assist in completing requirements of the Contract Documents if TAB firm fails to comply with the Contract Documents. Guarantee includes the following provisions:
1. The certified TAB firm has tested and balanced systems according to the Contract Documents.
  2. Systems are balanced to optimum performance capabilities within design and installation limits.
  3. Warranty Period: Five (5) years.

**PART 2 PRODUCTS**

**2.01 PLUGS**

- A Provide plastic plugs to seal holes drilled in ductwork for test purposes.

**2.02 INSULATION REPAIR MATERIAL**

- A Refer to individual insulation sections for repair of insulation removed or damaged during TAB work.

**PART 3 EXECUTION**

**3.01 GENERAL REQUIREMENTS**

- A Perform total system balance in accordance with one of the following:
1. AABC (NSTSB), AABC National Standards for Total System Balance.
- B Begin work after completion of systems to be tested, adjusted, or balanced and complete work prior to Substantial Completion of the project.
- C Where HVAC systems and/or components interface with life safety systems, including fire and smoke detection, alarm, and control, coordinate scheduling and testing and inspection procedures with the authorities having jurisdiction.
- D TAB Agency Qualifications:
1. Company specializing in the testing, adjusting, and balancing of systems specified in this section.
  2. Having minimum of three years documented experience.
  3. Certified by one of the following:
    - a. AABC, Associated Air Balance Council: [www.aabc.com/#sle](http://www.aabc.com/#sle); upon completion submit AABC National Performance Guaranty.
    - b. NEBB, National Environmental Balancing Bureau: [www.nebb.org/#sle](http://www.nebb.org/#sle).
- E TAB Supervisor and Technician Qualifications: Certified by same organization as TAB agency.
- F For each air handling system, provide a graphical static pressure profile indicating the pressure drop across each component of the air handling unit (filter, coils, dampers, wheel, etc).

**3.02 EXAMINATION**

- A Verify that systems are complete and operable before commencing work. Ensure the following conditions:
1. Systems are started and operating in a safe and normal condition.
  2. Temperature control systems are installed complete and operable.
  3. Proper thermal overload protection is in place for electrical equipment.
  4. Final filters are clean and in place. If required, install temporary media in addition to final filters.
  5. Duct systems are clean of debris.

- 6. Fans are rotating correctly.
- 7. Fire and volume dampers are in place and open.
- 8. Air coil fins are cleaned and combed.
- 9. Access doors are closed and duct end caps are in place.
- 10. Air outlets are installed and connected.
- 11. Duct system leakage is minimized.

B Submit field reports. Report defects and deficiencies that will or could prevent proper system balance.

C Beginning of work means acceptance of existing conditions.

**3.03 PREPARATION**

A Hold a pre-balancing meeting at least one week prior to starting TAB work.

- 1. Require attendance by all installers whose work will be tested, adjusted, or balanced.

B Obtain design drawings and specifications and become thoroughly acquainted with the design intent.

C Obtain copies of approved shop drawings of all air handling equipment, outlets (supply, return, and exhaust) and temperature control diagrams.

D Compare design to installed equipment and field installations.

E Walk the system to determine variations of installation from design.

F Check filters for cleanliness.

G Lubricate all motors and bearings.

**3.04 ADJUSTMENT TOLERANCES**

A Air Systems Tolerances

Systems - Air	Tolerances of Drawing Design	Remarks
Air Handling Units, Fans (Supply, Return, Exhaust)	-5% to + 10%	Systems with Filters must be tested at dirty conditions
Outdoor Air	100% to 110%	To obtain this accuracy requires ductwork be traversed
Terminal Units	+/- 5%	Calibrate all boxes at minimum of two points. Single point calibration is not acceptable.
Diffusers and Grilles	+/-10%	If design is less than 100 CFM, tolerance can be +/- 10 CFM
Pressurized Rooms - Positive	Supply +100-105% Exhaust or Return 100-95%	Room offset tolerance to design 100% to +110%
Pressurized rooms - Negative	Supply 95% to 100% Exhaust or Return 100% to 105%	Room offset tolerance to design 100% to 105%

**3.05 RECORDING AND ADJUSTING**

A Field Logs: Maintain written logs including:

- 1. Running log of events and issues.
- 2. Discrepancies, deficient or uncompleted work by others.
- 3. Contract interpretation requests.
- 4. Lists of completed tests.

B Ensure recorded data represents actual measured or observed conditions.

C Use only those instruments which have the maximum field measuring accuracy and are best suited to the function being measured.

D Apply instrument as recommended by the manufacturer.

E When averaging values, take a sufficient quantity of readings that will result in a repeatability error of less than 5 percent. When measuring a single point, repeat readings until 2 consecutive identical values are



obtained.

- F Permanently mark settings of valves, dampers, and other adjustment devices allowing settings to be restored. Set and lock memory stops.
- G Mark on drawings the locations where traverse and other critical measurements were taken and cross reference the location in the final report.
- H After adjustment, take measurements to verify balance has not been disrupted or that such disruption has been rectified.
- I Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.
- J Seal ducts and piping, and test for and repair leaks.
- K Seal insulation to re-establish integrity of vapor barrier.
- L Retest, adjust, and balance systems subsequent to significant system modifications and resubmit test results.

**3.06 AIR SYSTEM PROCEDURE**

- A Adjust air handling and distribution systems to provide required or design supply, return, and exhaust air quantities at site altitude.
- B Test, adjust, and balance the air systems before the hydronic systems.
- C Make air quantity measurements in ducts by Pitot tube traverse of entire cross sectional area of duct.
- D Measure air quantities at air inlets and outlets.
- E Adjust distribution system to obtain uniform space temperatures free from objectionable drafts and noise. This includes adjusting the deflection of all diffuser and grilles.
- F Use volume control devices to regulate air quantities only to extent that adjustments do not create objectionable air motion or sound levels. Effect volume control by duct internal devices such as dampers and splitters.
- G Vary total system air quantities by adjustment of fan speeds. Provide drive changes required. Vary branch air quantities by damper regulation.
- H Measure static air pressure conditions on air supply units, including filter and coil pressure drops, and total pressure across the fan. Make allowances for 50 percent loading of filters.
  - 1. Artificially load filters by partially blanking to produce static pressure air drop of filter manufacturer's recommended "dirty" pressure drop.
- 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 Where modulating dampers are provided, take measurements and balance at extreme conditions. Balance variable volume systems at maximum air flow rate, full cooling, and at minimum air flow rate, full heating.
- L Measure building static pressure and adjust supply, return, and exhaust air systems to provide required relationship between each to maintain approximately 0.05 inches positive static pressure near the building entries.

**3.07 CRITICAL FLOW PATH**

- A Provide a documented critical path for all fluid flows. There shall be at least one terminal device that can be traced back to the fan or pump where there is no damper or valves that are less than 100% open.

**3.08 DEMONSTRATION**

- A Training
  - 1. Train the Owner's maintenance personnel on troubleshooting procedures and testing, adjusting, and balancing procedures. Provide four (4) hours on site training. Review with the Owner's personnel the information contained in the Operating and Maintenance Data specified in Division 1 and Section 23 01 00.
  - 2. Schedule training with the Owner through the Engineer with at least 7 days prior notice.

**3.09 COMMISSIONING**

- A Perform prerequisites prior to starting commissioning activities.
- B Fill out Prefunctional Checklists for:
  - 1. Air side systems.

- C Furnish to the Commissioning Authority, upon request, any data gathered but not shown in the final TAB report.
- D Re-check minimum outdoor air intake flows and maximum and intermediate total airflow rates for 50 percent of the air handlers plus a random sample equivalent to 50 percent of the final TAB report data as directed by Commissioning Authority.
  - 1. Original TAB agency shall execute the re-checks, witnessed by the Commissioning Authority.
  - 2. Use the same test instruments as used in the original TAB work.
  - 3. Failure of more than 25 of the re-checked items of a given system shall result in the rejection of the system TAB report; rebalance the system, provide a new system TAB report, and repeat random re-checks.
  - 4. For purposes of re-check, failure is defined as follows:
    - a. Air Flow of Supply and Return: Deviation of more than 10 percent of instrument reading.
    - b. Minimum Outside Air Flow: Deviation of more than 20 percent of instrument reading; for inlet vane or VFD OSA compensation system using linear proportional control, deviation of more than 30 percent at intermediate supply flow.
    - c. Temperatures: Deviation of more than one degree F.
    - d. Air and Water Pressures: Deviation of more than 10 percent of full scale of test instrument reading.
    - e. Sound Pressures: Deviation of more than 3 decibels, with consideration for variations in background noise.
  - 5. For purposes of re-check, a whole system is defined as one in which inaccuracies will have little or no impact on connected systems; for example, the air distribution system served by one air handler or the hydronic chilled water supply system served by a chiller or the condenser water system.
- E In the presence of the Commissioning Authority, verify that:
  - 1. Final settings of all valves, splitters, dampers and other adjustment devices have been permanently marked.
  - 2. The air system is being controlled to the lowest possible static pressure while still meeting design loads, less diversity; this shall include a review of TAB methods, established control setpoints, and physical verification of at least one leg from fan to diffuser having all balancing dampers wide open and that during full cooling of all terminal units taking off downstream of the static pressure sensor, the terminal unit on the critical leg has its damper 90 percent or more open.

**3.10 SCOPE**

- A Test, adjust, and balance the following:
  - 1. Plumbing Pumps.
  - 2. Packaged Roof Top Heating/Cooling Units.
  - 3. Air Coils.
  - 4. Air Handling Units.
  - 5. Fans.
  - 6. Air Filters.
  - 7. Air Terminal Units.
  - 8. Air Inlets and Outlets.
- B This Section does NOT include:
  - 1. Testing boilers and pressure vessels for compliance with safety codes.
  - 2. Specifications for materials for patching mechanical systems.
  - 3. Specifications for materials and installation of adjusting and balancing; refer to the respective system sections for materials and installation requirements.
  - 4. Requirements and procedures for piping and ductwork systems leakage tests.

**3.11 MINIMUM DATA TO BE REPORTED**

- A Electric Motors:
  - 1. Manufacturer.

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2. Model/Frame.
  3. HP/BHP.
  4. Phase, voltage, amperage; nameplate, actual, no load.
  5. RPM.
  6. Service factor.
  7. Starter size, rating, heater elements.
  8. Sheave Make/Size/Bore.
- B V-Belt Drives:
1. Identification/location.
  2. Required driven RPM.
  3. Driven sheave, diameter and RPM.
  4. Belt, size and quantity.
  5. Motor sheave diameter and RPM.
  6. Center to center distance, maximum, minimum, and actual.
- C Combustion Equipment:
1. Model number.
  2. Firing rate.
  3. Gas pressure at meter outlet.
  4. Gas flow rate.
  5. Heat input.
  6. Flue gas temperature at outlet.
  7. Ambient temperature.
  8. Net stack temperature.
  9. Heat output.
- D Air Cooled Condensers:
1. Identification/number.
  2. Location.
  3. Manufacturer.
  4. Model number.
  5. Entering DB air temperature, design and actual.
  6. Leaving DB air temperature, design and actual.
- E Cooling Coils:
1. Identification/number.
  2. Location.
  3. Manufacturer.
  4. Air flow, design and actual.
  5. Entering air DB temperature, design and actual.
  6. Entering air WB temperature, design and actual.
  7. Leaving air DB temperature, design and actual.
  8. Leaving air WB temperature, design and actual.
  9. Air pressure drop, design and actual.
- F Heating Coils:
1. Identification/number.
  2. Location.
  3. Manufacturer.
  4. Air flow, design and actual.
  5. Entering air temperature, design and actual.
  6. Leaving air temperature, design and actual.
  7. Air pressure drop, design and actual.
- G Air Moving Equipment:

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1. Location.
  2. Manufacturer.
  3. Model number.
  4. Air flow, specified and actual.
  5. Return air flow, specified and actual.
  6. Outside air flow, specified and actual.
  7. Total static pressure (total external), specified and actual.
  8. Inlet pressure.
  9. Discharge pressure.
  10. Fan RPM.
- H Exhaust Fans:
1. Location.
  2. Manufacturer.
  3. Model number.
  4. Air flow, specified and actual.
  5. Total static pressure (total external), specified and actual.
  6. Inlet pressure.
  7. Discharge pressure.
  8. Fan RPM.
- I Duct Traverses:
1. System zone/branch.
  2. Duct size.
  3. Design air flow.
  4. Test velocity.
  5. Test air flow.
  6. Duct static pressure.
  7. Air temperature.
- J Flow Measuring Stations:
1. Identification/number.
  2. Location.
  3. Size.
  4. Manufacturer.
  5. Model number.
  6. Design Flow rate.
  7. Design pressure drop.
  8. Actual/final pressure drop.
  9. Actual/final flow rate.
- K Terminal Unit Data:
1. Manufacturer.
  2. Type, constant, variable, single, dual duct.
  3. Identification/number.
  4. Location.
  5. Model number.
  6. Size.
  7. Minimum design air flow.
  8. Maximum design air flow.
  9. Maximum actual air flow.
  10. Inlet static pressure.
- L Air Distribution Tests:
1. Air terminal number.

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2. Room number/location.
3. Terminal type.
4. Terminal size.
5. Design air flow.
6. Test (final) air flow.
7. Percent of design air flow.

**END OF SECTION 23 05 93**

**SECTION 23 07 13**  
**DUCT INSULATION**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A Duct insulation.
- B Duct liner.
- C Jacketing and accessories.

**1.02 REFERENCE STANDARDS**

- A ASTM B209/B209M - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate; 2021a.
- B ASTM C518 - Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus; 2021.
- C ASTM C534/C534M - Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form; 2023.
- D ASTM C553 - Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications; 2013 (Reapproved 2019).
- E ASTM C612 - Standard Specification for Mineral Fiber Block and Board Thermal Insulation; 2014 (Reapproved 2019).
- F ASTM C916 - Standard Specification for Adhesives for Duct Thermal Insulation; 2020.
- G ASTM C1071 - Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material); 2019.
- H ASTM C1338 - Standard Test Method for Determining Fungi Resistance of Insulation Materials and Facings; 2019 (Reapproved 2022).
- I ASTM C1371 - Standard Test Method for Determination of Emittance of Materials Near Room Temperature Using Portable Emissometers; 2015 (Reapproved 2022).
- J ASTM C1423 - Standard Guide for Selecting Jacketing Materials for Thermal Insulation; 2021.
- K ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2018b.
- L ASTM E96/E96M - Standard Test Methods for Gravimetric Determination of Water Vapor Transmission Rate of Materials; 2023.
- M ASTM G21 - Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi; 2015, with Editorial Revision (2021).
- N SAE AMS3779 - Tape, Adhesive, Pressure-Sensitive Thermal Radiation Resistant, Aluminum Coated Glass Cloth; 2016b.
- O UL 181A - Closure Systems for Use with Rigid Air Ducts; Current Edition, Including All Revisions.
- P UL 181B - Closure Systems for Use with Flexible Air Ducts and Air Connectors; Current Edition, Including All Revisions.
- Q UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials; Current Edition, Including All Revisions.

**1.03 SUBMITTALS**

- A Product Data: Provide product description, thermal characteristics, list of materials and thickness for each service, and locations. Include the following information:
  - 1. Schedule indicating insulation type, thickness, and location for each service
  - 2. Density
  - 3. Compressive Strength
  - 4. "k" value at 75 deg F
  - 5. Nominal "R" value
  - 6. Flame spread rating
- B Manufacturer's Instructions: Indicate installation procedures necessary to ensure acceptable workmanship and that installation standards will be achieved.

**1.04 QUALITY ASSURANCE**

- A Manufacturer Qualifications: Company specializing in manufacturing products of the type specified in this section with not less than three years of documented experience.

- B Applicator Qualifications: Company specializing in performing the type of work specified in this section, documented experience and approved by manufacturer.
- C Before installing insulation, build mockups for each type of insulation and finish listed below to demonstrate quality of insulation application and finishes. Build mockups in the location indicated or, if not indicated, as directed by Owner. Use materials indicated for the completed Work. Mockups shall include piping insulation, ductwork insulation and equipment insulation.
- D All the ductwork and piping in pump rooms, mechanical rooms and equipment rooms including areas without ceilings is to be considered as exposed piping or ductwork. This also includes penthouses, interstitial spaces, and crawl spaces, where applicable.

**1.05 DELIVERY, STORAGE, AND HANDLING**

- A Accept materials on site in original factory packaging, labelled with manufacturer's identification, including product density and thickness.
- B Protect insulation from weather and construction traffic, dirt, water, chemical, and mechanical damage, by storing in original wrapping.

**1.06 FIELD CONDITIONS**

- A Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements.
- B Maintain temperature during and after installation for minimum period of 24 hours.
- C Insulation shall not be installed until all testing and inspection of pipe, duct, vessel, etc. has been completed and approved by Engineer/Owner's representative.

**PART 2 PRODUCTS**

**2.01 REGULATORY REQUIREMENTS**

- A Surface Burning Characteristics: Flame spread index/Smoke developed index of 25/50, maximum, when tested in accordance with ASTM E84, UL 723, ASTM E84, or UL 723. These ratings must be as tested on composite of insulation, jacket or facing, and adhesive. Components such as adhesives, mastics, and cements must meet the same individual ratings as minimum requirements.

**2.02 GLASS FIBER, FLEXIBLE**

- A Manufacturer:
  - 1. CertainTeed Corporation
  - 2. Johns Manville
  - 3. Knauf Insulation
  - 4. Owens Corning Corporation
  - 5. Or Approved Equal
- B Insulation: ASTM C553; flexible, noncombustible blanket.
  - 1. K value: 0.36 at 75 degrees F, when tested in accordance with ASTM C518.
  - 2. Maximum Service Temperature: 1,200 degrees F.
  - 3. Maximum Water Vapor Absorption: 5.0 percent by weight.
- C Vapor Barrier Jacket:
  - 1. Kraft paper with glass fiber yarn and bonded to aluminized film.
  - 2. Moisture Vapor Permeability: 0.02 perm inch, when tested in accordance with ASTM E96/E96M.
  - 3. Secure with pressure-sensitive tape.
- D Vapor Barrier Tape:
  - 1. Kraft paper reinforced with glass fiber yarn and bonded to aluminized film, with pressure-sensitive rubber-based adhesive.
- E Indoor Vapor Barrier Mastic:
  - 1. Manufacturers:
    - a. Childers CP-35
    - b. Hardcast Seal-Tack AF
- F Tie Wire: Annealed steel, 16 gauge, 0.0508 inch diameter.

**2.03 GLASS FIBER, RIGID**

- A Manufacturer:

1. CertainTeed Corporation
  2. Johns Manville
  3. Knauf Insulation
  4. Owens Corning Corporation
  5. Or Approved Equal
- B** Insulation: ASTM C612; rigid, noncombustible blanket.
1. K Value: 0.24 at 75 degrees F, when tested in accordance with ASTM C518.
  2. Maximum Service Temperature: 450 degrees F.
  3. Maximum Water Vapor Absorption: 5.0 percent.
  4. Maximum Density: 8.0 pcf.
- C** Vapor Barrier Jacket:
1. Kraft paper with glass fiber yarn and bonded to aluminized film.
  2. Moisture Vapor Permeability: 0.02 perm inch, when tested in accordance with ASTM E96/E96M.
  3. Secure with pressure-sensitive tape.
- D** Vapor Barrier Tape:
1. Manufacturers:
    - a. 3M
    - b. Polyguard
    - c. Shurtape
  2. Kraft paper reinforced with glass fiber yarn and bonded to aluminized film, with pressure-sensitive rubber-based adhesive.
- E** Protective Coating:
1. Manufacturers:
    - a. Design Polymerics; DP 2510 Water Based, Low VOC, Duct Liner Protective Coating:
- F** Indoor Vapor Barrier Finish:
1. Cloth: Untreated; 9 oz/sq yd weight, glass fabric.
  2. Vinyl emulsion type acrylic, compatible with insulation, white color.

**2.04 POLYISOCYANURATE INSULATION BOARD**

- A** Manufacturer:
1. Dyplast
  2. Rmax
  3. Johns Manville
  4. Or Approved Equal
- B** Insulation:
1. Flat Foam Insulation with Heavy Duty Fiber-Reinforced Facers: closed-cell polyisocyanurate foam core laminated to extra durable heavy duty fiber-reinforced facers on both sides; conforming to ASTM C 1289, Type II, Class 2.
  2. Blowing Agent: Zero ODP, 3rd generation.
  3. Thickness 2.00 inch, R Value 11.4, flute spanability 4-3/8 inches
  4. 25/450 flame/smoke spread rating
- C** Vapor Barrier Jacket:
1. Asphalt Bitumen: ASTM D 312, Type III, or Type IV.
- D** Vapor Barrier Tape:
1. Kraft paper reinforced with glass fiber yarn and bonded to aluminized film, with pressure sensitive rubber based adhesive.

**2.05 JACKETING AND ACCESSORIES**

- A** Canvas Jacket: UL listed 6 oz/sq yd plain weave cotton fabric treated with dilute fire-retardant lagging adhesive.
1. Lagging Adhesive:
    - a. Manufacturers:



- 1) Design Polymeric; DP 3050 Water Based, Zero VOC, Premium Quality, Lagging Adhesive, and Vapor Retarder
- 2) Childers CP-35
  - b. Compatible with insulation.
- B Mineral Fiber (Outdoor) Jacket: Asphalt impregnated and coated sheet, 50 lb/square.
- C Aluminum Jacket:
  1. Comply with ASTM B209/B209M, Temper H14, minimum thickness of 0.016 inch with factory-applied polyethylene and kraft paper moisture barrier on the inside surface.
  2. Thickness: 0.016 inch sheet.
  3. Finish: Embossed.
  4. Joining: Longitudinal slip joints and 2 inch laps.
  5. Fittings: 0.016 inch thick die-shaped fitting covers with factory-attached protective liner.
  6. Metal Jacket Bands: 3/8 inch wide; 0.015 inch thick aluminum.
- D Flexible Weather-Proofing Outdoor Jacket: Self-healing, field-applied outdoor cladding.
  1. Material: Aluminum foil/polymer laminate with rubberized asphalt layer and acrylic adhesive.
  2. Thickness: 34 mil, 0.034 inch.
  3. Finish: Embossed.
  4. Color: Silver.
  5. Water Vapor Transmission: 0.002 perm inch, maximum, when tested in accordance with ASTM E96/E96M.
  6. Mold Resistance: Pass when tested in accordance with ASTM C1338.
  7. Emissivity: 0.30 when tested in accordance with ASTM C1371.
  8. Manufacturers:
    - a. Polyguard Products; Alumaguard
- E Reinforced Tape:
  1. FSK tape suitable for sealing seams between insulation, insulated elbows, and fittings resulting in a tight, smooth surface without wrinkles.
  2. Comply with UL 723 or ASTM E84.
  3. Moisture Vapor Permeability: 0.00 perm inch, when tested in accordance with ASTM E96/E96M.
- F UL181 Tape for Rigid and Flexible Ductwork:
  1. Comply with UL 181A for rigid ductwork.
  2. Comply with UL 181B for flexible ductwork.
  3. Aluminum foil coated with pressure-sensitive adhesive on paper release liner.
  4. Foil tape suitable for sealing seams between insulation, insulated elbows, and fittings resulting in a tight, smooth surface without wrinkles.
  5. Finish: Printed with UL Listing for identification.

## **2.06 FIRE BARRIER DUCT WRAP**

- A Two-layer wrap for grease ducts rated as a shaft alternative per ASTM E 2336. Zero clearance to combustible throughout the entire enclosure system.
- B High-temperature fibrous thermal insulation blanket encapsulated in a fiberglass-reinforced aluminized polyester foil. Duct Wrap density shall be nominal 6 pcf and have a nominal 1-1/2" thickness. The fiber blanket shall have a continuous use limit of 1000°C.
- C When installed in two layers, shall meet the criteria of ASTM E 2336 Standard Test Methods for Fire Resistive Grease Duct Enclosure Systems.
- D Smoke Developed Index and Flame Spread Index of the bare blanket, and of the foil encapsulated blanket shall be 0/0 per ASTM E 84. The foil encapsulation shall be bonded to the core blanket material.
- E Manufacturers:
  1. 3M Fire Barrier Duct Wrap 615+
  2. Unifrax Fyrewrap
  3. Or Approved Equal

**2.07 DUCT LINER**

- A Manufacturers:
  - 1. Armacell LLC
  - 2. CertainTeed Corporation
  - 3. Ductmate Industries, Inc, a DMI Company
  - 4. K-Flex
  - 5. Aerofoam
  - 6. Johns Manville
  - 7. Knauf Insulation
  - 8. Owens Corning Corporation
  - 9. Or Approved Equal
- B Elastomeric Foam Insulation: Preformed flexible elastomeric cellular rubber insulation complying with ASTM C534/C534M Grade 1, in sheet form.
  - 1. Minimum Service Temperature: Minus 40 degrees F.
  - 2. Maximum Service Temperature: 180 degrees F.
  - 3. Fungal Resistance: No growth when tested according to ASTM G21.
  - 4. Bacteria Resistance: No growth when tested according to ASTM G22.
  - 5. Apparent Thermal Conductivity: Maximum of 0.28 at 75 degrees F.
  - 6. Minimum Noise Reduction Coefficients:
    - a. 1 inch Thickness: 0.40.
    - b. 1-1/2 inches Thickness: 0.50.
    - c. 2 inch Thickness: 0.60.
  - 7. Erosion Resistance: Does not show evidence of breaking away, flaking off, or delamination at velocities of 10,000 fpm when tested in accordance with ASTM C1071.
  - 8. Connection: Waterproof vapor barrier adhesive.
  - 9. Made with EPA registered Microban® antimicrobial product protection.
- C Elastomeric Foam Adhesive: Air dried, contact adhesive, compatible with insulation. Comply with ASTM C916.
- D Polyester Insulation:
  - 1. Minimum Service Temperature: Minus 40 degrees F.
  - 2. Maximum Service Temperature: 220 degrees F.
  - 3. Fungal Resistance: No growth when tested according to ASTM G21.
  - 4. Bacteria Resistance: No growth when tested according to ASTM G22.
  - 5. Apparent Thermal Conductivity: Maximum of 0.28 at 75 degrees F.
  - 6. Minimum Noise Reduction Coefficients:
    - a. 1 inch Thickness: 0.6
    - b. 1.5 inch Thickness: 0.7
  - 7. Erosion Resistance: Does not show evidence of breaking away, flaking off, or delamination at velocities of 10,000 fpm per ASTM C1071.
- E Adhesive: Waterproof, fire-retardant type, ASTM C916.
  - 1. Manufacturers:
    - a. Design Polymerics; DP 2502 Water Based, Low VOC, Duct Liner Adhesive
    - b. Vimasco Corporation
    - c. ITW Ultratack
    - d. RCD #5 Ductliner Adhesive
- F Liner Fasteners: Galvanized steel, self-adhesive pad with integral head.
  - 1. Manufacturers:
    - a. Elgen Manufacturing Company, Inc; Peel and Press Insulation Hangers

**PART 3 EXECUTION**

**3.01 EXAMINATION**

- A Test ductwork for design pressure prior to applying insulation materials.

- B Verify that surfaces are clean, foreign material removed, and dry.

**3.02 INSTALLATION**

- A Install in accordance with manufacturer's instructions.
- B Insulate all supply diffusers and ducted return grilles with 2" R6 Duct Wrap. Cut diffusers so there is a folder 2" lap on all four sides. Tape with FSK tape where insulated flex meets duct insulation so there are no raw edges of fiberglass.
- C Use of duct liner shall be limited to transfer ducts only.
- D Install multiple layers of insulation with longitudinal and end seams staggered.
- E Install insulation with least number of joints practical.
- F The duct liner ends of all transfer ducts shall receive a channel nosing - 1" x liner thickness x 1", mechanically secured to the sheet metal duct in accordance with NAIMA fabrication standards.
- G Insulated Ducts Conveying Air Below Ambient Temperature:
  - 1. Insulation on all pipes or ducts conveying air or liquids below the ambient temperature is required to have a continuous vapor barrier. On all insulation with a vapor barrier, seal the joints, duct wrap seams, vapor retarder (ASJ) film seams and penetrations in insulation at hangers, supports, anchors, and other projections with a vapor-barrier coating/mastic as specified in the individual insulation sections.
  - 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 coating/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.
  - 5. Continue insulation through walls, sleeves, hangers, and other duct penetrations.
- H Ducts Exposed in Mechanical Equipment Rooms or Finished Spaces: Provide rigid fiberglass board insulation and finish with canvas jacket sized for finish painting.
- I Exterior Applications: Provide rigid polyisocyanurate board insulation with vapor barrier jacket. Provide rigid polyiso board insulation and cover with with calked aluminum jacket with seams located on bottom side of horizontal duct section.
- J External Duct Wrap Insulation Application:
  - 1. Secure insulation with vapor barrier with wires and seal jacket joints with vapor barrier adhesive or tape to match jacket.
  - 2. Install without sag on underside of duct. Use adhesive or mechanical fasteners where necessary to prevent sagging. Lift duct off trapeze hangers and insert spacers. Spacers shall be heavy density insulation board material. Refer to MICA 8th edition Plate 3-640.
  - 3. Seal vapor barrier penetrations by mechanical fasteners with vapor barrier adhesive.
  - 4. Stop and point insulation around access doors and damper operators to allow operation without disturbing wrapping.

**3.03 SCHEDULES**

- A All supply, outside air, and return air ductwork shall be completely insulated, unless otherwise noted on the plans. Insulation shall completely cover flexible connections. Insulation shall be minimum 2.5 inch thick or the thickness required to meet the R-values below.
- B All insulation within the building envelope, except in the attic (where applicable), shall have a minimum R-value of 6.0 based on installed thickness. Any insulation wrap or board installed outside the building envelope or in an attic, shall have a minimum R-value of 8.0 based on installed thickness.
- C All exhaust duct associated with any unit having energy recovery (enthalpy wheel, enthalpy plate, run around loop, etc.) shall be insulated to R6.0 inside the building and R8.0 outside the building.
- D Exhaust and Relief Ducts Within 10 ft of Exterior Openings or Building Envelope Penetrations: minimum R-value of 6.0 based on installed thickness.

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- E Kitchen Grease Duct: Where kitchen grease duct is not UL listed for 0 clearance to combustibles, wrap entire duct run with two layers of 3M Fire Barrier Duct Wrap 615+ or equivalent.

**END OF SECTION 23 07 13**

**SECTION 23 07 19**  
**HVAC PIPING INSULATION**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A Piping insulation.
- B Flexible removable and reusable blanket insulation.
- C Jacketing and accessories.

**1.02 REFERENCE STANDARDS**

- A ASTM B209/B209M - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate; 2021a.
- B ASTM C534/C534M - Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form; 2023.
- C ASTM C1136 - Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation; 2023.
- D ASTM C1423 - Standard Guide for Selecting Jacketing Materials for Thermal Insulation; 2021.
- E ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2018b.
- F ASTM E96/E96M - Standard Test Methods for Gravimetric Determination of Water Vapor Transmission Rate of Materials; 2023.
- G ASTM G153 - Standard Practice for Operating Enclosed Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials; 2013 (Reapproved 2021).
- H SAE AMS3779 - Tape, Adhesive, Pressure-Sensitive Thermal Radiation Resistant, Aluminum Coated Glass Cloth; 2016b.
- I MICA - Midwest Insulation Contractors Association National Commercial & Industrial Insulation Standards; 8th Edition.
- J UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials; Current Edition, Including All Revisions.

**1.03 SUBMITTALS**

- A Product Data: Provide product description, thermal characteristics, list of materials and thickness for each service, and locations. Provide the following information:
  - 1. Schedule indicating insulation type, thickness, and location for each service (equipment, duct, and pipe with size).
  - 2. Density
  - 3. Compressive Strength
  - 4. "k" value at 75 deg F
  - 5. Nominal "R" value
  - 6. Mean temperature range
  - 7. Flame spread rating
- B Shop Drawings: Show details for the following:
  - 1. Application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
  - 2. Attachment and covering of heat tracing inside insulation.
  - 3. Insulation application at pipe expansion joints for each type of insulation.
  - 4. Insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
  - 5. Application of field-applied jackets.
- C Manufacturer's Instructions: Indicate installation procedures that ensure acceptable workmanship and installation standards will be achieved.
- D Provide plates from MICA 8th edition manual for each insulation system on the project as part of the submittals. The plates for each system shall be filled out by the insulating contractor for each product being used.

**1.04 QUALITY ASSURANCE**

- A Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with not less than three years of documented experience.

- B Applicator Qualifications: Company specializing in performing the type of work specified in this section with minimum five years of experience.

**1.05 DELIVERY, STORAGE, AND HANDLING**

- A Accept materials on site, labeled with manufacturer's identification, product density, and thickness.
- B Store insulation in original wrapping and protect from weather and construction traffic. Protect insulation against dirt, water, chemical, and mechanical damage.

**1.06 FIELD CONDITIONS**

- A Maintain ambient conditions required by manufacturers of each product.
- B Maintain temperature before, during, and after installation for minimum of 24 hours.
- C Insulation shall not be installed until all testing and inspection of pipe, duct, vessel, etc. has been completed and approved by Engineer/Owner's representative.
- D Replace insulation damaged by either moisture or other means. Insulation which has been wet, whether dried or not, is considered damaged. Make repairs where condensation is caused by improper installation of insulation. Also replace any materials damaged by the condensation.

**PART 2 PRODUCTS**

**2.01 REGULATORY REQUIREMENTS**

- A Surface Burning Characteristics: Flame spread index/Smoke developed index of 25/50, maximum, when tested in accordance with ASTM E84, UL 723, ASTM E84, or UL 723.

**2.02 FLEXIBLE ELASTOMERIC CELLULAR INSULATION**

- A Manufacturers:
  - 1. Aeroflex USA, Inc
  - 2. Armacell LLC
  - 3. K-Flex USA LLC
  - 4. Or Approved Equal
- B Insulation: Preformed flexible elastomeric cellular rubber insulation complying with ASTM C534/C534M Grade 1; use molded tubular material wherever possible.
  - 1. Minimum Service Temperature: Minus 40 degrees F.
  - 2. Maximum Service Temperature: 180 degrees F.
  - 3. Connection: Waterproof vapor barrier adhesive.
- C Elastomeric Foam Adhesive: Air dried, contact adhesive, compatible with insulation.

**2.03 JACKETING AND ACCESSORIES**

- A Canvas Jacket: UL listed 6 oz/sq yd plain weave cotton fabric treated with dilute fire-retardant lagging adhesive.
  - 1. Lagging Adhesive: Compatible with insulation.
    - a. Manufacturers:
      - 1) Vimasco Corporation:
      - 2) GLT Products
- B Aluminum Jacket:
  - 1. Manufacturers:
    - a. Alumaguard.
    - b. ITW.
  - 2. Comply with ASTM B209/B209M, Temper H14, minimum thickness of 0.016 inch with factory-applied polyethylene and kraft paper moisture barrier on the inside surface.
  - 3. Thickness: 0.016 inch sheet.
  - 4. Finish: Embossed.
  - 5. Joining: Longitudinal slip joints and 2 inch laps.
  - 6. Fittings: 0.016 inch thick die-shaped fitting covers with factory-attached protective liner.
  - 7. Metal Jacket Bands: 3/8 inch wide; 0.015 inch thick aluminum.
- C Reinforced Tape:
  - 1. FSK tape suitable for sealing seams between insulation, insulated pipe bends, and fittings resulting in a tight, smooth surface without wrinkles.

2. Comply with UL 723, ASTM E84.
3. Moisture Vapor Permeability: 0.00 perm inch, when tested in accordance with ASTM E96/E96M.
4. Finish: Match insulation.

**D Plain Foil Tape:**

1. Aluminum foil with pressure-sensitive adhesive on paper release liner.

**PART 3 EXECUTION**

**3.01 EXAMINATION**

- A Test piping for design pressure, liquid tightness, and continuity prior to applying insulation materials.
- B Verify that surfaces are clean and dry, with foreign material removed.

**3.02 INSTALLATION**

- A Install in accordance with manufacturer's instructions and the MICA manual 8th edition. In cases of conflict, the more stringent instructions shall apply.
- B Where existing piping insulation is either removed or damaged during construction, it shall be reinsulated per these specifications.
- C Where insulation thickness exceeds 3 inches, the insulation shall be two layers. Secure first layer before installing the next layer and stagger the joints.
- D Install multiple layers of insulation with longitudinal and end seams staggered.
- E 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.
- F Install insulation with least number of joints practical.
- G Exposed Piping: Locate insulation and cover seams in least visible locations.
- H Insulated Pipes Conveying Fluids Below Ambient Temperature:
  1. Insulate entire system, including fittings, valves, unions, flanges, strainers, flexible connections, and expansion joints.
  2. Insulation on all pipes or ducts conveying air or liquids below the ambient temperature is required to have a continuous vapor barrier. On all insulation with a vapor barrier, seal the joints, duct wrap seams, vapor retarder (ASJ) film seams and penetrations in insulation at hangers, supports, anchors, and other projections with a vapor-barrier coating/mastic as specified in the individual insulation sections.
  3. 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 coating/mastic.
  4. 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.
  5. 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.
- I Inserts and Shields:
  1. Shields: Galvanized steel, 20 gauge, one half the circumference of the insulation, and a minimum of 12 inches long, between pipe hangers or pipe hanger rolls and inserts.
  2. Insert location: Between support shield and piping and under the finish jacket.
  3. Insert Configuration: Minimum 6 inches long, of same thickness and contour as adjoining insulation; may be factory fabricated.
  4. Insert Material: Hydrous calcium silicate insulation or other heavy density insulating material suitable for the planned temperature range.
- J Continue insulation through walls, sleeves, pipe hangers, and other pipe penetrations. Finish at supports, protrusions, and interruptions. At fire separations, see Section 07 84 00.
- K Pipe Exposed in Mechanical Rooms and Finished Spaces: Finish with canvas jacket sized for finish painting. Canvas shall be coated twice with Foster fireproof lagging to ensure specified flame and smoke spread ratings.
- L For refrigerant line sets and condensate piping exposed to view serving wall mounted units, provide lineset cover system. Speedichannel by DiversiTech, Hide-A-Line by DuctlessAire, or equivalent by Inaba Denko.

- M Exterior Applications: Provide vapor barrier jacket. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe, and finish with glass mesh reinforced vapor barrier cement. Provide with 0.016 inch aluminum rolled jacket. Cover with aluminum jacket with aluminum bands 12 inches on center and at each butt joint located on bottom side of horizontal piping. Fittings shall be covered with two piece factory fabricated "ELL-JACS."
- N All exposed piping surfaces, insulation, supports, etc., shall be painted with two coats of oil base paint. Color shall be selected by the Owner.
- O Insulation systems shall be installed per the applicable plate from the MICA manual 8th edition:
  - 1. Pre-formed Pipe Insulation Single Layer Construction: Plate 1-100
  - 2. Flexible Foam Insulation: Plate 1-200
  - 3. Field applied Metal Jacketing: Plate 1-400
  - 4. Non-metallic sealed jacketing systems: PVC, etc: Plate 1-510
  - 5. Split Ring Hangers: Plate 1-600
  - 6. Clevis Hanger with High Density Inserts: Plate 1-610
  - 7. Pre-Insulated Pipe Support, Standoff Clamp: Plate 1-640
  - 8. Vapor Stop (Dam) - Pipe: Plate 1-660
  - 9. Refrigerant and Low Temperature: Plate 1-801
  - 10. Traced Piping: Plate 1-900
  - 11. Pre-formed Elbow Insulation: Plate 2-100
  - 12. Mechanical Fitting Field Fabricated: Plate 2-116
  - 13. Pre-formed or Fabricated Tee Insulation: Plate 2-120
  - 14. Field or Factory-Fabricated Valve Insulation: Plate 2-130
  - 15. In-line Flange Insulation Built-up and Beveled: Plate 2-135
  - 16. Flexible Foam Fittings: 90s and 45s: Plate 2-200
  - 17. Flexible Foam Fittings, Ts: 2-220
  - 18. Flexible Foam Ts: Plate 2-225
  - 19. PVC/Insert Valve Insulation: Plate 2-530
  - 20. PVC/Insert Mechanical Coupling on In-line Flange: Plate 2-535
  - 21. Non-metallic Jackets: Fitting and Valve Insulation Sealed Jacketing Systems: Plate 2-536
  - 22. PVC End Cap Over Insulation: 2-540
  - 23. Flexible Foam for Low Temperature Equipment: 4-210
  - 24. Vapor Stop (Dam) - Equipment: 4-660

**3.03 SCHEDULE**

- A Condensate
  - 1. Condensate lines shall be insulated with 1.0 inch thick closed cell insulation. The insulation shall extend from the connection on the unit until it either terminates at a floor drain or other indirect waste receptor, or turns underground.
- B Refrigerant
  - 1. Refrigerant lines shall be insulated with 1.5 inch thick closed cell elastomeric foam insulation. Both gas and liquid lines should be insulated.

**END OF SECTION 23 07 19**



**SECTION 23 08 00**  
**COMMISSIONING OF HVAC**

**PART 1 GENERAL**

**1.01 SUMMARY**

- A This section covers the Contractor's responsibilities for commissioning; each subcontractor or installer responsible for the installation of a particular system or equipment item to be commissioned is responsible for the commissioning activities relating to that system or equipment item.
- B The Commissioning Authority (CA) directs and coordinates all commissioning activities and provides Prefunctional Checklists and Functional Test Procedures for Contractor's use.
- C The entire HVAC system is to be commissioned, including commissioning activities for the following specific items:
  - 1. Control system.
  - 2. Major and minor equipment items.
  - 3. Piping systems and equipment.
  - 4. Ductwork and accessories.
  - 5. Variable frequency drives.
  - 6. Other equipment and systems explicitly identified elsewhere in Contract Documents as requiring commissioning.
- D The Prefunctional Checklist and Functional Test requirements specified in this section are in addition to, not a substitute for, inspection or testing specified in other sections.

**1.02 REFERENCE STANDARDS**

- A ASHRAE Guideline 1.1 - HVAC&R Technical Requirements for the Commissioning Process; 2007, with Errata (2012).

**1.03 SUBMITTALS**

- A Updated Submittals: Keep the Commissioning Authority informed of all changes to control system documentation made during programming and setup; revise and resubmit when substantial changes are made.
  - a. Description of the expected field adjustments for transmitters, controllers and control actuators should control responses fall outside of expected values.
- B Startup Reports, Prefunctional Checklists, and Trend Logs: Submit for approval of Commissioning Authority.
- C HVAC Control System O&M Manual Requirements. In addition to documentation specified elsewhere, compile and organize at minimum the following data on the control system:
  - 1. Specific step-by-step instructions on how to perform and apply all functions, features, modes, etc. mentioned in the controls training sections of this specification and other features of this system. Provide an index and clear table of contents. Include the detailed technical manual for programming and customizing control loops and algorithms.
  - 2. Full as-built set of control drawings.
  - 3. Full as-built sequence of operations for each piece of equipment.
  - 4. Full points list; in addition to the information on the original points list submittal, include a listing of all rooms with the following information for each room:
    - a. Floor.
    - b. Room number.
    - c. Room name.
    - d. Air handler unit ID.
    - e. Reference drawing number.
    - f. Air terminal unit tag ID.
    - g. Heating and/or cooling valve tag ID.
    - h. Minimum air flow rate.
    - i. Maximum air flow rate.
  - 5. Full print out of all schedules and set points after testing and acceptance of the system.

6. Full as-built print out of software program.
7. Electronic copy on disk of the entire program for this facility.
8. Marking of all system sensors and thermostats on the as-built floor plan and HVAC drawings with their control system designations.
9. Maintenance instructions, including sensor calibration requirements and methods by sensor type, etc.
10. Control equipment component submittals, parts lists, etc.
11. Warranty requirements.
12. Copies of all checkout tests and calibrations performed by the Contractor (not commissioning tests).
13. Organize and subdivide the manual with permanently labeled tabs for each of the following data in the given order:
  - a. Sequences of operation.
  - b. Control drawings.
  - c. Points lists.
  - d. Controller and/or module data.
  - e. Thermostats and timers.
  - f. Sensors and DP switches.
  - g. Dampers and damper actuators.
  - h. Program setups (software program printouts).
- D Project Record Documents: See Section 01 78 00 for additional requirements.
  1. Submit updated version of control system documentation, for inclusion with operation and maintenance data.
  2. Show actual locations of all static and differential pressure sensors (air, water and building pressure) and air-flow stations on project record drawings.
- E Draft Training Plan: In addition to requirements specified in Section 01 79 00, include:
  1. Follow the recommendations of ASHRAE Guideline 1.1.
  2. Control system manufacturer's recommended training.
  3. Demonstration and instruction on function and overrides of any local packaged controls not controlled by the HVAC control system.
- F Training Manuals: Refer to Division 01 requirements
  1. Provide three extra copies of the controls training manuals in a separate manual from the O&M manuals.

**PART 2 PRODUCTS**

**2.01 TEST EQUIPMENT**

- A Provide all standard testing equipment required to perform startup and initial checkout and required functional performance testing; unless otherwise noted such testing equipment will NOT become the property of Owner.
- B Equipment-Specific Tools: Where special testing equipment, tools and instruments are specific to a piece of equipment, are only available from the vendor, and are required in order to accomplish startup or Functional Testing, provide such equipment, tools, and instruments as part of the work at no extra cost to Owner; such equipment, tools, and instruments are to become the property of Owner.

**PART 3 EXECUTION**

**3.01 PREPARATION**

- A Cooperate with the Commissioning Authority in development of the Prefunctional Checklists and Functional Test Procedures.
- B Furnish additional information requested by the Commissioning Authority.
- C Prepare a preliminary schedule for HVAC pipe and duct system testing, flushing and cleaning, equipment start-up and testing, adjusting, and balancing start and completion for use by the Commissioning Authority; update the schedule as appropriate.
- D Notify the Commissioning Authority when pipe and duct system testing, flushing, cleaning, startup of each piece of equipment and testing, adjusting, and balancing will occur; when commissioning activities not yet performed or not yet scheduled will delay construction notify ahead of time and be proactive in seeing that

the Commissioning Authority has the scheduling information needed to efficiently execute the commissioning process.

- E Put all HVAC equipment and systems into operation and continue operation during each working day of testing, adjusting, and balancing and commissioning, as required.
  - 1. Include cost of sheaves and belts that may be required for testing, adjusting, and balancing.
- F Provide test holes in ducts and plenums where directed to allow air measurements and air balancing; close with an approved plug.
- G Provide temperature and pressure taps in accordance with Contract Documents.

### **3.02 INSPECTING AND TESTING - GENERAL**

- A Submit startup plans, startup reports, and Prefunctional Checklists for each item of equipment or other assembly to be commissioned.
- B Perform the Functional Tests directed by the Commissioning Authority for each item of equipment or other assembly to be commissioned.
- C Provide two-way radios for use during the testing.
- D Valve/Damper Stroke Setup and Check:
  - 1. For all valve/damper actuator positions checked, verify the actual position against the control system readout.
  - 2. Set pump/fan to normal operating mode.
  - 3. Command valve/damper closed; visually verify that valve/damper is closed and adjust output zero signal as required.
  - 4. Command valve/damper open; verify position is full open and adjust output signal as required.
  - 5. Command valve/damper to a few intermediate positions.
  - 6. If actual valve/damper position does not reasonably correspond, replace actuator or add pilot positioner (for pneumatics).
- E Isolation Valve or System Valve Leak Check: For valves not by coils.
  - 1. With full pressure in the system, command valve closed.
  - 2. Use an ultra-sonic flow meter to detect flow or leakage.
- F Deficiencies: Correct deficiencies and re-inspect or re-test, as applicable, at no extra cost to Owner.

### **3.03 TAB COORDINATION**

- A TAB: Testing, adjusting, and balancing of HVAC.
- B Coordinate commissioning schedule with TAB schedule.
- C Review the TAB plan to determine the capabilities of the control system toward completing TAB.
- D Provide all necessary unique instruments and instruct the TAB technicians in their use; such as handheld control system interface for setting terminal unit boxes, etc.
- E Have all required Prefunctional Checklists, calibrations, startup and component Functional Tests of the system completed and approved by the Commissioning Authority prior to starting TAB.
- F Provide a qualified control system technician to operate the controls to assist the TAB technicians or provide sufficient training for the TAB technicians to operate the system without assistance.

### **3.04 CONTROL SYSTEM FUNCTIONAL TESTING**

- A Prefunctional Checklists for control system components will require a signed and dated certification that all system programming is complete as required to accomplish the requirements of Contract Documents and the detailed Sequences of Operation documentation submittal.
- B Do not start Functional Testing until all controlled components have themselves been successfully Functionally Tested in accordance with Contract Documents.
- C Using a skilled technician who is familiar with this building, execute the Functional Testing of the control system as required by the Commissioning Authority.
- D Functional Testing of the control system constitutes demonstration and trend logging of control points monitored by the control system.
  - 1. The scope of trend logging is partially specified; trend log up to 50 percent more points than specified at no extra cost to Owner.
  - 2. Perform all trend logging specified in Prefunctional Checklists and Functional Test procedures.

- E Functionally Test integral or stand-alone controls in conjunction with the Functional Tests of the equipment they are attached to, including any interlocks with other equipment or systems; further testing during control system Functional Test is not required unless specifically indicated below.
- F Demonstrate the following to the Commissioning Authority during testing of controlled equipment; coordinate with commissioning of equipment.
  - 1. Setpoint changing features and functions.
  - 2. Sensor calibrations.
- G Demonstrate to the Commissioning Authority:
  - 1. That all specified functions and features are set up, debugged and fully operable.
  - 2. That scheduling features are fully functional and setup, including holidays.
  - 3. That all graphic screens and value readouts are completed.
  - 4. Correct date and time setting in central computer.
  - 5. That field panels read the same time as the central computer; sample 10 percent of field panels; if any of those fail, sample another 10 percent; if any of those fail test all remaining units at no extra cost to Owner.
  - 6. Functionality of field panels using local operator keypads and local ports (plug-ins) using portable computer/keypad; demonstrate 100 percent of panels and 10 percent of ports; if any ports fail, sample another 10 percent; if any of those fail, test all remaining units at no extra cost to Owner.
  - 7. Power failure and battery backup and power-up restart functions.
  - 8. Global commands features.
  - 9. Security and access codes.
  - 10. Occupant over-rides (manual, telephone, key, keypad, etc.).
  - 11. O&M schedules and alarms.
  - 12. Occupancy sensors and controls.
  - 13. All control strategies and sequences not tested during controlled equipment testing.
- H If the control system, integral control components, or related equipment do not respond to changing conditions and parameters appropriately as expected, as specified and according to acceptable operating practice, under any of the conditions, sequences, or modes tested, correct all systems, equipment, components, and software required at no additional cost to Owner.

**3.05 OPERATION AND MAINTENANCE MANUALS**

- A Add design intent documentation furnished by Architect to manuals prior to submission to Owner.
- B Submit manuals related to items that were commissioned to Commissioning Authority for review; make changes recommended by Commissioning Authority.
- C Commissioning Authority will add commissioning records to manuals after submission to Owner.

**3.06 DEMONSTRATION AND TRAINING**

- A Demonstrate operation and maintenance of HVAC system to Owner' personnel; if during any demonstration, the system fails to perform in accordance with the information included in the O&M manual, stop demonstration, repair or adjust, and repeat demonstration. Demonstrations may be combined with training sessions if appropriate.
- B These demonstrations are in addition to, and not a substitute for, Prefunctional Checklists and demonstrations to the Commissioning Authority during Functional Testing.
- C TAB Review: Instruct Owner's personnel for minimum 4 hours, after completion of TAB, on the following:
  - 1. Review final TAB report, explaining the layout and meanings of each data type.
  - 2. Discuss any outstanding deficient items in control, ducting or design that may affect the proper delivery of air or water.
  - 3. Identify and discuss any terminal units, duct runs, diffusers, coils, fans and pumps that are close to or are not meeting their design capacity.
  - 4. Discuss any temporary settings and steps to finalize them for any areas that are not finished.
  - 5. Other salient information that may be useful for facility operations, relative to TAB.
- D HVAC Control System Training: Perform training in at least three phases:

1. Phase 1 - Basic Control System: Provide minimum of 8 hours of actual training on the control system itself. Upon completion of training, each attendee, using appropriate documentation, should be able to perform elementary operations and describe general hardware architecture and functionality of the system.
    - a. This training may be held on-site.
  2. Phase 2 - Integrating with HVAC Systems: Provide minimum of 8 hours of on-site, hands-on training after completion of Functional Testing. Include instruction on:
    - a. The specific hardware configuration of installed systems in this facility and specific instruction for operating the installed system, including interfaces with other systems, if any.
    - b. Security levels, alarms, system start-up, shut-down, power outage and restart routines, changing setpoints and alarms and other typical changed parameters, overrides, freeze protection, manual operation of equipment, optional control strategies that can be considered, energy savings strategies and set points that if changed will adversely affect energy consumption, energy accounting, procedures for obtaining vendor assistance, etc.
    - c. Trend logging and monitoring features (values, change of state, totalization, etc.), including setting up, executing, downloading, viewing both tabular and graphically and printing trends; provide practice in setting up trend logging and monitoring during training session.
    - d. Every display screen, allowing time for questions.
    - e. Setting up and changing an air terminal unit controller.
    - f. Point database entry and modifications.
  3. Phase 3 - Post-Occupancy: Six months after occupancy conduct minimum of 8 hours of training. Tailor training session to questions and topics solicited beforehand from Owner. Also be prepared to address topics brought up and answer questions concerning operation of the system.
- E Provide the services of manufacturer representatives to assist instructors where necessary.
- F Provide the services of the HVAC controls instructor at other training sessions, when requested, to discuss the interaction of the controls system as it relates to the equipment being discussed.

**END OF SECTION 23 08 00**

**SECTION 23 09 13.23**  
**BAS SENSORS AND TRANSMITTERS**

**PART 1 GENERAL**

**1.01 REFERENCES**

- A Refer to Section 23 09 00 - References

**1.02 ACRONYMS, ABBREVIATIONS AND DEFINITIONS**

- A Refer to Section 23 09 00 - Acronyms, Abbreviations and Definitions

**PART 2 PRODUCT**

**2.01 SENSORS AND DEVICES**

- A Input/output sensors and devices shall be closely matched to the requirements of the BAS controller for accurate, responsive, noise-free signal input/output. Control input response shall be high sensitivity and matched to the loop gain requirements for precise and responsive control.
- B Sensors and transmitters shall be manually calibrated on site so that the wiring length does not detract from the sensor accuracy specified.
- C Provide guards (plastic or wire) for sensors, thermostats, and transmitters that are installed in public areas such as gymnasiums, classrooms, corridors, and vestibules.
- D Temperature sensors shall have the following characteristics:
1. Sensors shall have +/- 1.0 °F accuracy between 32 °F and 212 °F.
  2. Space temperature sensors
    - a. Shall consist of an element within a ventilated cover.
    - b. Space sensors located in mechanical rooms and public shall contain a network jack, but shall have no ability to adjust temperature setpoint (Set Point Adjustment).
    - c. Space sensors shall be provided in accordance with the drawings and specifications with the following options:
      - 1) Sensor complete with Network Jack, and Set Point Adjustment
      - 2) Sensor complete with Network Jack, Set Point Adjustment, and illuminated Override switch
- E RTD Transmitter
1. Where reference is made on the drawings for a RTD transmitter, it shall be interpreted as follows:
  2. Transmitters shall meet at minimum the following requirements:
    - a. Provide an RTD transmitter in configurations below meeting the following requirements:
      - 1) 100 ohm or 1000 ohm PT RTD
      - 2) 24V ac/dc power supply.
      - 3) 4-20 mA, 0-10Vdc or 0-5Vdc outputs compatible with BMS.
      - 4) Electronics accuracy of +/-0.1% of span.
      - 5) Operating temperature range of 32°F to 158°F. OSA only - operating temperature range of -40°F to 185°F.
      - 6) Optional LCD display
- F Temperature Sensor – Outside Air
1. Provide outside air temperature sensors as indicated within the field termination schedules and/or controls diagrams.
  2. Temperature sensors shall meet, at minimum, the following requirements:
    - a. Aluminum LB with PVC sun and windscreen.
    - b. Wall mount weatherproof enclosure with conduit entrance.
    - c. Thermistor or RTD compatible with BMS
- G Temperature Sensor – Duct Mounted – Single Point
1. Provide duct mounted, single point, temperature sensor as indicated within the field termination schedules and/or controls diagrams as follows:
    - a. In ducts less than 10 ft<sup>2</sup> in cross-sectional area.
    - b. In ducts greater than 10 ft<sup>2</sup> in cross-sectional area if there is no heating coil and no cooling coil and no mixing of air flows of different temperature upstream.
  2. Temperature sensors shall meet, at minimum, the following requirements:

- a. 0.25" stainless steel probe of length between one-third and two-thirds of the duct width.
  - b. Thermistor or RTD compatible with BMS, sealed in probe with 3 part moisture protection system.
  - c. Duct mounted ABS plenum rated housing with conduit entrance. (Optional metal, weather proof or no enclosure available)
- H Temperature Sensor-Wall Mounted-Microprocessor Based
1. Provide wall mounted temperature sensors for non-public spaces as indicated within the field termination schedules and/or controls diagrams as follows.
  2. Temperature sensors shall meet, at minimum, the following requirements:
    - a. White protective enclosure.
    - b. The location to be selected by the Engineer/Architect at a height of 4 feet. No sensor shall be mounted until the Engineer/Architect gives specific location instructions.
    - c. Thermistor or RTD compatible with BMS.
    - d. 3.5 digit LCD display of room temperature and set-point
    - e. Push button set-point adjustment-resistance or analog
    - f. override switch
    - g. LED
- I Temperature Sensor – Wall Mounted – Lobby, Hallways Or Security Spaces
1. Provide wall mounted stainless plate temperature sensors for lobbies and lobby vestibule spaces as indicated within the field termination schedules and/or control diagrams as follows.
  2. Temperature sensors shall meet, at minimum, the following requirements:
    - a. Stainless plate sensors to fit 100 x 50mm (4"X2") junction box, available with or without tamperproof screws.
    - b. Thermistor or RTD compatible with BMS.
- J Relative Humidity Sensor – Wall Mounted
1. Provide wall mounted relative humidity sensors as indicated within the Field termination schedules and/or control diagrams. Humidity sensors shall meet, at minimum, the following requirements:
    - a. White protective enclosure
    - b. Sensor to be laser trimmed thermoset polymer based capacitive type.
    - c. 24 Vac/dc power supply
    - d. 4-20 mA two wire, 0-10 Vdc and 0-5 Vdc output proportional to relative humidity range of 0% to 100% and compatible with BMS.
    - e. 2% accurate (5-95% RH). (3 & 5 % accurate units available)
    - f. Operating temperature range of 32°F to 158°F.
    - g. Reverse voltage protected and output limited.
    - h. Optional LCD display-SP and RH100A series
    - i. Optional set point adjustment-SP series
    - j. Optional push button override-RH100A series
- K Combination Relative Humidity And Temperature Sensors
1. Where there is a requirement for the monitoring of both relative humidity and temperature at the same location, the BMS Contractor shall provide a combination relative humidity sensor and temperature sensor. The individual sensors must each meet the specifications details above.
- L Differential Pressure Switch – Air
1. Provide air differential pressure switches as indicated in field termination schedules and/or control diagrams. Air differential pressure switches shall meet, at minimum, the following requirements:
    - a. An IP54 (NEMA 13) polycarbonate housing.
    - b. SPDT switch rated at 250 Vac at 1 amp.
    - c. Field adjustable range from 0.02" wc to max range of device. Select range as required, taking into consideration pressure drop across filter or coil. Typically 0.2-2" wc range for low-pressure commercial duct.
    - d. Temperature range of -4°F to 140°F.
    - e. Set point adjustment knob with indication.

- f. Automatic reset.
- M Current Relay/Switch
  - 1. Provide current sensing relays as indicated in the Field termination schedules and/or control diagrams. Current sensing relays shall meet, at minimum, the following specifications:
    - a. Rated for the applicable load.
    - b. The output relay shall have an accessible trip adjustment over its complete operating range. Provide LED indication of relay status.
    - c. Current relay shall have input and output isolation via current transformer.
    - d. Current relay shall be self-powered with no insertion loss.
    - e. Relay shall be in a dustproof housing.
    - f. Accuracy to be <2% of full-scale max.
    - g. Temperature rating of 5°F to 140°F.
    - h. Whenever the status of a single speed motor is monitored it shall be done via a current sensing relay.
    - i. The BMS contractor shall provide current sensing relays at the MCC starters.
    - j. The BMS contractor shall provide the current sensing relays for motors with local starters and no MCC starter.
- N Current Sensor
  - 1. Provide monitoring of the current as identified in Field termination sheets and/or control drawings. Current monitoring shall meet, at minimum, the following requirements:
    - a. 4-20 mA, 0-10 or 0-5 Vdc output proportional to current draw.
    - b. Reverse polarity protected and output limited.
    - c. 50/60 Hz operation.
    - d. Accuracy of better than 1%.
    - e. Operating temperature range of -20°F to 120°F.
- O Carbon Dioxide (CO2) Sensor
  - 1. Provide a space or duct carbon dioxide gas detection sensor as indicated within the field termination schedules and/or control diagrams. Carbon dioxide detection sensors shall meet, at minimum, the following requirements:
    - a. Set-up to be fully microprocessor based c/w LCD.
    - b. 4-20 mA, 0-10 or 0-5 Vdc output compatible with BMS proportional to 0 to 2000 ppm of carbon dioxide concentration
    - c. Power supply to be 20-28Vac/dc @ 140 mA max for 24 Vac and 80 mA avg. @24 Vdc.
    - d. No maintenance or periodic sensor replacement needed. The sensor shall have a 5-year calibration interval, utilizing the Automatic Calibration Logic Program (ACLP).
    - e. Standard accuracy to be 3% of reading or 75 ppm, whichever is greater.
    - f. Optional integral humidity and temperature transmitter or temperature sensor (thermistor or RTD)
    - g. BACnet communications
    - h. Optional setpoint adjustment, override switch and relay.
    - i. Operating temperature of 32°F to 122°F.

### **PART 3 EXECUTION**

#### **3.01 INSTALLATION OF SENSORS**

- A Install sensors according to manufacturer's recommendations.
- B Mount sensors rigidly and adequately for operating environment.
- C Install room temperature sensors on concealed junction boxes properly supported by wall framing. Box heights shall be coordinated with Division 26 and other trades such that device heights match exactly light switches and other similar control devices.
- D Air seal wires attached to sensors in their raceways or in the wall to prevent sensor readings from being affected by air transmitted from other areas.
- E Use averaging sensors in mixing plenums and hot and cold decks. Install averaging sensors in a serpentine manner vertically across duct. Support each bend with a capillary clip.



- F Install mixing plenum low-limit sensors in a serpentine manner horizontally across duct. Support each bend with a capillary clip. Provide 1 ft. of sensing element for each 1 ft<sup>2</sup> of coil area.
- G Install outdoor air temperature sensors on north wall at designated location with sun shield.
- H Smoke detectors, high and low limit thermostats, high-pressure cut-offs, and other safety switches shall be hard-wired to de-energize equipment as described in the sequence of operation. Switches shall require manual reset. Provide contacts that allow DDC software to monitor safety switch status.

**END OF SECTION 23 09 13.23**

**SECTION 23 09 13.43**  
**BAS CONTROL DAMPERS**

**PART 1 GENERAL**

**1.01 REFERENCE STANDARDS**

- A ANSI/AMCA Standard 500-D, Laboratory Methods of Testing Dampers for Rating.

**1.02 ACRONYMS, ABBREVIATIONS AND DEFINITIONS**

- A Refer to Section 23 09 00 - Acronyms, Abbreviations and Definitions

**1.03 QUALITY ASSURANCE**

- A All dampers shall be certified to bear the AMCA Certified Ratings Program seal for Air Performance, Efficiency, and Air Leakage.

**1.04 SUBMITTALS**

- A Product Data: Submit manufacturer's product data.
  1. Include leakage, velocity, pressure drop, maximum pressure data and energy efficiency performance.
  2. Indicate materials, construction, and dimensions.
  3. Include pressure drop data for all damper sizes in accordance with AMCA 500-D test figures 5.2 (Ducted Inlet, Free Outlet), 5.3 (Ducted Inlet, Ducted Outlet) and 5.5 (Free Inlet, Free Outlet).
  4. Include a copy of Installation Instructions.

**1.05 DELIVERY, STORAGE, AND HANDLING**

- A Delivery: Deliver materials to site in manufacturer's original, unopened containers and packaging, with labels clearly indicating manufacturer, material, and location of installation.
- B Storage: Store materials in a dry area indoor, protected from damage, and in accordance with manufacturer's instructions.
- C Handling: Handle and lift dampers in accordance with manufacturer's instructions. Protect materials and finishes during handling and installation to prevent damage.

**PART 2 PRODUCT**

**2.01 AUTOMATIC CONTROL DAMPERS**

- A Manufacturers:
  1. Tamco
  2. Ruskin
  3. Johnson
  4. Greenheck
  5. Nailor
  6. Or Approved Equal
- B Dampers shall be minimum leakage type to conserve energy and the temperature control manufacturer shall submit leakage data for all control dampers with the temperature control submittal.
- C Damper leakage ratings shall be certified in accordance with AMCA Standard 500-D.
- D Provide any automatic control dampers not specified to be integral with other equipment.

**2.02 RECTANGULAR LOW LEAKAGE CONTROL DAMPER**

- A Dampers shall have a maximum leakage of Class 1 @ 4 in. wg or Class 1A @ 1 in. wg as defined by AMCA (Leakage class 1 is defined as 8 cfm/ sq. ft. @ 4 in. wg and class 1A is defined as 3 cfm/ sq. ft. @ 1 in. wg. at -40°F).
- B Dampers shall meet or exceed the IECC (International Energy Conservation Code) requirements for damper leakage ratings of 3 cfm/ sq. ft. @ 1 in. wg or 8 cfm/sq. ft. @ 4in. wg or less when integral to the building envelope.
- C Dampers shall have a maximum differential pressure rating of 6 in. wg.
- D Dampers shall have a maximum velocity rating of 6000 fpm.
- E The Damper manufacturer's submittal data shall certify that all pressure drop data is licensed in accordance with the AMCA Certified Ratings Program for Test Figures 5.2, 5.3, and 5.5. Damper air performance data shall be developed in accordance with the latest edition of AMCA Standard 500-D. Dampers shall be labeled with the AMCA Air Performance Seal. AMCA certified pressure drop for a 24 in. wide x 24 in. high damper shall not exceed 0.06 in. wg when subjected to an airflow velocity of 1500 fpm according to AMCA Test

Figure 5.3.

F Blade Action:Opposed

G Frame:

1. Damper frame shall be 16 ga. galvanized steel formed into a 5 in. x 1 in. structural hat channel. Top and bottom frame members on dampers less than 17 in. high shall be low profile design to maximize the free area of these smaller dampers. Frame shall be 4-piece construction with 1 ½ in. (minimum) integral overlapping gusset reinforcements in each corner to assure square corners and provide maximum resistance to racking.
2. Blades:
  - a. Damper blades shall be heavy gauge extruded aluminum airfoil shape with metal blade to blade overlap. Each blade shall be symmetrical relative to its axle pivot point, presenting identical performance characteristics with air flowing in either direction through the damper. Provide symmetrical blades of varying size as required to completely fill the damper opening. Blade orientation is horizontal.
3. Seals:
  - a. Shall be TEP mechanically fastened to each blade.
  - b. Jamb: Flexible stainless steel compression type.
4. Blade Stops:
  - a. Dampers of whole inch height increments shall not require blade stops. When required, individual blade stops shall occupy no more than ½ in. of the damper opening to provide maximum free area and minimal pressure loss.
5. Linkage: Plated steel.
6. Axles: Minimum ½ in. dia. Plated steel
7. Bearings:
  - a. Axle bearings shall be synthetic (acetal) sleeve rotating in polished extruded holes in the damper frame.
8. Finish: Mill galvanized finish

**2.03 ROUND LOW LEAKAGE CONTROL DAMPER**

- A Dampers shall have a rating of 4 cfm /sq. ft. @ 1 in wg.
- B Dampers shall have a minimum differential pressure rating of 4 in. wg.
- C Dampers shall have a minimum velocity rating of 3000 fpm.
- D Construction:
  1. Frame and Sleeve: The damper frame and sleeve shall be of one piece design, made with 20 ga. galvanized steel and a groove for added strength.
  2. Blades: galvanized steel
  3. Blade Seals: Silicone mechanically secured to the blades.
  4. Axles: Minimum ½ in. dia., material isplated steel
  5. Bearings: Axle bearings shall be bronze.
  6. Mounting: Vertical or horizontal

**PART 3 EXECUTION**

**3.01 INSTALLATION**

- A Install dampers in accordance with manufacturer’s Installation Instructions.
- B Dampers must be accessible to allow inspection, adjustment, and replacement of components. The sheet metal contractor shall furnish any access doors or removable section of duct in ductwork or plenums required to provide this access. The mechanical contractor shall furnish any access doors required in walls, ceilings, or other general building construction.
- C Install dampers square and free from racking.
- D The installing contractor shall provide and install bracing for multiple section assemblies to support assembly weight and to hold against system pressure.
- E Do not compress or stretch the damper frame into the duct or opening.

- F Attach multiple damper section assemblies together in accordance with manufacturer's instructions. Install support mullions as reinforcement between assemblies as required.
- G Handle dampers using the frame or sleeve. Do not lift or move dampers using blades, actuator or jackshaft.

**3.02 CO-ORDINATION**

- A Coordinate delivery of dampers to site.
- B Clearly tag and mark dampers for their purpose and location.
- C Supervise Mechanical Contractor in the installation of the dampers ensuring proper dampers(s) are located and installed in proper location(s)

**END OF SECTION 23 09 13.43**

**SECTION 23 09 23.03**  
**BAS DIRECT DIGITAL CONTROL SYSTEM**

**PART 1 - GENERAL**

**1.01 RELATED DOCUMENTS:**

- A The requirements of the General and Special Conditions and Contract Requirements - Division 0 and Division 1 apply to all Work under this Section.
- B The BAS shall be capable of total integration of the facility infrastructure systems with user access to all system data either locally over a secure Intranet within the building or by remote access by a standard Web Browser over the Internet. This shall include HVAC control, energy management, alarm monitoring, trending, reporting and maintenance management functions related to normal building operations as indicated on the drawings or elsewhere in this specification.

**1.02 DESCRIPTION OF WORK:**

- A Open, Interoperable, Integrated Architecture:
- B The intent of this specification is to provide a peer-to-peer networked, stand-alone, distributed control system with the capability to integrate both the ANSI/ASHRAE Standard 135-2012 BACNet technology communication protocols in one open, interoperable system.
- C The supplied computer software shall employ object-oriented technology (OOT) for representation of all data and control devices within the system. In addition, adherence to industry standards including ANSI / ASHRAE™ Standard 135-2012, BACNet or LonMark to assure interoperability between all system components is required. For each LonWorks device that does not have LonMark certification, the device supplier must provide an XIF file for the device. For each BACNet device, the device supplier must provide a PICS document showing the installed device's compliance level. Minimum compliance is Level 3; with the ability to support data read and write functionality. Physical connection of BACNet devices shall be BACnet/IP via or Master Slave/Token Passing (MS/TP) via RS-485.
- D All components and controllers supplied under this contract shall be true "peer-to-peer" communicating devices. Components or controllers requiring "polling" by a host to pass data shall not be acceptable.
- E The supplied system must incorporate the ability to access all data using Java enabled browsers without requiring proprietary operator interface and configuration programs. An Open Database Connectivity (ODBC) or Structured Query Language (SQL) compliant server database is required for all system database parameter storage. This data shall reside on a supplier-installed server for all database access. Systems requiring proprietary database and user interface programs shall not be acceptable.
- F A hierarchical topology is required to assure reasonable system response times and to manage the flow and sharing of data without unduly burdening the customer's internal intranet network. Systems employing a "flat" single tiered architecture shall not be acceptable.

**1.03 LOCAL AREA NETWORKS:**

- A The Local Area Network (LAN) shall be either a 10 or 100 Megabits/sec Ethernet network supporting BACNet, Java, XML, HTTP, and CORBA IIOP for maximum flexibility for integration of building data with enterprise information systems and providing support for multiple SNC's and user workstations.
- B Local area network minimum physical and media access requirements:
  - 1. Ethernet; IEEE standard 802.3
  - 2. Cable; 10 Base-T, UTP-8 wire, category 6
  - 3. Minimum throughput; 10 Mbps, with ability to increase to 100 Mbps

**1.04 ADDITIONAL GENERAL REQUIREMENTS FOR BAS:**

- A All wiring, conduit, and panels for all BAS temperature controls.
- B The 120 volt power required for each stand-alone BAS controller shall be provided by the electrical contractor.
- C Perform all wiring in accordance with all local and national codes.
- D Surge transient protection shall be incorporated in the design of the system to protect electrical components in all system components as described below under "General Product Description."
- E Programming modifications necessary to fine-tune sequences during commissioning of systems at no additional cost to the owner as well as throughout the warranty period.

- F After a power failure and upon power restoration, the BAS initiates automatic sequential restart of equipment based on current program time and program requirements without operator intervention.
- G Provide multiple controllers to prevent a single-failure catastrophe. Failure of any single controller does not affect other controllers.
- H Mount all control devices inside of a UL-listed steel enclosure panel, with hinged locking cover and key locking latch. Pre-wire electrical components mounted in the cabinet to numbered terminal strips within the cabinet. All control panels shall be assembled in a UL –508A panel shop and bear a UL label.

**1.05 WIRING AND CONTROLS:**

- A Mechanical Contractor shall provide taps and isolation valves as necessary for pipe-mounted control devices furnished by this Section.
- B Control Contractor will be responsible for the installation and wiring of temperature controls, control interlock wiring, electrical controls and devices in the temperature control system.

**1.06 QUALITY ASSURANCE AND STANDARDS:**

- A Materials and equipment shall be the cataloged products of manufacturers regularly engaged in production and installation of integrated control systems and shall be manufacturer’s latest standard design that complies with the specification requirements.
- B All products used in this project installation shall be new and currently being manufactured. This installation shall not be used as a test site for any new products. Spare parts shall be available for at least five years after completion of this contract.
- C Install system using competent workmen who are fully trained in the installation of integrated control systems.
- D Single source responsibility of supplier shall be the complete installation and proper operation of the BAS and control system and shall include debugging and proper calibration of each component in the entire system.
- E Supplier shall have an in-place support facility within 100 miles of the site with technical staff, spare parts inventory and all necessary test and diagnostic equipment.
- F The BAS Contractor and manufacturer representative shall support the installed system for a minimum of 1 year. The support shall provide full material warranty of controllers.
- G All electronic equipment shall conform to the requirements of FCC Regulation, Part 15, Section 15, governing Radio Frequency Electromagnetic Interference and be so labeled.
- H BAS shall comply with UL 916 and be so listed at the time of bid.
- I Design and build all system components to be fault-tolerant.
  - 1. Satisfactory operation without damage at 110% and 85% of rated voltage and at plus 3-Hertz variation in line frequency.
  - 2. Static, transient and short-circuit protection on all inputs and outputs.
  - 3. Protect communication lines against incorrect wiring, static transients and induced magnetic interference.
  - 4. Network-connected devices to be A.C. coupled or equivalent or that any single device failure will not disrupt or halt network communication.
  - 5. All real time clocks and data file RAM to be battery-backed for a minimum 72 hours and include local and system low battery indication.
  - 6. All programs shall retain their memory for a minimum of 7 days upon loss of power.
- J Comply with NFPA 90A, Standard for Installation of Air Conditioning and Ventilating Systems.
- K Provide wiring in accordance with NEC requirements.
- L Upon request (not required as part of the base submittal) Building Automation System Contractors desiring to provide this system must submit four copies of their qualifications in the following format:
  - 1. Experience and Qualifications:
    - a. Local Office:
      - 1) Duration of continuous service
      - 2) Organization
      - 3) Staff

- 4) Experience
- 5) Spare parts
- 6) Test equipment
- 7) Software development facility
- 8) Training
  - (a) Related Experience:
    - (1) Temperature controls
    - (2) Building automation
    - (3) Computerized energy control
    - (4) Direct digital control
    - (5) Similar jobs

**1.07 SUBMITTALS:**

- A Product Data: Submit 4 copies of manufacturer's technical product data for each control device furnished. Indicate dimensions, capacities, performance, electrical characteristics, material finishes; also include installation and start-up instructions.
- B Shop Drawings: Submit 4 copies of shop drawings for each control system, containing at least the following information:
  1. Schematic flow diagram of system showing fans, pumps, coils, dampers, valves, control devices and all interconnections between devices.
  2. Indicate all required electrical wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.
  3. Written description of sequence of operation.

**1.08 DELIVERY, STORAGE AND HANDLING**

- A Provide equipment and control devices in factory shipping carton. Maintain in cartons while shipping, storing and handling as required to prevent equipment damage and to keep dirt and moisture from equipment. Store equipment and materials inside and protect from weather.

**PART 2 PRODUCT**

**2.01 MANUFACTURERS:**

- A Only temperature control systems by the following manufacturers are acceptable. Only the specific system listed for a particular manufacturer is acceptable.
  1. Alerton
  2. DisTech
  3. Honeywell, Tridium WEBS AX/Excel 5000, Inc. (Preferred Alternate)
  4. Schneider Electric, I/A Series Niagara AX
  5. ABB Cylon
  6. Vykon

**2.02 GENERAL PRODUCT DESCRIPTION:**

- A The BAS shall consist of the following components:
  1. Application Specific Controllers (ASC)
  2. Programmable Equipment Controllers (PEC)
  3. System Network Controllers (SNC)
  4. Operator Workstation (OWS)
  5. Lighting Control Panels (LCP)

**2.03 APPLICATION SPECIFIC CONTROLLER (ASC):**

- A These controllers are designed to control and operate specific types of unitary equipment (VAV boxes, heat pumps, unit ventilators, fan coils, etc.).
- B The controllers can be configurable (application program fixed for the type of equipment), or they can be fully programmable.
- C The controllers do need to be capable of peer-to-peer communication.
- D The following communication protocols will be acceptable:
  1. BACNET

**2.04 PROGRAMMABLE EQUIPMENT CONTROLLER (PEC):**

- A These controllers are designed to control and operate large air handling units and central plant equipment (large VAV air handling units, chilled water systems, heat pump fluid loops, etc.).
- B These controllers must be fully programmable to meet the unique requirements of the systems they control.
- C The controllers need to be capable of peer-to-peer communication.
- D The following communication protocols will be acceptable:
  - 1. BACNET

**2.05 SYSTEM NETWORK CONTROLLERS (SNC):**

- A These controllers are designed to manage communications between the programmable equipment controllers (PEC) and application specific controllers (ASC) which are connected to its communications trunks, manage communications between itself and other system network controllers (SNC) and with any operator workstations (OWS) that are part of the BAS, and perform control and operating strategies for the system based on information from any controller connected to the BAS.
- B The controllers must be fully programmable to meet the unique requirements of the facility it must control.
- C The controllers must be capable of peer-to-peer communications with other SNC's and with any OWS connected to the BAS, whether the OWS is directly connected, connected via modem or connected via the Internet.
- D The communication protocols utilized for peer-to-peer communications between SNC's will be Niagara AX, BACnet TCP/IP or SNMP. Use of a proprietary communication protocol for peer-to-peer communications between SNC's is not allowed.
- E The SNC shall be capable of executing application control programs to provide:
  - 1. Calendar functions
  - 2. Scheduling
  - 3. Trending
  - 4. Alarm monitoring and routing
  - 5. Time synchronization
  - 6. Integration of third party equipment protocols.
  - 7. Network management functions for all SNC, PEC and ASC based devices
    - a. The SNC must provide the following hardware features as a minimum:
      - 1) One Ethernet Port-10/100 Mdps
      - 2) One RS-232/485 port
      - 3) Battery Backup
      - 4) Flash memory for long term data backup (If battery backup or flash memory is not supplied, the controller must contain a hard disk with at least 1 gigabyte storage capacity)
    - b. The SNC or OWS shall support standard Web browser access via the intranet/Internet.
    - c. The SNC or OWS shall provide alarm recognition, storage, routing, management and analysis to supplement distributed capabilities of equipment or application specific controllers.
    - d. The SNC or OWS shall be able to route any alarm condition to any defined user location whether connected to a local network or remote via dial-up, telephone connection, or wide-area network.
      - 1) Alarm generation shall be selectable for annunciation type and acknowledgement requirements including but not limited to:
        - (a) Alarm,
        - (b) Return to normal,
        - (c) To default.
          - (1) Alarms shall be annunciated in any of the following manners as defined by the user:
          - (2) Screen message text,
          - (3) Email of complete alarm message to multiple recipients.
          - (4) Pagers via paging services that initiate a page on receipt of email message.
          - (5) Graphics with flashing alarm object(s).
          - (6) The following shall be recorded by the SNC for each alarm (at a minimum):



- (7) Time and date
- (8) Equipment (air handler #, accessway, etc.)
- (9) Acknowledge time, date, and user who issued acknowledgement.

**2.06 LIGHTING CONTROL PANEL (LCP):**

- A LCPs shall be assembled in a UL-508A panel shop and bear a UL-508A label.
- B BAS contractor shall supply LCPs as required to control interior and exterior lighting circuits as shown on the electrical plans. Each LCP shall include latching relays and contactors as required. Panels shall be pre-assembled with terminal blocks to accept lighting circuits.
- C Lighting circuits shall be controlled by a time of day schedule. Activating an override switch during unoccupied hours shall turn the associated lighting circuit on for two hours. After the expiration of two hour override, the circuit shall be turned off. Activating the override switch a second time, prior to the two hour timed expiration shall turn the associated circuit off.
- D Wiring from the LCP terminal blocks to the electrical panels and lights shall be by Division 26.
- E BAS contractor shall provide override switches, face plates (match Division 26 specifications), low voltage wiring, and programming. Boxes and raceway associated with override switches shall be by Division 26.
- F BAS contractor shall provide all graphics and programming as necessary to enable the scheduling and override of lighting zones and circuits by the system operator through the Operator Workstation.

**2.07 PRODUCTS:**

- A Provide electronic building automation system products with all major components produced by one manufacturer for a complete and operable system.
- B All instrumentation devices shall be delivered to the site complete with documentation covering unpacking, assembly, installation, start-up, calibration and field service. Product specifications shall also be included.
- C All controllers on all levels shall function with power supply tolerance of -15% to +20% of the nominal input voltage without the need for external power conditioners.
- D Provide secure internet access for remote communication to the BAS.

**2.08 APPLICATION SPECIFIC CONTROLLERS (ASC):**

- A Application Specific Controllers (ASC's) shall be standalone EEPROM based configured to perform the sequences specified, and with I/O selected for the application. All unitary DDC controllers shall support the LonMark Functional Profile or be BACnet listed for the given application. ASC's shall be tested and listed under UL916 for computing devices. ASC enclosures shall be flame retardant compact plastic conforming to UL94-V5 for plenum mounting or plated steel. Each ASC shall be provided with face mounted LED type annunciation to continually display its operational mode: power, normal, or in an alarm state. As an alternative to the face mounted integral LED, the control contractor shall provide relay driven pilot lights mounted at the ASC location, which shall provide the specified annunciation. ASC's shall be configured for DIN rail mounting using industry standard clip on adapters or direct panel mounted. The controller shall be programmable and configurable.
  1. Input/Output Module
    - a. Provide a remote input/output module that connects sensors and actuators onto the field bus network for use by the NAC, ILC and ASC DDC Controllers. I/O Device shall support LonMark or BACnet standard network communication technology for controller-to-controller communications. I/O Device shall have extended operating temperature rating from -40F to +150F so Device can be mounted directly in wiring cabinet of monitored appliances.
      - 1) Fan Coil Controller
        - (a) Provide a stand alone DDC Fan Coil Controller for common two pipe or four pipe fan coil units featuring preprogrammed heating and cooling control algorithms for single or up to three fan speed applications. Controller shall use BACnet communication technology for field bus and shall utilize the BACnet Fan Coil Unit (FCU) communication profile for interoperability with similar protocol third party devices in network applications. Controllers shall have integral transformers and fan speed relays directly wired to line voltage power 115Vac and 230Vac. Controller application software shall include a setpoint reset for energy demand limit control. Separate

unoccupied heating and cooling setpoints shall be provided. A standby feature shall be provided to reset the occupied temperature set point back to a user definable limit based on status from an auxiliary device, such as an occupancy sensor or window contact. Controller shall include a temperature wall module connection that may be used in any applications where the wall module must: sense temperature, control set point temperature, control Occ/Unocc or control fan speed. In addition to internal I/O selected for the application, controller shall also support distributed I/O from the network.

## 2.09 PROGRAMMABLE EQUIPMENT CONTROLLERS (PEC):

- A HVAC control shall be accomplished using LonMark or BACnet based devices where the application has a LonMark or BACnet profile defined. Where LonMark or BACnet devices are not available for a particular application, devices based on LonWorks or BACnet shall be acceptable. For each LonWorks or BACnet device that does not have LonMark or BACnet certification, the device supplier must provide an XIF file for the device. The controller platform shall provide options and advanced system functions, programmable and configurable that allow standard and customizable control solutions required in executing the “Sequence of Operation”.
- B All PECs shall be application programmable and shall at all times maintain their LonMark or BACnet certification. All control sequences within or programmed into the ILC shall be stored in non-volatile memory, which is not dependent upon the presence of a battery to be retained.
- C The PECs shall communicate with the SNC at a baud rate of not less than 78.8K baud. The PEC shall provide LED indication of communication and controller performance to the technician, without cover removal.
- D Each PEC shall have expansion ability to support additional I/O requirements through the use of remote input/output modules

## 2.10 ADVANCED UNITARY CONTROLLERS:

- A The advanced unitary controller (AUC) platform shall be designed specifically to control HVAC – ventilation, filtration, heating, cooling, humidification, and distribution. Equipment includes: VAV air handlers, heat pumps, and fan coils. The controller platform shall provide options and advanced system functions, programmable and configurable that allow standard and customizable control solutions required in executing the “Sequence of Operation”.
- B Minimum Requirements:
  - 1. The controller shall be fully programmable with full functionality on the OWS.
    - a. Support downloads to the controller
    - b. Support uploads from the controller
    - c. Support simulation/debug mode of the controller.
    - d. Maintain native GUI.
    - e. Native function-block programming
      - 1) The controller shall be capable of either integrating with other devices or stand-alone operation.
      - 2) The controller shall have an FTT transformer-coupled communications port interface for common mode-noise rejection and DC isolation.
      - 3) The controller shall have an internal time clock with the ability to automatically revert from a master time clock on failure.
        - (a) Operating Range: 24 hour, 365 day, multi-year calendar including day of week and configuration for automatic day-light savings time adjustment to occur on configured start and stop dates.
        - (b) Accuracy:  $\pm 1$  minute per month at 77° F (25° C).
        - (c) Power Failure Backup: 24 hours at 32° to 122° F (0° to 50° C).
      - 4) The controller shall have Significant Event Notification, Periodic Update capability, and Failure Detect when network inputs fail to be detected within their configurable time frame.
      - 5) The controller shall have an internal DC power supply to power external sensors.

- (a) Power Output: 20 VDC  $\pm$ 10% at 75 mA.
- 6) The controller shall have a visual indication (LED) of the status of the device:
  - (a) Controller operating normally.
  - (b) Controller in process of download.
  - (c) Controller in manual mode under control of software tool.
  - (d) Controller lost its configuration.
  - (e) No power to controller, low voltage, or controller damage.
  - (f) Processor and/or controller are not operating.
- 7) The minimum controller Environmental ratings
  - (a) Operating Temperature Ambient Rating: -40° to 150° F (-40° to 65.5° C).
  - (b) Storage Temperature Ambient Rating: -40° to 150° F (-40° to 65.5° C).
  - (c) Relative Humidity: 5% to 95% non-condensing.
- 8) The controller shall have the additional approval requirements, listings, and approvals:
  - (a) UL/cUL (E87741) listed under UL916 (Standard for Open Energy Management Equipment) with plenum rating.
  - (b) CSA (LR95329-3) Listed
  - (c) Meets FCC Part 15, Subpart B, Class B (radiated emissions) requirements.
  - (d) Meets Canadian standard C108.8 (radiated emissions).
  - (e) Conforms requirements European Consortium standard EN 61000-6-1; 2001 (EU Immunity)
  - (f) Conforms requirements European Consortium standard EN 61000-6-3; 2001 (EU Emission)
- 9) The controller housing shall be UL plenum rated mounting to either a panel or DIN rail (standard EN50022; 7.5mm x 35mm).
- 10) The controller shall have a mix of digital inputs (DI), digital Triac outputs (DO), analog outputs (AO), and universal inputs (UI).
  - (a) Analog outputs (AO) shall be capable of being configured as digital outputs (DO)
  - (b) Input and Output wiring terminal strips shall be removable from the controller without disconnecting wiring.
  - (c) Input and Output wiring terminals shall be designated with color coded labels.
  - (d) Universal inputs shall be capable of being configured as binary inputs, resistive inputs, voltage inputs (0-10 VDC), or current inputs (4-20 mA)
- 11) The controller shall provide for “user defined” Network Variables (NV) for customized configurations and naming.
  - (a) The controller shall support 62 Network Variables with a byte count of 31 per variable.
  - (b) The controller shall support 1,922 separate data values.
- 12) The controller shall provide “continuous” automated loop tuning with an Adaptive Integral Algorithm Control Loop.
- 13) The controller platform shall have standard HVAC application programs that are modifiable to support both the traditional and specialized “sequence of operations” as outlined in Section 4.
  - (a) Discharge air control and low limit
  - (b) Pressure-dependent dual duct without flow mixing.
  - (c) Variable air volume with return flow tracking.
  - (d) Economizer with differential enthalpy.
  - (e) Minimum airflow coordinated with CO2.
  - (f) Unit ventilator cycle (1, 2, 3) 2-pipe.
  - (g) Unit ventilator cycle (1, 2, 3) 2-pipe with face/bypass.
  - (h) Unit ventilator cycle (1, 2, 3) 4-pipe.
  - (i) Unit ventilator cycle (1, 2, 3) 4-pipe with EOC valve.

**2.11 DUCT MOUNTED SMOKE DETECTORS:**

- A General: Smoke detectors shall be furnished by the electrical contractor and installed by the mechanical contractor. Connection to the fire alarm system shall be by the Electrical Contractor. Verify proper compliance with the requirements of NFPA 90A.

**2.12 PORTABLE OPERATOR'S WORKSTATION (LAPTOP COMPUTER)**

- A Provide a laptop computer with the following specifications for the owner with all controls software preinstalled.
1. Intel® Core™ i7-3612QM processor (12M Cache, up to 3.8 GHz)
  2. Windows® 11, 64Bit, English
  3. 17.3" High Definition+ (900p) LED Display with Truelife
  4. 16GB Dual Channel DDR3 SDRAM at 1600MHz
  5. 2TB 5400 RPM SATA Hard Drive
  6. Intel® HD Graphics 4000
  7. 90 days Premium Phone Support + 1 Year In-Home Service after Remote Diagnosis

**2.13 SOFTWARE:**

- A General:
1. Unless previously provided, one licensed copy of controller programming software shall be provided to owner.
  2. Furnished as an integral part of each controller and not dependent on any higher level computer.
  3. Discreet programs that can be implemented in any combination to provide the proper control requirements by providing the necessary input sensors, programming the required sequence, and executing proper commands to the output devices.
  4. Analog data points may be assigned high and low limits for use as alarm and control settings
  5. Application Software:
    - a. Establish sequences for individual control systems.
    - b. Includes items such as sensor location, set-point, compensation start point, proportional band, direct or reverse action, actuator maximum and minimum position, PI output, P output, PID output, and output location assignment.
    - c. Written by the supplier incorporating standard software as well as all necessary subroutines to provide the specified control operation.

**2.14 STANDARD SOFTWARE:**

- A ROM resident and addressable through the programmer's terminal with RAM resident parameters modifiable through the terminal at the appropriate programming level with the proper password.
- B Optimum Start:
1. Minimize total energy consumption in the daily start-up of each heating/cooling system by calculating a start time for each system which will bring its respective zone temperature to the boundary of the comfort zone at the time of occupancy start.
  2. Execute one optimum start command per day for each system controlled from the program.
  3. Automatically adjusts operation based on previous start-ups.
    - a. Load Reset: Control heating and/or cooling to minimize energy use in the building by resetting heating and cooling supply temperatures only to values necessary to maintain comfort conditions.
    - b. Night Cycle: Protect the building against specified temperature extremes during unoccupied hours with a minimum expenditure of energy by restarting systems during off periods to keep the space temperature within preprogrammed limits in heating or cooling applications.
    - c. Optimum Stop: Minimize total energy consumption in the daily shutdown of each heating/cooling system by shutting down the system as much before the end of occupancy as possible, but not so early as to let the temperature drift out of the specified comfort range.
    - d. Reduced Occupancy: Provide minimal comfort conditions to occupants who must be in the building at other than normal occupancy hours by amending the control sequences for the system and allowing manual zone input.

- e. Occupied/Unoccupied: The BAS system provides for time-of-day, day-of-week time scheduling of the systems. Based on the time-of-day and the day-of-week the BAS system will index the systems to occupied or unoccupied.
- f. Partial Occupancy: Allow use of a partially completed building and mechanical system to provide early move-in for the building owner through selective control of on-line mechanical equipment to provide minimum comfort conditions for isolated sections of the building. Additional control is incorporated as the building is completed with minimum disturbance to existing occupants.

**2.15 CUSTOM SOFTWARE:**

- A Provide a control language for user programming of HVAC applications designed to accomplish transition from hardware control system design to software-based control system design.
- B Allow the user to program custom control sequences directly into microcomputer memory at the SNC level.
- C User selected input sensor data, parameters, and algorithms can be entered into the custom software program, and the result of the algorithms used to position actuators.

**2.16 SOFTWARE LICENSING:**

- A Software licensing shall give the owner the capability to control their system and determine which contractors can bid and engineer their system.
- B It shall be possible to ensure the owner can prevent unauthorized parties from accessing the system for engineering changes.
- C Software licensing shall have no restrictions on which brand of controller tools can interact with the system.
- D Software licensing shall have the ability to individually manage authorized and independent parties.

**2.17 REPORTS:**

- A User programmed to generate custom designed reports.
- B Any information being monitored is available for reports.
- C Provide initially programmed reports as described in the sequence of operation.
- D Data Storage: Store any data available to the control system at specified intervals for user-specified periods of time. Controller databases will be backed up on CD-ROM and given to the owner before the job is complete.

**PART 3 EXECUTION**

**3.01 INSPECTION:**

- A Examine areas and conditions under which BAS systems are to be installed.
- B Do not proceed with work until unsatisfactory conditions have been corrected in a manner acceptable to installer.
- C Installation - General:
- D Install systems and materials in accordance with manufacturer's instructions in a neat workmanlike manner.
- E Coordinate with other trades on the project as the work progresses so that each will be aware of the extent of all work. Carefully plan all work and check for interferences before installation. No extras will be allowed for changes caused by failure to check for interferences.
- F Provide structural supports as required for panels and control devices.
- G Unless shown or specified otherwise, mount bottom of room sensors at 5'-0" above floor.
- H Supervise installation of all automatic control valves and separable wells for immersion elements.
- I Supervise installation of all control dampers.
- J Install metering devices away from bends and elbows with minimum upstream and downstream straight distances per manufacturer's recommendations and as shown on Drawings.

**3.02 CONTROL WIRING:**

- A Install color-coded control wiring without splices between terminal points in accordance with National Electrical Code.
- B Install circuits over 25 volts with color-coded No. 12 or 14.
- C Install circuits under 25 volts with color-coded cable as recommended and approved by the manufacturer. All cable used to be plenum rated.

- D Within walls and inside mechanical rooms, install low voltage circuits in electrical metallic conduit or other suitable raceway. Where located above ceilings, plenum rated cable installed in cable tray or grouped and suspended with J-hooks may be used.

**3.03 TESTING:**

- A When installation of the control system is complete, calibrate equipment and verify transmission media operation before the system is placed on-line.
- B Provide a cross check of each control point within the control system by making a comparison between the control command and the field-controlled device.
- C Replace any work found defective. After replacement, repeat test.

**3.04 START-UP AND DEMONSTRATION:**

- A After completion and testing of the installation, regulate, adjust and service as necessary all control devices in the systems, placing each item in complete and proper operation.
- B Demonstrate that all systems are operable from local controls in the specified failure mode upon electronic control system failure or loss of power.
- C Complete all commissioning requirements as specified elsewhere, as applicable to this scope of work.

**3.05 INSTRUCTION:**

- A Provide the services of manufacturer's technical personnel for 8 hours of instruction to Owner's personnel in the operation, maintenance and programming of the control system. Orient the training specifically to the system installed rather than a general training course.
- B Provide training manuals, equipment and material required for classroom training.
- C Training to include the following items:
  - 1. Operation of equipment
  - 2. Programming
  - 3. Diagnostics
  - 4. Failure recovery procedures
  - 5. Alarm formats (where applicable)
  - 6. Maintenance and calibration
  - 7. Trouble shooting, diagnostics, and repair instructions

**END OF SECTION 23 09 23 23 09 23.03**

**SECTION 23 11 23**  
**FACILITY NATURAL-GAS PIPING**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A Pipe, pipe fittings, valves, and connections for natural gas piping systems.

**1.02 REFERENCE STANDARDS**

- A ANSI Z21.18/CSA 6.3 - Gas Appliance Pressure Regulators; 2019.
- B ANSI Z21.80/CSA 6.22 - Line Pressure Regulators; 2019.
- C ASME BPVC-IX - Boiler and Pressure Vessel Code, Section IX - Qualification Standard for Welding, Brazing, and Fusing Procedures; Welders; Brazers; and Welding, Brazing, and Fusing Operators; 2023.
- D ASME B16.3 - Malleable Iron Threaded Fittings: Classes 150 and 300; 2021.
- E ASME B31.1 - Power Piping; 2022.
- F ASME B31.9 - Building Services Piping; 2020.
- G ASTM A53/A53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless; 2022.
- H ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products; 2017.
- I ASTM A234/A234M - Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service; 2023a.
- J MSS SP-78 - Gray Iron Plug Valves, Flanged and Threaded Ends; 2011.
- K MSS SP-110 - Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends; 2010, with Errata .

**1.03 SUBMITTALS**

- A Product Data: Provide data on pipe materials, pipe fittings, valves, and accessories. Provide manufacturers catalog information. Indicate valve data and ratings.
- B Welders' Certificates: Submit certification of welders' compliance with ASME BPVC-IX.
- C Shop Drawings: For non-penetrating rooftop supports, submit detailed layout developed for this project, with design calculations for loadings and spacings.

**1.04 QUALITY ASSURANCE**

- A Perform work in accordance with applicable codes.
- B Valves: Manufacturer's name and pressure rating marked on valve body.
- C Welding Materials and Procedures: Comply with ASME BPVC-IX and applicable state labor regulations.
- D Identify pipe with marking including size, ASTM material classification, and ASTM specification.

**1.05 DELIVERY, STORAGE, AND HANDLING**

- A Accept valves on site in shipping containers with labeling in place. Inspect for damage.
- B Provide temporary protective coating on cast iron and steel valves.
- C Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.
- D Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

**PART 2 PRODUCTS**

**2.01 NATURAL GAS PIPING, ABOVE GRADE**

- A Steel Pipe: ASTM A53/A53M, Grade B, Type F, Schedule 40 black.
  - 1. Fittings: ASME B16.3, malleable iron, or ASTM A234/A234M, wrought steel welding type.
  - 2. Joints: Threaded (2 inch and under only) or welded to ASME B31.1.

**2.02 FLANGES, UNIONS, AND COUPLINGS**

- A Unions for Pipe Sizes 2 Inches and Under:
  - 1. Ferrous pipe: Class 150 malleable iron threaded unions.
- B Flanges for Pipe Size Over 2 Inch:
  - 1. Ferrous Pipe: Class 150 forged steel slip-on flanges; preformed neoprene gaskets.
- C Dielectric Connections: Union with galvanized or plated steel threaded end, copper solder end, water impervious isolation barrier.

### **2.03 PIPE HANGERS AND SUPPORTS**

- A Provide hangers and supports that comply with MSS SP-58.
1. If type of hanger or support for a particular situation is not indicated, select appropriate type using MSS SP-58 recommendations.
  2. Pipe Hangers for Hot and Chilled Water 6" and smaller: Cooper B3100, Anvil Fig. 260, or equivalent.
  3. Hangers for Hot Pipe 8" and larger: Adjustable steel yoke, cast iron roll, double hanger. Cooper B3110, Anvil Fig. 181, or equivalent.
  4. Riser Clamps: Cooper B3373, Anvil Fig. 40, or equivalent.
  5. Beam Clamps: Cooper B3050, Anvil Fig. 134, or equivalent.
  6. Offset Clamps: Cooper B3148, Anvil Fig. 103, or equivalent.
  7. Ceiling Plate: Cooper B3199, Anvil Fig. 610, or equivalent.
  8. Wall Brackets: Cooper B3067, Anvil Fig. 199, or equivalent.
  9. Rod Ceiling Plate: Cooper, Anvil Fig. 610, or equivalent.
  10. Concrete Inserts: Cooper B2500, Anvil Fig. 95 or equivalent.
  11. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
  12. Rooftop Supports for Low-Slope Roofs: Steel pedestals with bases that rest on top of roofing membrane, not requiring any attachment to the roof structure and not penetrating the roofing assembly, with support fixtures as specified; and as follows:
    - a. Bases: High density polypropylene.
    - b. Base Sizes: As required to distribute load sufficiently to prevent indentation of roofing assembly.
    - c. Steel Components: Stainless steel, or carbon steel hot-dip galvanized after fabrication in accordance with ASTM A123/A123M.
    - d. Attachment/Support Fixtures: As recommended by manufacturer, same type as indicated for equivalent indoor hangers and supports; corrosion resistant material.
    - e. Height: Provide minimum clearance of 6 inches under pipe to top of roofing.
    - f. Manufacturers:
      - 1) PHP Systems/Design
      - 2) Caddy
      - 3) Miro

### **2.04 BALL VALVES**

- A Manufacturers:
1. Conbraco Industries, Inc
  2. Grinnell Products, a Tyco Business
  3. Milwaukee Valve Company
  4. Nibco, Inc
  5. Apollo
- B Construction, 4 Inches and Smaller: MSS SP-110, Class 150, 400 psi CWP, bronze or ductile iron body, 304 stainless steel ball, regular port, Teflon seats and stuffing box ring, blow-out proof stem, lever handle with balancing stops, threaded or grooved ends with union.

### **2.05 PLUG VALVES**

- A Construction 2-1/2 Inches and Larger: MSS SP-78, 175 psi CWP, cast iron body and plug, pressure lubricated, Teflon or Buna N packing, flanged or grooved ends. Provide lever operator with set screw.

### **2.06 STRAINERS**

- A Manufacturers:
1. Armstrong International, Inc
  2. Green Country Filter Manufacturing
  3. WEAMCO
  4. Or Approved Equal
- B Size 2 inch and Under:
1. Threaded brass body for 175 psi CWP, Y pattern with 1/32 inch stainless steel perforated screen.



2. Class 150, threaded bronze body 300 psi CWP, Y pattern with 1/32 inch stainless steel perforated screen.

C Size 1-1/2 inch to 4 inch:

1. Class 125, flanged iron body, Y pattern with 1/16 inch stainless steel perforated screen.

**2.07 LINE PRESSURE REGULATORS AND APPLIANCE REGULATORS INDICATORS**

A Manufacturers:

1. Actaris Metering Systems (A brand of ITT Controls)
2. Dungs Combustion Controls
3. Maxitrol Company
4. Pietro Fiorentini
5. Or Approved Equal

B Compliance Requirements:

1. Appliance Regulator: ANSI Z21.18/CSA 6.3.
2. Line Pressure Regulator: ANSI Z21.80/CSA 6.22.

C Materials in Contact With Gas:

1. Housing: Aluminum, steel (free of non-ferrous metals).
2. Seals and Diaphragms: NBR-based rubber.

D Maximum Inlet Operating Pressure: 10 psi.

1. Appliance Regulator: 10 psi.
2. Line Pressure Regulator: 10 psi.

E Maximum Body Pressure: 10 psi.

F Output Pressure Range: 1 inch wc to 80 inch wc.

**PART 3 EXECUTION**

**3.01 PREPARATION**

- A Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
- B Remove scale and dirt, on inside and outside, before assembly.
- C Prepare piping connections to equipment with flanges or unions.

**3.02 INSTALLATION**

- A Install in accordance with manufacturer's instructions.
- B Provide non-conducting dielectric connections wherever jointing dissimilar metals.
- C Route piping in orderly manner and maintain gradient. Route parallel and perpendicular to walls.
- D Install piping to maintain headroom, conserve space, and not interfere with use of space.
- E Group piping whenever practical at common elevations.
- F Provide clearance in hangers and from structure and other equipment for installation of insulation and access to valves and fittings.
- G Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welding.
- H Install valves with stems upright or horizontal, not inverted.
- I Pipe vents from gas pressure reducing valves to outdoors and terminate in weather proof hood.
- J Sleeve pipes passing through partitions, walls and floors.
- K Inserts:
  1. Where concrete slabs form finished ceiling, locate inserts flush with slab surface.
  2. Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut above slab.
- L Pipe Hangers and Supports:
  1. Install in accordance with ASME B31.9.
  2. Place hangers within 12 inches of each horizontal elbow.
  3. Prime coat exposed steel hangers and supports. Hangers and supports located in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.

**3.03 TESTING**

- A All gas piping systems shall be tested in strict accordance with the National Fire Protection Association's National Fuel Gas Code NFPA54, and the State Building Code.
- B All gas piping system shall be air tested at 50 psi for a period of not less than four (4) hours without loss of pressure. Any leaks that occur shall be repaired and another test started. All joints shall be checked for leaks with a water-soap solution. Where leaks are found, the joint shall be re-made. The piping shall then be put back under pressure and shall hold for four (4) straight hours.

**3.04 APPLICATION**

- A Install unions downstream of valves and at equipment or apparatus connections.
- B Install brass male adapters each side of valves in copper piped system. Solder adapters to pipe.
- C Install ball valves for shut-off and to isolate equipment, part of systems, or vertical risers.

**3.05 SCHEDULES**

- A Pipe Hanger Spacing:
  - 1. Metal Piping:
    - a. Pipe Size: 1/2 inches to 1-1/4 inches:
      - 1) Maximum Hanger Spacing: 6.5 ft.
      - 2) Hanger Rod Diameter: 3/8 inches.
    - b. Pipe Size: 1-1/2 inches to 2 inches:
      - 1) Maximum Hanger Spacing: 10 ft.
      - 2) Hanger Rod Diameter: 3/8 inch.
    - c. Pipe Size: 2-1/2 inches to 3 inches:
      - 1) Maximum Hanger Spacing: 10 ft.
      - 2) Hanger Rod Diameter: 1/2 inch.
    - d. Pipe Size: 4 inches to 6 inches:
      - 1) Maximum Hanger Spacing: 10 ft.

**END OF SECTION 23 11 23**

**SECTION 23 23 00**  
**REFRIGERANT PIPING**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A Piping.
- B Moisture and liquid indicators.
- C Valves.
- D Strainers.
- E Filter-driers.
- F Flexible connections.
- G Exterior penetration accessories.

**1.02 REFERENCE STANDARDS**

- A ASHRAE Std 15 - Safety Standard for Refrigeration Systems; 2022, with Addendum (2024).
- B ASME BPVC-IX - Boiler and Pressure Vessel Code, Section IX - Qualification Standard for Welding, Brazing, and Fusing Procedures; Welders; Brazers; and Welding, Brazing, and Fusing Operators; 2023.
- C ASME B16.22 - Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings; 2021.
- D ASME B31.5 - Refrigeration Piping and Heat Transfer Components; 2022.
- E ASME B31.9 - Building Services Piping; 2020.
- F ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products; 2017.
- G AWS A5.8M/A5.8 - Specification for Filler Metals for Brazing and Braze Welding; 2019.
- H MSS SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation; 2018, with Amendment (2019).

**1.03 SUBMITTALS**

- A Product Data: Provide general assembly of specialties, including manufacturer's catalogue information. Provide manufacturer's catalog data including load capacity.
- B Shop Drawings: Indicate schematic layout of system, including equipment, critical dimensions, and sizes.
- C Design Data: Submit design data indicating pipe sizing. Indicate load-carrying capacity of trapeze, multiple pipe, and riser support hangers.

**1.04 DELIVERY, STORAGE, AND HANDLING**

- A Deliver and store piping and specialties in shipping containers with labeling in place.
- B Protect piping and specialties from entry of contaminating material by leaving end caps and plugs in place until installation.
- C Dehydrate and charge components such as piping and receivers, seal prior to shipment, until connected into system.

**PART 2 PRODUCTS**

**2.01 SYSTEM DESCRIPTION**

- A Filter-Driers:
  - 1. Use a filter-drier immediately ahead of liquid-line controls, such as thermostatic expansion valves, solenoid valves, and moisture indicators.

**2.02 REGULATORY REQUIREMENTS**

- A Comply with ASME B31.9 for installation of piping system.
- B Welding Materials and Procedures: Comply with ASME BPVC-IX and applicable state labor regulations.
- C Products Requiring Electrical Connection: Listed and classified by UL, as suitable for the purpose indicated.

**2.03 REFRIGERANT PIPING**

- A Copper Tube: ASTM B280, H58 hard drawn only. Soft annealed copper tube will not be accepted.
  - 1. Fittings: ASME B16.22 wrought copper.
  - 2. Joints: Braze, AWS A5.8M/A5.8 BCuP silver/phosphorus/copper alloy.

**2.04 CONDENSATE PIPING AND EQUIPMENT DRAINS**

- A Copper Tube: ASTM B88 (ASTM B88M), Type L (B), drawn; using one of the following joint types:

1. Solder Joints: ASME B16.18 cast brass/bronze or ASME B16.22 solder wrought copper fittings; ASTM B32 lead-free solder, HB alloy (95-5 tin-antimony) or tin and silver.

**2.05 PIPE SUPPORTS AND ANCHORS:**

- A Provide hangers and supports that comply with MSS SP-58.
- B Pipe Hangers for pipe 6" and smaller: Cooper B3100, Anvil Fig. 260, or equivalent.
- C Riser Clamps: Cooper B3373, Anvil Fig. 40, or equivalent.
- D Beam Clamps: Cooper B3050, Anvil Fig. 134, or equivalent.
- E Offset Clamps: Cooper B3148, Anvil Fig. 103, or equivalent
- F Ceiling Plate: Cooper B3199, Anvil Fig. 610, or equivalent
- G Wall Brackets: Cooper B3067, Anvil Fig. 199, or equivalent.
- H Rod Ceiling Plate: Cooper, Anvil Fig. 610, or equivalent.
- I Concrete Inserts: Cooper B2500, Anvil Fig. 95 or equivalent.
- J Copper Pipe Support: Carbon steel ring, adjustable, copper plated.
- K Hanger Rods: Mild steel threaded both ends, threaded one end, or continuous threaded.
- L Rooftop Supports for Low-Slope Roofs: Steel pedestals with bases that rest on top of roofing membrane, not requiring any attachment to the roof structure and not penetrating the roofing assembly, with support fixtures as specified; and as follows:
  1. Bases: High density, UV tolerant, polypropylene or reinforced PVC.
  2. Base Sizes: As required to distribute load sufficiently to prevent indentation of roofing assembly.
  3. Steel Components: Stainless steel, or carbon steel hot-dip galvanized after fabrication in accordance with ASTM A123/A123M.
  4. Attachment/Support Fixtures: As recommended by manufacturer, same type as indicated for equivalent indoor hangers and supports; corrosion resistant material.
  5. Height: Provide minimum clearance of 6 inches under pipe to top of roofing.
  6. Manufacturers:
    - a. PHP Systems/Design
    - b. Miro
    - c. Caddy
    - d. Bigfoot Systems

**2.06 MOISTURE AND LIQUID INDICATORS**

- A Manufacturers:
  1. Henry Technologies
  2. Parker Hannifin/Refrigeration and Air Conditioning
  3. Sporlan, a Division of Parker Hannifin
  4. Or Approved Equal
- B Indicators: Single port type, UL listed, with copper or brass body, flared or soldered ends, sight glass, color coded paper moisture indicator with removable element cartridge and plastic cap; for maximum temperature of 200 degrees F and maximum working pressure of 500 psi.

**2.07 VALVES**

- A Manufacturers:
  1. Hansen Technologies Corporation
  2. Henry Technologies
  3. Flomatic Valves
  4. Or Approved Equal
- B Diaphragm Packless Valves:
  1. UL listed, globe or angle pattern, forged brass body and bonnet, phosphor bronze and stainless steel diaphragms, rising stem and handwheel, stainless steel spring, nylon seat disc, soldered or flared ends, with positive backseating; for maximum working pressure of 500 psi and maximum temperature of 275 degrees F.
- C Packed Angle Valves:

1. Forged brass or nickel plated forged steel, forged brass seal caps with copper gasket, rising stem and seat with backseating, molded stem packing, soldered or flared ends; for maximum working pressure of 500 psi and maximum temperature of 275 degrees F.
- D Ball Valves:
  1. Two piece bolted forged brass body with teflon ball seals and copper tube extensions, brass bonnet and seal cap, chrome plated ball, stem with neoprene ring stem seals; for maximum working pressure of 500 psi and maximum temperature of 300 degrees F.
- E Service Valves:
  1. Forged brass body with copper stubs, brass caps, removable valve core, integral ball check valve, flared or soldered ends, for maximum pressure of 500 psi.

**2.08 STRAINERS**

- A Manufacturers:
  1. Hansen Technologies Corporation
  2. Parker Hannifin/Refrigeration and Air Conditioning
  3. Sporlan, a Division of Parker Hannifin
- B Straight Line or Angle Line Type:
  1. Brass or steel shell, steel cap and flange, and replaceable cartridge, with screen of stainless steel wire or monel reinforced with brass; for maximum working pressure of 430 psi.

**2.09 FILTER-DRIERS**

- A Manufacturers:
  1. Alco
  2. Cash
  3. Flow Controls Division of Emerson Electric
  4. Henry
  5. Parker Hannifin/Refrigeration and Air Conditioning
  6. Sporlan, a Division of Parker Hannifin
  7. Or Approved Equal
- B Cores: Molded or loose-fill molecular sieve desiccant compatible with refrigerant, activated alumina, activated charcoal, and filtration to 40 microns, with secondary filtration to 20 microns; of construction that will not pass into refrigerant lines.
- C Construction: UL listed.
  1. Sealed Type: Copper shell.
  2. Connections: Soldered.

**2.10 FLEXIBLE CONNECTORS**

- A Manufacturers:
  1. Circuit Hydraulics, Ltd
  2. Flexicraft Industries
  3. Penflex
  4. Or Approved Equal
- B Corrugated stainless steel hose with single layer of stainless steel exterior braiding, minimum 9 inches long with copper tube ends; for maximum working pressure of 640 psi.

**2.11 EXPANSION LOOPS**

- A Flexible hose expansion loops shall be manufactured complete with two parallel sections of corrugated metal house, compatible braid, 180° return bend, with inlet and outlet connections. Field fabricated loops shall not be acceptable.
- B Flexible hose expansion loops shall impart no thrust loads to system support, anchors or building structure.
- C Flexible hose expansion loops to be "VRF Metraloop" as manufactured by The Metraflex Company
- D Corrugated Hose shall be Type 321 stainless Steel
- E Braid shall be double layer of type 304 Stainless Steel
- F Fittings shall be Sch 40 S Type 304 Stainless in accordance with ASTM A240

- G Copper pipe systems, the VRF Metraloop shall be equipped with a stainless-steel to copper conversion fitting with XHP copper stub ends.
- H Flexible hose expansion loops shall have a factory supplied; hanger / support lug located at the bottom of the 180° return.
- I Rated for 700 PSI @ 300°F

**2.12 EXTERIOR PENETRATION ACCESSORIES**

- A Flashing Panels for Exterior Wall Penetrations: Premanufactured components and accessories as required to preserve integrity of building envelope; suitable for conduits and facade materials to be installed.
- B Sealing Systems for Roof Penetrations: Premanufactured components and accessories as required to preserve integrity of roofing system and maintain roof warranty; suitable for conduits and roofing system to be installed; designed to accommodate existing penetrations where applicable.

**PART 3 EXECUTION**

**3.01 PREPARATION**

- A Ream pipe and tube ends. Remove burrs. Bevel plain-end ferrous pipe.
- B Remove scale and dirt on inside and outside before assembly.
- C Prepare piping connections to equipment with flanges or unions.

**3.02 INSTALLATION**

- A Install refrigeration specialties in accordance with manufacturer's instructions.
- B Space refrigerant piping far enough apart to allow for field installed insulation of thickness specified.
- C The installation of piping and related items shall be made neatly and in such a manner as not to interfere with access to valves or equipment. Expansion, drainage and maintenance of installed piping shall be possible.
- D Route piping in orderly manner, with plumbing parallel to building structure, and maintain gradient.
- E Install piping to conserve building space and avoid interference with use of space.
- F Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
- G Sleeves shall be provided wherever pipes pass through walls, floors and ceilings. Sleeves shall be Schedule 40, black steel, one-half inch in diameter larger than the pipe or insulation on the pipe. Sleeves through walls and ceilings shall be flush. Sleeves through floors shall extend one inch above finished floor. Sleeves through exterior walls shall be caulked and made watertight.
- H Pipe Hangers and Supports:
  - 1. Install in accordance with ASME B31.5.
  - 2. Support horizontal piping as indicated.
  - 3. Place hangers within 12 inches of each horizontal elbow.
  - 4. Provide copper plated hangers and supports for copper piping.
- I Arrange piping to return oil to compressor. Provide traps and loops in piping, and provide double risers as required. Slope horizontal piping 0.40 percent in direction of flow.
- J Provide clearance for installation of insulation and access to valves and fittings.
- K Flood piping system with nitrogen when brazing.
- L Follow ASHRAE Std 15 procedures for charging and purging of systems and for disposal of refrigerant.
- M Fully charge completed system with refrigerant after testing.

**3.03 FIELD QUALITY CONTROL**

- A Test refrigeration system in accordance with ASME B31.5.
- B All refrigerant equipment not tested at the factory shall be shut off from the rest of the system and tested under a vacuum with no evidence of leakage. Piping systems shall be tested after installation, and before any insulation is applied. All controls and other apparatus that may be damaged by the test pressure shall be removed before tests are made.
- C Refrigerant piping leak testing shall be as follows, unless equipment manufacturer mandates or recommends or more stringent procedure:
  - 1. Connect the refrigerant manifold gauge hoses to the liquid side and gas side service ports on the equipment and connect the center hose to a nitrogen tank fitted with a pressure regulator.
  - 2. Fill the lines with nitrogen to 590 psi but no more than 595 psi.

3. Monitor the pressure periodically for a minimum of 24 hours. If the pressure drops, use soapy water to check for leaks. Bubbles will occur if joints are not tight.
  4. Repair leaks. Repeat the previous steps until the pressure remains constant for 24 hours.
  5. Maintain 145 psi of pressure for 15 minutes and check for further leakage. If the pressure drops, check for leaks and repair. Repeat this step until 145 psi of pressure is maintained for 15 minutes.
  6. Remove hoses from service ports.
- D Evacuation Procedure. After performing leak test, use a vacuum pump to triple evacuate the system as described below:
1. Use a vacuum pump with a check valve to prevent pump oil from flowing backward while the vacuum pump is closed. Completely close the liquid-vapor line service valves of the outdoor unit.
  2. Using vacuum-rated hoses, connect the manifold gauges to the liquid and suction (and high pressure, if applicable) gas pipes.
  3. Evacuate the system to 750 microns, hold for 5 minutes, and check for leaks. Repair and repeat as necessary until vacuum holds.
  4. Break the vacuum by applying 10 psi of nitrogen.
  5. Evacuate the system to 500 microns, hold for 5 minutes, and check for leaks. Repair and repeat as necessary until vacuum holds.
  6. Break the vacuum by applying 10 psi of nitrogen.
  7. Evacuate the system to 200 microns. Wait for 15 minutes. A rise of no more than 200 microns is acceptable. If over 400 microns, check for leaks, repair, and repeat.
  8. If under 400 microns, continue holding vacuum for 2.5 hours. If vacuum exceeds 400 microns at end of period, check for leaks, repair, and repeat.
  9. If system holds under 400 microns for 2.5 hours, system is ready for charging.

### **3.04 SCHEDULES**

- A Hanger Spacing for Copper Tubing.
1. 1/2 inch, 5/8 inch, and 7/8 inch OD: Maximum span, 5 feet; minimum rod size, 1/4 inch.
  2. 1-1/8 inch OD: Maximum span, 6 feet; minimum rod size, 1/4 inch.
  3. 1-3/8 inch OD: Maximum span, 7 feet; minimum rod size, 3/8 inch.
  4. 1-5/8 inch OD: Maximum span, 8 feet; minimum rod size, 3/8 inch.
  5. 2-1/8 inch OD: Maximum span, 8 feet; minimum rod size, 3/8 inch.

**END OF SECTION 23 23 00**

**SECTION 23 31 00**  
**HVAC DUCTS AND CASINGS**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A Metal ducts.
- B Flexible ducts.
- C Ducts for kitchen exhaust applications.

**1.02 REFERENCE STANDARDS**

- A ASHRAE (FUND) - ASHRAE Handbook - Fundamentals; Most Recent Edition Cited by Referring Code or Reference Standard.
- B ASTM A36/A36M - Standard Specification for Carbon Structural Steel; 2019.
- C ASTM A653/A653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process; 2023.
- D ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2018b.
- E ASTM E814 - Standard Test Method for Fire Tests of Penetration Firestop Systems; 2023a.
- F ASTM E2336 - Standard Test Methods for Fire Resistive Grease Duct Enclosure Systems; 2020.
- G NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems; 2021.
- H NFPA 96 - Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations; 2024.
- I SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible; 2020.
- J SMACNA (KVS) - Kitchen Ventilation Systems and Food Service Equipment Fabrication and Installation Guidelines; 2001.
- K SMACNA (LEAK) - HVAC Air Duct Leakage Test Manual; 2012.
- L UL 181 - Standard for Factory-Made Air Ducts and Air Connectors; current edition, including all revisions.
- M UL 1479 - Standard for Fire Tests of Penetration Firestops; Current Edition, Including All Revisions.
- N UL 1978 - Grease Ducts; Current Edition, Including All Revisions.
- O UL 2221 - Tests of Fire Resistive Grease Duct Enclosure Assemblies; Current Edition, Including All Revisions.

**1.03 SUBMITTALS**

- A Product Data: Provide data for duct materials and duct connections.
- B Shop Drawings: Indicate duct fittings, particulars such as gages, sizes, welds, and configuration prior to start of work for all systems.
  - 1. Clearly indicate which fittings shall be used on the project: elbows, wyes, takeoffs, transitions, offsets, etc.
- C Test Reports: Indicate pressure tests performed. Include date, section tested, test pressure, and leakage rate per appropriate seal class, following SMACNA (LEAK).

**1.04 QUALITY ASSURANCE**

- A Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience, and approved by manufacturer.
- B Galvanizing thickness and country of origin must be clearly stenciled on each duct section. At the discretion of the Engineer, sheet metal gauges and reinforcing may be randomly checked to verify all duct construction is in compliance.
- C Ductwork and fittings must have a computer generated label affixed to each section detailing the duct dimensions, sheet metal gauge, intermediate and joint reinforcement size, and the transverse connector brand and classification.

**1.05 FIELD CONDITIONS**

- A Do not install duct sealants when temperatures are less than those recommended by sealant manufacturers.
- B Maintain temperatures within acceptable range during and after installation of duct sealants.
- C If ductwork is stored on site, elevate duct above floors and maintain protection on ends.



**PART 2 PRODUCTS**

**2.01 GENERAL REQUIREMENTS**

- A Provide ductwork, fittings, hangers, supports, and appurtenances in accordance with NFPA 90A and SMACNA (DCS) guidelines unless stated otherwise.
- B Duct Sealing and Leakage in accordance with Static Pressure Class:
  - 1. Low Pressure Service: Up to 2 in-wc:
    - a. Seal: Class C, apply to seal off transverse joints.
    - b. Leakage:
      - 1) Rectangular: Class 16
      - 2) Round: Class 8
- C Duct Fabrication Requirements:
  - 1. Duct and Fitting Fabrication and Support: SMACNA (DCS) including specifics for continuously welded round and oval duct fittings.
  - 2. Use reinforced and sealed sheet-metal materials at recommended gauges for indicated operating pressures or pressure class.
  - 3. Construct tees, bends, and elbows with radius of not less than 1-1/2 times width of duct on centerline. Where not possible and where rectangular elbows must be used, provide airfoil turning vanes of perforated metal with glass fiber insulation.
  - 4. Provide turning vanes of perforated metal with glass fiber insulation when acoustical lining is indicated.
  - 5. Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible; maximum 30 degrees divergence upstream of equipment and 45 degrees convergence downstream.
  - 6. Provide turning vanes of perforated metal with glass fiber insulation when an acoustical lining is required.
  - 7. Where ducts are connected to exterior wall louvers and duct outlet is smaller than louver frame, provide blank-out panels sealing louver area around duct. Use same material as duct, painted black on exterior side; seal to louver frame and duct.
- D Duct transverse joints and reinforcement materials, including angle ring flanges and stiffeners, shall be of the same material as the duct.
- E Low Pressure Supply: 2 inch w.g. pressure class, galvanized steel.
- F Return and Relief: -2 inch w.g. pressure class, galvanized steel.
- G General Exhaust: -2 inch w.g. pressure class, galvanized steel.
- H Grease Exhaust: -6 inch w.g. pressure class, stainless steel.
- I Outside Air Intake: -2 inch w.g. pressure class, galvanized steel.
- J Combustion Air: 1 inch w.g. pressure class, galvanized steel.
- K Transfer Air and Sound Boots: 1 inch w.g. pressure class.

**2.02 MATERIALS**

- A Galvanized Steel for Ducts: Hot-dipped galvanized steel sheet, ASTM A653/A653M FS Type B, with G90/Z275 coating.
- B "Paint Grip" Finish or Mill Phosphatized Steel (Exposed Ductwork):
  - 1. Galvanized G90 steel shall be put through a phosphate bath and have a layer of Chromate applied and dried leaving it ready to accept paint. This shall be done at the mill. The process produces a dull gray colored finish.
- C Joint Sealers and Sealants: Non-hardening, water resistant, mildew and mold resistant.
  - 1. Manufacturers:
    - a. Childers
    - b. Ductmate
    - c. Durodyne
    - d. Foster
    - e. Hardcast
    - f. McGill Airseal

- g. Sheet Metal Connectors, Inc.
- h. Or Approved Equal
- 2. Flexible, water-based, adhesive sealant designed for use in all pressure duct systems. After curing, it shall be resistant to ultraviolet light and shall prevent the entry of water, air, and moisture into the duct system. Sealer shall be UL 723 and UL 181B-M listed and meet NFPA requirements for Class 1 ductwork. VOC shall be <75 g/l.
- 3. Neoprene gasket must be closed cell rubber based sealing tape and must pass UL 94 HF-1.
- 4. Butyl rubber gasket which complies with UL 723, Mil-C 18969B and TTS-S-001657. This material, in addition to the above, shall not contain vegetable oils, fish oils, or any other type vehicle that will support fungal and/or bacterial growth.
- 5. Surface Burning Characteristics: Flame spread index of zero and smoke developed index of zero, when tested in accordance with ASTM E84.
- D Hanger Rod: ASTM A36/A36M; steel, galvanized; threaded both ends, threaded one end, or continuously threaded.
- E Cable Suspension System:
  - 1. Suspension system shall be Gripple Hang-Fast as manufactured and supplied by Gripple, Inc., or Ductmate "Clutcher" cable hanging system.
  - 2. Suspension system shall be load rated and verified by SMACNA Testing and Research Institute to be in compliance with SMACNA Standards.
  - 3. All suspension systems shall used galvanized hardware.

### **2.03 DUCTWORK FABRICATION**

- A Fabricate and support in accordance with SMACNA (DCS) and as indicated.
  - 1. Internal tie rods or bracing are not allowed for ductwork 36" and below. Tie rods shall be 1/2", 3/4", 1", 1-1/4" or 1-1/2" galvanized rods with bolt assembly consisting of rubber washer and friction anchored threaded insert similar to Ductmate Easyrod or PPI Condu-Lock.
  - 2. Internal tie rods are not allowed for ductwork in chase and other non-accessible locations.
- B Where the size for a duct segment is not indicated, the duct segment size shall be equal to the largest duct segment to which it is connected. Transition to smaller size shall occur on the side of the fitting where smaller size is indicated.
- C No variation of duct configuration or size permitted except by written permission. Size round duct installed in place of rectangular ducts in accordance with ASHRAE (FUND) Handbook - Fundamentals.
- D Construct T's, bends, and elbows with radius of not less than 1-1/2 times width of duct on centerline. Where not possible and where rectangular elbows must be used, provide air foil turning vanes of perforated metal with glass fiber insulation.
- E Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible; maximum 30 degrees divergence upstream of equipment and 45 degrees convergence downstream.
- F Fabricate continuously welded round and oval duct fittings in accordance with SMACNA (DCS).
- G Where ducts are connected to exterior wall louvers and duct outlet is smaller than louver frame, provide blank-out panels sealing louver area around duct. Use same material as duct, painted black on exterior side; seal to louver frame and duct.

### **2.04 HANGERS AND SUPPORTS**

- A Refer to the Structural Drawngs and Details for the limitations and applications of each type of hanger and weight when attaching to bar joists, trusses, or other building Structural elements. The Contractor shall be responsible for providing additional miscellaenous steel, unistrut, and other components to span multiple joists as required by the Structural Drawings to distribute concentrated loads.
- B Unless otherwise indicated, use straps or Z bar hangers with 3/8" rods to support rectangular ducts 48" wide and smaller and trapeze hangers with rods or angles to support rectangular ducts over 48" wide.
  - 1. Use trapeze hangers to support externally insulated ductwork with weight bearing inserts.
- C For round ducts 24" diameter or smaller, use single hanger.
  - 1. Cable Suspension System may be used up to 16" diameter
  - 2. Round Duct Strap Bracket by Ductmate Industries may be used up to 24" diameter.

- D For round ducts over 24" diameter, use 2 hangers with half round trapeze.
- E For round ducts over 25" diameter or larger, use 2 minimum 3/8" rods with trapeze.
- F The following upper attachments, upper attachment devices, lower hanger attachments, hanger devices, and/or hanger attachments are not allowed except where specifically indicated:
  - 1. Hook or loop.
  - 2. Nailed pin fasteners.
  - 3. Expansion nails without washers.
  - 4. Powder charged or mechanically driven fasteners (forced entry anchors).
  - 5. Beam or "C" clamps without retaining clips or friction clamps (provide retaining clips
  - 6. for "C" clamps).
  - 7. Friction clamps for ductwork over 12".
  - 8. Non-factory manufactured upper attachments for metal pan deck including wire coil and double circle (Items 16 and 17 of Fig 4-3 of SMACNA HVAC Duct Construction Standards 95).
  - 9. Wire hanger.
  - 10. Trapeze hangers supported by wires or straps.
  - 11. Rods, straps or welded studs directly attached to metal deck.
  - 12. Drilled hole with attachment to structural steel.
  - 13. Lag screw expansion anchor.
  - 14. Rivets.
- G Supporting devices shall be standard products of manufacturers having published load ratings.
- H Unless drawings indicate the required framing, provide angle iron framing around roof opening where duct penetrates through roof decking, to maintain roof decking structural integrity in accordance with roof decking manufacturer's recommendations. This is not required for concrete decking. For concrete decking, consult with Structural Engineer for location and size of opening prior to execution of Work.
- I For welded ducts, soldered ducts or ducts with water tight joints, do not use supports utilizing screws or other penetrations into ductwork.
- J All hangers and supports shall be fully galvanized.

**2.05 METAL DUCTS**

- A Material Requirements:
  - 1. Galvanized Steel: Hot-dipped galvanized steel sheet, ASTM A653/A653M FS Type B, with G90/Z275 coating.
- B Double Wall Insulated Round Ducts: Round spiral lockseam duct with "paint grip" finish steel outer wall, perforated galvanized steel inner wall; fitting with solid inner wall.
  - 1. Manufacture in accordance with SMACNA (DCS).
  - 2. Insulation:
    - a. Thickness: 1 inch.
    - b. Material: Fiberglass or elastomeric foam.
    - c. Finish: "Paint grip" mill phosphatized
  - 3. Manufacturers:
    - a. MKT Metal Manufacturing
    - b. Hamlin
    - c. SMC
    - d. McGill Airflow
    - e. Or Approved Equal
- C Double Wall Insulated Rectangular Ducts: Rectangular spiral lockseam duct with "paint grip" fini steel outer wall, perforated galvanized steel inner wall; fitting with solid inner wall.
  - 1. Manufacture in accordance with SMACNA (DCS).
  - 2. Insulation:
    - a. Thickness: 1 inch.
    - b. Material: Fiberglass or elastomeric foam.
    - c. Finish: "Paint grip" mill phosphatized

- D Spiral Ducts: Round spiral lockseam duct with galvanized steel outer wall. "Paint grip" finish if exposed to view.
  - 1. Manufacture in accordance with SMACNA (DCS).
  - 2. Manufacturers:
    - a. EHG, a DMI Company
    - b. GSI, a DMI Company
    - c. Linx Industries, Inc, a DMI Company
    - d. MKT Metal Manufacturing
    - e. Or Approved Equal

**2.06 FLEXIBLE DUCTS**

- A Flexible Air Ducts:
  - 1. UL 181, Class 0, interlocking spiral of aluminum foil.
  - 2. Insulation: Fiberglass insulation with aluminized vapor barrier film.
  - 3. Pressure Rating: 8 in-wc positive or negative.
  - 4. Maximum Velocity: 5,000 fpm.
  - 5. Temperature Range: Minus 20 to 250 degrees F.

**2.07 LONGITUDINAL SEAM:**

- A Rectangular Duct:
  - 1. Unless otherwise indicated, use Pittsburgh lock seam construction.
  - 2. Seal longitudinal seams with approved sealant or provide pre-sealed from factory with encapsulated mastic.
  - 3. Button punch snap lock construction (SMACNA L-2) is not allowed except for ductwork that is both low pressure (2" WG or lower pressure class) and 18" and smaller duct width.
  - 4. Button punch snap lock construction is not allowed for ductwork in chases and areas above inaccessible ceilings.
  - 5. Button punch snaplock construction is not allowed on exhaust ductwork or aluminum ductwork
- B Round and Oval Duct
  - 1. Unless otherwise indicated, longitudinal seams shall be in accordance with SMACNA HVAC Duct Construction Standards with the following exceptions:
    - a. Snaplock seams are not allowed.
    - b. SMACNA seam types RL-3, 6A, 6B, 7, and 8 shown in Figure 3-2 are not allowed, except for 2" w.g. class round ducts 16" or less in diameter.

**2.08 RECTANGULAR TRANSVERSE JOINT CONNECTORS:**

- A Slide-on Transverse Joint Connectors:
  - 1. Duct constructed using engineered slide-on connector systems must be submitted and conform to manufacturer's published duct construction standards and guidelines for joint classification, sheet metal gauge, intermediate and joint reinforcement size and spacing, unless otherwise specified.
  - 2. Manufacturer of engineered connector system must have certified independent performance testing for leakage, deflection and seismic stability.
  - 3. All components of the engineered system must be clearly embossed with the manufacturer's name, model number or identifying marking.
  - 4. Butyl rubber gasket must be applied per the manufacturer's instructions on all connections except for breakaway connections. Closed Cell Neoprene gasket must be applied per the manufacturer's instructions on all breakaway connections. No substitution of connector system components or gaskets is permitted.
  - 5. All duct installed using engineered connectors must adhere to the manufacturer's published assembly and installation guidelines for all standard, breakaway, roof-top or specialty connections unless otherwise specified.
- B Formed-on Flanges:
  - 1. Lockformers TDC or Engles TDF may be used in accordance with T-25 flanges of SMACNA HVAC Duct Construction Standards, provided that corner pieces with bolts are used. If TDF/TDC flanges are

damaged, replace the damaged joint(s) by straightening and reinforcing with minimum 1-1/2 x 1-1/2 x 1/4 angle at each side of transverse joint

## **2.09 DUCTS FOR KITCHEN EXHAUST APPLICATIONS**

- A Provide ductwork, fittings, and appurtenances per NFPA 96, SMACNA (KVS), UL 1978, and UL 2221 requirements and guidelines.
- B Class 1 duct for air with gas and grease particle exhaust at an air velocity of 1,500 to 2,500 fpm.
- C Where ducts are not self-draining back to equipment, provide low-point drain pocket with the copper drain pipe to a sanitary sewer.
- D Design, fabricate, and install liquidtight preventing exhaust leakage into building.
- E Dishwasher Exhaust Duct:
  - 1. Duct Size: 2 in-wc pressure class stainless steel.
  - 2. Fabricate using single wall, 16-gauge, 0.059-inch sheet steel with continuous external welded joints to form rectangular sections.
  - 3. Seal joints during installation with factory-supplied overlapping V-bands and sealant.
  - 4. Manufacturers:
    - a. AMPCO by Hart & Cooley, Inc; Model N
    - b. Selkirk Corporation; Model G:
- F Kitchen Hood and Grease Exhaust Duct:
  - 1. Fabricate in accordance with ductwork manufacturer's instructions, SMACNA (DCS), SMACNA (KVS), and NFPA 96.
  - 2. Zero Clearance, 2-Hour Fire-Rated, Round, Double-Wall, Premanufactured Grease Duct:
    - a. UL Listed and labeled to UL 1978 and UL 2221.
    - b. Nominal 3 inches thick, high density body soluble fiber insulation between 20-gauge, 0.035-inch Type 304 stainless steel liner, and 24-gauge, 0.0239-inch aluminized steel sheet outer jacket.
    - c. Seal joints during installation with factory-supplied overlapping V-bands and sealant.
    - d. Through-penetration firestop listed to UL 1479 or ASTM E814.
    - e. Minimum horizontal slope of 1/16 inch per foot per manufacturers listing to UL 1978.
  - 3. Zero Clearance, 2-Hour Fire-Rated, Rectangular, Double-Wall, Premanufactured Grease Duct:
    - a. Listed when tested in accordance with UL 1978 and ASTM E2336.
    - b. Construct of 18-gauge, 0.050-inch stainless steel using continuous external welded joints in rectangular sections.
    - c. Liquidtight with continuous external weld for seams and joints.
    - d. Where ducts are not self-draining back to equipment, provide low-point drain pocket with copper drain pipe to sanitary sewer.
    - e. Through-penetration firestop listed to UL 1479 or ASTM E814.
  - 4. Grease Exhaust Duct Access Doors:
    - a. Listed when tested in accordance with UL 1978.
    - b. Install hinged access doors where indicated or required for access for cleaning and inspection of duct.
    - c. Reinforce door frames with steel angles tied to horizontal and vertical plenum supporting angles.

## **PART 3 EXECUTION**

### **3.01 INSTALLATION**

- A Install, support, and seal ducts in accordance with SMACNA (DCS).
- B During construction, provide temporary closures of metal or taped polyethylene on open ductwork to prevent construction dust from entering the ductwork system.
- C Install ductwork parallel to building walls and ceilings and at such heights not to obstruct any portion of window, doorway, stairway, or passageway. Install ductwork to allow adequate access and service space for equipment and access clearances for cable tray/j-hooks. Refer to drawings and/or manufacturer's recommendations. Install vertical ductwork plumb. Make allowances for beams, pipes or other obstructions in building construction and for work of other contractors. Check plans showing work of other trades and consult with Engineer in event of any interference.

- D Where interferences develop in the field, offset or reroute ductwork as required to clear such interferences. Do not divide duct and do not route any other utilities such as piping or conduit through duct. In all cases, consult drawings for exact location of space allocated for duct, ceiling heights, door and window openings, or other architectural details before fabricating or installing duct. Consult Designer where conflicts arise between ductwork and other utilities which cannot be resolved by relocating duct.
- E Where offsets in ductwork are required, contractor to use standard 30, 45 or 90-degree elbows. Where space constraints do not allow for the use of standard elbows for offsets, use of angled offsets as depicted by SMACNA Figure 2-7 (Angled Offset Type 1) may be used with maximum angle of offset not to exceed 15 degrees maximum. Offsets Type 2 and 3 in SMACNA Figure 2-7 shall not be allowed.
- F Rectangular Duct Elbows:
  - 1. Rectangular Duct: Unless specific type is indicated, provide radius elbows with splitter vanes with minimum centerline radius to width or diameter ratio of 1.5
    - a. 1.5 radius elbows with full splitter vanes as follows:
      - 1) One vane for duct width 2-12"
      - 2) Two vanes for duct width 13-20"
      - 3) Three vanes for duct width 21"-36"
      - 4) Four vanes for duct width 38" and larger
      - 5) Fabricate vanes in accordance with SMACNA.
    - b. Rectangular throat elbows with turning vanes where 1.5 radius elbows do not fit.
    - c. Rectangular throat/radius heel elbows or rectangular elbows without turning vanes shall not be used.
- G Round and Oval Duct Elbows:
  - 1. Unless specific type is indicated, use radius elbows with centerline radius to diameter ratio of 1.5. ONLY where 1.5 radius elbows do not fit, 1.0 radius elbows may be used if approved by the Engineer.
- H Construct ductwork so that interior surfaces are smooth. Internal duct hangers and internal bracing are not allowed. Refer to above for internal tie rods.
- I Support coils, filters, air terminals, dampers, sound attenuating devices, or other devices installed in duct systems with angles or channels and make all connections to such equipment including equipment furnished by others. Secure frames with gaskets, nuts, bolts and washers.
- J Flexible ducts shall not exceed 5 feet in length. Bends, kinks, and sagging of flexible duct will not be accepted. The maximum permitted sag is 1/2" per foot of support spacing.
- K Install outside air intake duct to pitch down at minimum 1" per 20 ft toward intake louver or plenum and to drain to outside of building. Solder or seal seams to form watertight joints.
- L Install exhaust air duct to pitch down at minimum 1" per 20 ft toward exhaust louver.
- M Where 2 different metal ducts meet, install joint in such a manner that metal ducts do not contact each other by using proper gasket seal or compound.
- N Flexible Ducts: Connect to metal ducts with adhesive plus sheet metal screws.
  - 1. Flexible ducts are not allowed for special exhaust systems, such as laboratory exhaust, vehicle exhaust, etc.
  - 2. Splicing of flexible duct will not be allowed.
  - 3. Flexible ducts shall not pass through any partition, wall, floor, or ceiling.
- O Residential Clothes Dryer Exhaust Duct: Provide stenciled label. Label shall indicate the following:
  - 1. Equivalent length ----- feet. Any installed dryer must be equipped with an exhaust system that meets or exceeds this equivalent length requirement.
- P Kitchen Hood Exhaust: Provide residue traps at the base of vertical risers with provisions for the cleanout.
- Q For kitchen hood exhaust, provide a documented light test of all joints in the kitchen hood system per 506.3.2.5 of the NC Mechanical Code.
- R Where kitchen grease duct is not UL listed for 0 clearance to combustibles, wrap entire duct run with two layers of 3M Fire Barrier Duct Wrap 615+ or equivalent.
- S All ducts conveying hazardous or flammable vapors shall be labeled via stencilled painting or permanent nameplates. Labels shall be every 10 feet where above accessible ceilings or in mechanical rooms or on roof.

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- T Duct sizes indicated are precise inside dimensions. For lined ducts, maintain sizes inside lining.
- U Provide openings in ductwork as indicated to accommodate thermometers and controllers. Provide pilot tube openings as indicated for testing of systems, complete with metal can with spring device or screw to insure against air leakage. For openings, insulate ductwork and install insulation material inside a metal ring.
- V Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.
- W All exposed ductwork to be painted shall be mill bonderized or "paint grip." The contractor shall thoroughly clean all ductwork surfaces to be free from oils, grease, lubricants, and other contaminants prior to application of paint. Follow
- X 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.
- Y Use double nuts and lock washers on threaded rod supports.
- Z Connect terminal units to supply ducts with hard duct. Maintain minimum three (3) feet or three (3) duct diameters (whichever is greater) of straight duct prior to inlet of box. Connecting flex duct to the inlets of terminal units will NOT be acceptable.
- AA Provide minimum 5 ft of straight duct on outlet side of VAV boxes before first tap.
- BB At exterior wall louvers, seal duct to louver frame and install blank-out panels.
- CC All trapeze hanger rods shall be cut to within 1" of the bottom nut.

**END OF SECTION 23 31 00**

**SECTION 23 33 00**  
**AIR DUCT ACCESSORIES**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A Backdraft dampers - metal.
- B Combination fire and smoke dampers.
- C Duct access doors.
- D Duct test holes.
- E Fire dampers.
- F Flexible duct connectors.
- G Volume control dampers.
- H Miscellaneous products:
  - 1. Internal strut end plugs.
  - 2. Duct opening closure film.

**1.02 REFERENCE STANDARDS**

- A NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems; 2021.
- B NFPA 92 - Standard for Smoke Control Systems; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- C NFPA 96 - Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations; 2024.
- D SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible; 2020.
- E UL 33 - Safety Heat Responsive Links for Fire-Protection Service; Current Edition, Including All Revisions.
- F UL 555 - Standard for Fire Dampers; Current Edition, Including All Revisions.
- G UL 555S - Standard for Smoke Dampers; Current Edition, Including All Revisions.

**1.03 SUBMITTALS**

- A Product Data: Provide for shop fabricated assemblies including volume control dampers. Include electrical characteristics and connection requirements.
- B Manufacturer's Installation Instructions: Provide instructions for fire dampers and combination fire and smoke dampers.
- C Project Record Drawings: Record actual locations of access doors and test holes.
- D Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
  - 1. Extra Fusible Links: One of each type and size.

**1.04 QUALITY ASSURANCE**

- A Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum five years of documented experience.
- B Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.
- C All dampers shall be certified to bear the AMCA Certified Ratings Program seal for Air Performance, Efficiency, and Air Leakage.

**1.05 DELIVERY, STORAGE, AND HANDLING**

- A Protect dampers from damage to operating linkages and blades.
- B Storage: Store materials in a dry area indoor, protected from physical damage and in accordance with manufacturer's instructions.

**PART 2 PRODUCTS**

**2.01 AIR TURNING DEVICES/EXTRACTORS**

- A Manufacturers:
  - 1. Carlisle HVAC Products
  - 2. Elgen Manufacturing, Inc
  - 3. Ruskin Company
  - 4. Titus HVAC, a brand of Johnson Controls
  - 5. Ward Industries, a brand of Hart and Cooley, Inc
  - 6. Or Approved Equal



- B Multi-blade device with blades aligned in short dimension; steel construction; with individually adjustable blades, mounting straps.

**2.02 BACKDRAFT DAMPERS - METAL**

- A Manufacturers:
  - 1. Nailor Industries, Inc
  - 2. Ruskin Company, a brand of Johnson Controls
  - 3. United Enertech
  - 4. Greenheck
  - 5. Arrow
  - 6. Or Approved Equal
- B Frames shall be flanged, a minimum of 3 inches wide, and a minimum of 20 gauge roll formed galvanized steel or 0.125 inch extruded aluminum with pre-punched mounting holes and welded corner clips for maximum rigidity.
- C Blades shall be single piece, with a maximum width of 6 inches, counter balanced, and shall be constructed of minimum 26 gauge roll formed galvanized steel or 0.070 inch extruded aluminum. Blade ends shall overlap for maximum weather protection.
- D Blade seals shall be extruded vinyl and mechanically attached to blade edge.
- E Bearings shall be corrosion resistant synthetic.
- F Linkages shall use a galvanized tie bar with stainless steel pivot pins.
- G Axles shall be stainless steel.
- H Mounting shall be suitable for the required orientation.

**2.03 DUCT AIR TURNING VANES**

- A Provide factory manufactured turning vanes in each elbow where inside radius is less than the width of the duct, and in all square or rectangular elbows.
- B Turning vane assemblies shall be adequately supported and affixed to prevent rattling, breakaway, and shall not deform. Assemblies longer than 12 inches shall be double wall.
- C Turning vanes in negative pressure ductwork with pressure rating above 2 inches shall be installed in accordance with SMACNA Industrial Duct Construction Standard.
- D Turning vanes shall match the duct material construction.
- E Rectangular Throat Elbow Turning Vanes (Vane Runner Length up to 18" and Vane Length up to 36")
  - 1. Provide single blade type vanes having 2" radius and 1-1/2" spacing, 24 gauge minimum. Construct vanes in accordance with SMACNA HVAC Duct Construction Standards.
  - 2. If duct size changes in mitered elbow, use single blade type vanes with trailing edge extension.
- F Rectangular Throat Elbow Turning Vanes (Vane Runner Length up to 18" and Vane Length up to 36"):
  - 1. Use double wall airfoil type with smoothly-rounded entry nose and extended trailing edge on 2.4" center spacing.
  - 2. Vanes shall be equal to HEP (High Efficiency Profile) vanes as manufactured by Aero/Dyne Co.
- G Radius Elbow Splitter Vanes:
  - 1. Splitter vanes for radius elbows shall be extended entire length of fitting and constructed in accordance with SMACNA HVAC Duct Construction Standards.
- H Manufacturers:
  - 1. Aero Dyne
  - 2. Ductmate, Inc.
  - 3. Sheet Metal Connectors, Inc.
  - 4. Duro-Dyne
  - 5. DynAir Inc.
  - 6. Or Approved Equal

**2.04 WIRE MESH SCREENS**

- A Screen assemblies shall be removable.
- B Mesh: 1/2 inch square pattern, 1/16 inch galvanized wire, interwoven, welded at wire intersections and to the frame to prevent rattles.

- C Frames: Minimum of 1 inch by 1 inch by 1/8 inch galvanized steel angles for duct sizes through 24 inches, 1-1/2 inch by 1-1/2 inch by 3/16 inch for duct sizes between 25 inches and 48 inches, and 2 inches by 2 inches for ducts larger than 48 inches continuous around perimeter of screen. Provide intermediate supports to limit screen deflection to 1/16 inch at maximum design airflow.

**2.05 COMBINATION FIRE AND SMOKE DAMPERS**

- A Manufacturers:
  - 1. Air Balance/ABI
  - 2. Nailor Industries, Inc
  - 3. NCA, a brand of Metal Industries Inc
  - 4. Pottorff
  - 5. Ruskin Company, a brand of Johnson Controls
  - 6. United Enertech
  - 7. Metal Industries
  - 8. ATI Industries
  - 9. Or Approved Equal
- B Fabricate in accordance with NFPA 90A, UL 555, UL 555S, and as indicated.
- C Provide factory sleeve and collar for each damper. Minimum 20 gauge thickness. Silicon caulk factory applied to sleeve at damper frame to comply with leakage rating requirements.
- D UL 555S Leakage Rating: Class 1 (8 CFM at 4 in. w.g. differential pressure)
- E Maximum Velocity: 4000 fpm
- F Maximum Pressure: 8 in w.g.
- G Maximum Pressure Drop: The maximum allowable pressure drop across the damper shall not exceed 0.15 in w.g. at 2000 FPM.
- H Frame: 5 inches x minimum 16 gage roll formed, galvanized steel hat-shaped channel, reinforced at corners. Structurally equivalent to 13 gage (2.3 mm) U-channel type frame.
  - 1. Provide single section construction for duct sizes up to 48x30. Section shall be equivalent to duct opening indicated on Drawings.
- I Blades:
  - 1. Style: True airfoil-shaped, single piece, double skin.
  - 2. Action: Opposed.
  - 3. Material: Minimum 14 gage equivalent thickness, galvanized steel.
  - 4. Width: Maximum 6 inches.
  - 5. Orientation: Vertical or Horizontal
- J Bearings: Self-lubricating stainless steel sleeve, turning in extruded hole in frame.
- K Seals:
  - 1. Inflatable silicone fiberglass material to maintain smoke leakage rating to a minimum of 450 degrees F and galvanized steel for flame seal to 1,900 degrees F. Mechanically attached to blade edge (glue-on or grip type seals are not acceptable).
  - 2. Jamb: Stainless steel, flexible metal compression type.
- L Linkage: Concealed in frame.
- M Axles: Minimum 1/2 inch diameter plated steel, hex-shaped, mechanically attached to blade.
- N Mounting: Vertical and/or Horizontal.
- O Operators: UL listed and labelled spring return electric type suitable for 120 volts, single phase, 60 Hz. Provide end switches to indicate damper position. Locate damper operator on exterior of duct and link to damper operating shaft.
- P Normally Closed Smoke Responsive Fire Dampers: Curtain type, opening by gravity upon actuation of electro thermal link, flexible stainless steel blade edge seals to provide constant sealing pressure.
- Q Provide damper test switch accessory for cycle testing.
- R Provide optional auxiliary switch package to allow remote indication of damper blade position.
- S Electro Thermal Link: Fusible link melting at 165 degrees F; 120 volts, single phase, 60 Hz; UL listed and labeled.

**2.06 FLEXIBLE DUCT 90° ELBOW SUPPORT**

- A Manufacturers:
  - 1. Build Right Products
  - 2. Hart and Cooley
  - 3. Thermaflex
  - 4. Or Approved Equal
- B Pre-manufactured support to form any brand flexible duct into a smooth 90 degree elbow.
  - 1. One size shall fit 4" to 16" flexible ducts
  - 2. No additional tools shall be required for installation
  - 3. UL listed for use in Return Air Plenums

**2.07 DUCT ACCESS DOORS**

- A Manufacturers:
  - 1. Acudor Products Inc, a Division of Nelson Industrial Inc
  - 2. Ductmate Industries, Inc, a DMI Company
  - 3. Durodyne
  - 4. Elgen Manufacturing
  - 5. MKT Metal Manufacturing
  - 6. Nailor Industries Inc
  - 7. Ruskin Company
  - 8. SEMCO LLC
  - 9. Or Approved Equal
- B Fabrication: Rigid and close-fitting of galvanized steel with sealing gaskets and quick fastening locking devices. For insulated ducts, install minimum 1 inch thick insulation with sheet metal cover.
  - 1. Up to 18 inches Square: Provide two hinges and two sash locks.
  - 2. Up to 24 by 48 inches: Three hinges and two compression latches with outside and inside handles.
- C Access doors with sheet metal screw fasteners are not acceptable.
- D Provide access doors of adequate size to allow easy access to the equipment that will require maintenance. Provide insulated or acoustically lined doors to prevent condensation where applicable.
- E Manufacturer shall provide a neoprene gasket around perimeter of access door for airtight seal.
- F Systems 2" w.g. or less shall use a hinged, cam, or hinged & cam square framed access door.
- G Systems 3" w.g. and above shall use a sandwich type access door. Construct doors in accordance with Figure 7-3 of the 2005 SMACNA Manual, "HVAC Duct Construction Standards, Metal & Flexible," Third Edition. Doors shall be rated for +/- 10" w.g.

**2.08 DUCT TEST HOLES**

- A Temporary Test Holes: Cut or drill in ducts as required. Cap with neat patches, neoprene plugs, threaded plugs, or threaded or twist-on metal caps.
- B Permanent Test Holes: Factory fabricated, air tight flanged fittings with screw cap. Provide extended neck fittings to clear insulation.

**2.09 FIRE DAMPERS**

- A Manufacturers:
  - 1. Nailor Industries Inc
  - 2. NCA, a brand of Metal Industries Inc
  - 3. Pottorff
  - 4. Ruskin Company
  - 5. United Enertech
  - 6. Air Balance/ABI
  - 7. Greenheck
  - 8. Metal Industries
  - 9. Prefco
  - 10. ATI Industries
  - 11. Or Approved Equal

- B Fabricate in accordance with NFPA 90A and UL 555, and as indicated.
- C Fire Resistance: 1-1/2 hours or 3 hours as required by assembly rating.
- D Dynamic Closure Rating: Dampers shall be classified for dynamic closure to 4000 fpm and 4 inches w.g. static pressure.
- E Construction:
  - 1. Integral Sleeve Frame: Minimum 20 gauge roll formed galvanized steel. Sleeve length to be determined by Contractor for each condition.
  - 2. Blades:
    - a. Curtain type
    - b. Action: Spring or gravity closure upon fusible link release.
    - c. Orientation: Horizontal.
    - d. Material: Minimum 24 gage roll formed, galvanized steel.
  - 3. Closure Springs: Type 301 stainless steel, constant force type, if required.
  - 4. Mounting: Vertical and/or Horizontal.
  - 5. Duct Transition Connection, Damper Style:
    - a. B style – rectangular connection, blades out of air stream, high free area.
    - b. G style – A style connection, grille mounting tabs at end of sleeve for grille.
    - c. CR style – round connection, sealed.
  - 6. Finish: Mill galvanized.
- F Fusible Links: UL 33, separate at 165 degrees F with adjustable link straps for combination fire/balancing dampers.
- G Breakaway Connection:
  - 1. Ductmate or Drivemate.

**2.10 FLEXIBLE DUCT CONNECTORS**

- A Manufacturers:
  - 1. Carlisle HVAC Products
  - 2. Ductmate Industries, Inc, a DMI Company
  - 3. Elgen Manufacturing, Inc
  - 4. Durodyne
  - 5. Or Approved Equal
- B Flexible duct connector shall be used where ductwork connects to fan apparatus or fan casings to isolate vibration transfer. Connectors shall be attached in such a manner as to provide an airtight and waterproof seal.
- C Connectors will comply with NFPA 90A, “Installation of Air Conditioning & Ventilation Systems” and NFPA 90B, “Installation of Warm Air Heating & Air Conditioning Systems”.
- D Connector fabrics shall meet NFPA 701 (formerly UL 214.)
- E Connector fabrics shall be mildew resistant per ASTM G21.
- F Indoor installations shall be NFPA 701 listed, fire retardant Vinyl coated woven nylon or Neoprene coated woven fiberglass fabric. Minimum density of Vinyl is 20 oz. /sq. yd. and rated to 200F. Minimum density of Neoprene 30 oz. / sq. yard and rated to 200F.
- G Outdoor installations shall be NFPA 701 listed UV-resistant Hypalon coated woven fiberglass fabric. Minimum density 24 oz. /sq. yd. and rated to 250F.
- H High temperature applications shall be NFPA 701 listed, Silicone coated satin weave fiberglass fabric. Minimum density 17.5 oz. /sq. yd. and rated to 500 F.
- I Chemical resistant applications shall be of Teflon coated woven fiberglass fabric. Minimum density 18 oz. /sq. yd. and rated to 500 F.
- J Fabricate in accordance with SMACNA (DCS) and as indicated.
- K Flexible Duct Connections: Fabric crimped into metal edging strip.

**2.11 SMOKE DAMPERS**

- A Manufacturers:
  - 1. NCA

2. Nailor Industries, Inc
  3. Ruskin Company, a brand of Johnson Controls
  4. United Enertech
  5. Air Balance/ABI
  6. Greenheck
  7. Metal Industries
  8. Pottorff
  9. ATI Industries
  10. Or Approved Equal
- B Fabricate in accordance with NFPA 90A and UL 555S, and as indicated.
- C Fabricate in accordance with NFPA 90A, UL 555, UL 555S, and as indicated.
- D Provide factory sleeve and collar for each damper. Minimum 20 gauge thickness. Silicon caulk factory applied to sleeve at damper frame to comply with leakage rating requirements.
- E UL 555S Leakage Rating: Class 1 (8 CFM at 4 in. w.g. differential pressure)
- F Maximum Velocity: 4000 fpm
- G Maximum Pressure: 8 in w.g.
- H Frame: 5 inches x minimum 16 gage roll formed, galvanized steel hat-shaped channel, reinforced at corners. Structurally equivalent to 13 gage (2.3 mm) U-channel type frame.
- I Blades:
1. Style: True airfoil-shaped, single piece, double skin.
  2. Action: Opposed.
  3. Material: Minimum 14 gage equivalent thickness, galvanized steel.
  4. Width: Maximum 6 inches.
- J Bearings: Self-lubricating stainless steel sleeve, turning in extruded hole in frame.
- K Seals:
1. Inflatable silicone fiberglass material to maintain smoke leakage rating to a minimum of 450 degrees F and galvanized steel for flame seal to 1,900 degrees F. Mechanically attached to blade edge (glue-on or grip type seals are not acceptable).
  2. Jamb: Stainless steel, flexible metal compression type.
- L Linkage: Concealed in frame.
- M Axles: Minimum ½ inch diameter plated steel, hex-shaped, mechanically attached to blade.
- N Mounting: Vertical and/or Horizontal.
- O Provide damper test switch accessory for cycle testing.
- P Provide optional auxiliary switch package to allow remote indication of damper blade position.
- Q Electro Thermal Link: Fusible link melting at 165 degrees F; 120 volts, single phase, 60 Hz; UL listed and labeled.

**2.12 VOLUME CONTROL DAMPERS**

- A Manufacturers:
1. MKT Metal Manufacturing
  2. Nailor Industries Inc
  3. NCA, a brand of Metal Industries Inc
  4. Ruskin Company:
  5. United Enertech
  6. Greenheck
  7. Pottorff
  8. Johnson Controls
  9. Air Balance, Inc.
  10. Or Approved Equal
- B Fabricate in accordance with SMACNA (DCS) and as indicated.
- C Round Control Damper - 1 in w.g. and below:
1. Velocity: Up to 2,000 fpm

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2. Temperature: 180°F
3. Construction:
  - a. Frame Material - Galvanized Steel
  - b. Frame Thickness: 20 gauge
  - c. Blade Material: Galvanized Steel
  - d. Axle Bearings: Bronze
  - e. Axle Material: Plated Steel
  - f. Operator: 3/8 inch sq. locking manual quadrant.
    - 1) On insulated ducts, provide 2 inch standoff bracket
  - g. Manufacturers:
    - 1) Greenheck MBDR-50
    - 2) Ruskin
    - 3) Nailor
- D Round Control Damper - 4 in w.g. and below:
  1. Velocity: Up to 3,000 fpm
  2. Temperature: 180°F
  3. Leakage: 4 cfm/ft<sup>2</sup> @ 1 in. wg
  4. Construction:
    - a. Frame Material - Galvanized Steel
    - b. Frame Thickness: 20 gauge
    - c. Blade Material: Galvanized Steel
    - d. Blade seal: Silicone
    - e. Axle Bearings: Bronze
    - f. Axle Material: Plated Steel
    - g. Operator: 3/8 inch sq. locking manual quadrant.
      - 1) On insulated ducts, provide 2 inch standoff bracket
  5. Manufacturers:
    - a. Greenheck VCDR-53
    - b. Ruskin
    - c. Nailor
- E Rectangular Single Blade Dampers: 1 in w.g. and below, up to 10 x 30 inch duct
  1. Velocity: Up to 2,000 fpm
  2. Temperature: 180°F
  3. Construction:
    - a. Frame Material - Galvanized Steel
    - b. Frame Thickness: 20 gauge
    - c. Blade Material: Galvanized Steel
    - d. Axle Bearings: Synthetic sleeve type
    - e. Axle Material: Plated Steel
    - f. Operator: 3/8 inch sq. locking manual quadrant, 2-1/2 inch long extension
      - 1) On insulated ducts, provide 2 inch standoff bracket
  4. Manufacturers:
    - a. Greenheck MBD-10M
    - b. Ruskin
    - c. Nailor
- F Rectangular Multi-Blade Balancing Dampers: 2 in w.g. and below
  1. Pressure: Up to 4 in w.g.
  2. Velocity: 2,000 fpm
  3. Temperature: 180°F
  4. Construction:
    - a. Frame Material - Galvanized Steel

- b. Frame Thickness: 16 gauge
  - c. Blade Material: Galvanized Steel
  - d. Blade Thickness: 16 gauge
  - e. Blade Type: 3V
  - f. Blade Operation: Opposed
  - g. Axle Bearings: Synthetic sleeve type
  - h. Axle Material: Plated Steel
  - i. Operator: 1/2 inch locking manual quadrant, 1-1/2 inch long standoff bracket
  - j. Extension Pin: 1/2 inch diagonal glass reinforced polymer extends 3-1/2 inch beyond frame
5. Manufacturers:
- a. Greenheck MBD-15
  - b. Ruskin
  - c. Nailor
- G Quadrants:
- 1. Provide locking, indicating quadrant regulators on single and multi-blade dampers.
  - 2. On insulated ducts mount quadrant regulators on stand-off mounting brackets, bases, or adapters.
  - 3. Where rod lengths exceed 30 inches provide regulator at both ends.

**2.13 MISCELLANEOUS PRODUCTS**

- A Internal Strut End Plugs: Combination end-mounting and sealing plugs for metal conduit used as internal reinforcement struts for metal ducts; plug crimped inside conduit with outside gasketed washer seal.
- B Duct Opening Closure Film: Mold-resistant, self-adhesive film to keep debris out of ducts during construction.
  - 1. Thickness: 2 mils.
  - 2. High tack water based adhesive.
  - 3. UV stable light blue color.
  - 4. Elongation Before Break: 325 percent, minimum.
  - 5. Manufacturers:
    - a. Carlisle HVAC Products; Dynair Duct Protection Film
    - b. Surface Shields
    - c. Trimaco
    - d. Ductmate ProGuard
    - e. Or Approved Equal

**PART 3 EXECUTION**

**3.01 INSTALLATION**

- A Install accessories in accordance with manufacturer's instructions, NFPA 90A, and follow SMACNA (DCS). Refer to Section 23 31 00 for duct construction and pressure class.
- B Provide backdraft dampers on exhaust fans or exhaust ducts nearest to outside and where indicated.
- C Provide a pre-manufactured support at each diffuser to turn the flex duct into a 90° elbow.
- D Contractor shall identify balancing dampers above the ceiling by either spray painting them bright orange or hanging an orange flag from the damper handle. If hanging a flag in a return air plenum, material shall comply with fire and smoke spread ratings for plenum use.
- E All fire dampers, smoke dampers, and combination fire/smoke dampers shall be installed with bottom edge 24" maximum above lay-in ceiling.
- F All balancing dampers shall be installed maximum 30" above the lay-in ceiling.
- G Provide duct access doors for inspection and cleaning before and after filters, coils, fans, automatic dampers, at fire dampers, combination fire and smoke dampers, and elsewhere as indicated. Provide for cleaning kitchen exhaust ducts in accordance with NFPA 96 Provide minimum 12 by 12 inch size for hand access, size for shoulder access, and as indicated. Provide 8 by 8 inch for balancing dampers only. Review locations prior to fabrication.
- H Provide duct test holes where indicated and required for testing and balancing purposes.

- I Provide fire dampers, combination fire and smoke dampers, and smoke dampers at locations indicated, where ducts and outlets pass through fire rated components. Install with required perimeter mounting angles, sleeves, breakaway duct connections, corrosion resistant springs, bearings, bushings and hinges.
- J Install smoke dampers and combination smoke and fire dampers in accordance with NFPA 92.
- K The Contractor shall inspect and test all fire dampers, smoke dampers, and combination fire/smoke dampers in accordance with NFPA 80 in the presence of the Authority Having Jurisdiction.
- L Demonstrate re-setting of fire dampers to Owner's representative.
- M At fans and motorized equipment associated with ducts, provide flexible duct connections immediately adjacent to the equipment.
- N At equipment supported by vibration isolators, provide flexible duct connections immediately adjacent to the equipment.
  - 1. Refer to Section 23 05 48.
- O Provide balancing dampers at points on supply, return, and exhaust systems where branches are taken from larger ducts as required for air balancing. Install minimum 2 duct widths from duct take-off.
- P Provide balancing dampers on duct take-off to diffusers, grilles, and registers, regardless of whether dampers are specified as part of the diffuser, grille, or register assembly.

**END OF SECTION 23 33 00**



**SECTION 23 34 20**

**PRE-MANUFACTURED ROOF PENETRATION HOUSING**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A Pipe and Duct Penetrations in Roofing

**1.02 REFERENCES**

- A ICC-500, FEMA 320/361 - Third Party Tested to +225 mph
- B ICC 2015 Energy Code - Third Party Tested to ASTM E 2078-13 Standard Test Method for Air Permeance of Building Materials
- C ASTM E 1980 Solar Reflectance Index (SRI)
- D FEMA P749 - Seismic Provisions

**1.03 SUBMITTALS**

- A Product Data: Manufacturer's Data Sheets on each product to be used, including:
- B Preparation instructions and recommendations
- C Installation methods
  - 1. Shop drawings: physical size, installation and working space required.
  - 2. Third Party Testing Identification for Wind and Air Permeance Levels

**1.04 QUALITY ASSURANCE**

- A Manufacturer - Product to be manufactured by an ISO 9000 Facility

**1.05 DELIVERY, STORAGE, AND HANDLING**

- A Deliver and Store Products in Manufacturer's Original Packaging Bearing the Brand Name and Manufacturer's Identification until Ready for Installation.
- B Handle Materials to Avoid Damage. Protect From Construction Conditions

**1.06 WARRANTY**

- A Product to Carry a 20-Year Limited Insured Warranty

**PART 2 PRODUCT**

**2.01 MANUFACTURERS**

- A Acceptable Manufacturers:
  - 1. Alta Products, LLC
  - 2. Roof Penetration Housings
  - 3. Or Approved Equal

**2.02 PRODUCT**

- A Construction:
  - 1. 0.080 inch (2mm) thick aluminum housing and curb
  - 2. UV protected powder coated finish (2 mil (.05 mm) thick)
  - 3. Stainless Steel. V.P. fasteners
  - 4. Gasketed lid to housing and housing to curb connection joints to ensure
  - 5. Compliance to ICC 2015 Air Permeance Levels
  - 6. Standard Color: Beige - To meet an initial SRI of 85 (White available for SRI 100)
  - 7. Seismic Seismic calculations, conditions to be furnished to RPH by engineer
  - 8. Constructed to withstand wind to 225+ MPH, third party tested.
  - 9. Pre-Insulated curb, 6" Thick, R-40 Factor.
- B Mini Size
  - 1. L - 12" W - 10" H - 22"
  - 2. Application: Electrical power switch/disconnects and small satellite dish mounts
- C Small Size
  - 1. L - 16-1/2" W - 9-3/4" H - 10"
  - 2. Application: Up to 1.9 OD pipes/conduits/telecommunication cables. Designed for a power conduit, control conduit, liquid line and suction line.
- D Medium Size

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- 1. L - 20-1/2" W - 14-1/2" H - 12"
- 2. Application: Multiple pipes/conduit/telecommunication cables to the roof. Up to four (4) condensing units (two on each side). Up to sixteen (16) Exit Seals.
- E Large Size
  - 1. L - 34" W - 34" H - 24"
  - 2. Application: Allows for a wide variety of installation choices, including multiple AC units, larger pipe diameters, large electrical disconnects and ducts up to 30+ Series 5000 Exit Seals
- F Custom Sizes
  - 1. Consult Factory
- G Sizes given above for Housing only. Add 11" for total height (14" for curb less 3" overlap)
- H Provide all components plus the Pre-Insulated curb extension.
- I Aluminum Extension between housing and curb shall accommodate 6" Insulation ( R-40 Rating) supplied by manufacturer on the outside of the curb, +1" to accommodate roofing material.
- J Exit Seals
  - 1. Design: Weather tight seal for vertical surface/plane penetrations. Seal construction to be manufactured in all aluminum construction and 100% Sil-X-14 silicone gaskets.
  - 2. Series 5000 - .25" to 1.90"
  - 3. Series 6000 - 2" to 3.125"
  - 4. Series 7000 - 3.5" Large Diameter Double Gasketed inside and out
- K Penetration Pipe Type as Applicable: Copper K and L, copper ACR, steel Schedule 40, PVC Schedule 40 and 80, electrical EMT, electrical rigid, aluminum, liquid light, and A/C or Plumbing Ducts
- L Electrical Disconnect Support (EDS)
  - 1. Same as above w/2 aluminum support legs and uprights. Can support multiple breaker/disconnect boxes.

**PART 3 EXECUTION**

**3.01 EXAMINATION**

- A Inspect substrate for readiness
- B Coordinate with roofing contractor for installation, flashing, etc.

**3.02 PREPARATION**

- A Clean surfaces thoroughly prior to installation

**3.03 INSTALLATION**

- A Install in accordance with manufacturer's instructions
- B Curb & Unit installed by Roofing Contractor

**3.04 PROTECTION**

- A Protect installed products until completion of project

**END OF SECTION 23 34 20**

**SECTION 23 34 23**  
**HVAC POWER VENTILATORS**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A Roof exhausters.
- B Cabinet exhaust fans.
- C Upblast roof exhausters.

**1.02 REFERENCE STANDARDS**

- A AMCA (DIR) - (Directory of) Products Licensed Under AMCA International Certified Ratings Program; 2015.
- B AMCA 99 - Standards Handbook; 2016.
- C AMCA 204 - Balance Quality and Vibration Levels for Fans; 2020.
- D AMCA 208-18 - Calculation of the Fan Energy Index.
- E AMCA 210 - Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating; 2016, with Errata (2018).
- F NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum); 2020.
- G UL 705 - Power Ventilators; Current Edition, Including All Revisions.

**1.03 SUBMITTALS**

- A Product Data: Provide data on fans and accessories including fan curves with specified operating point clearly plotted, power, RPM, sound power levels at rated capacity, and electrical characteristics and connection requirements.
- B All fans shall be certified to bear the AMCA Certified Ratings Program seal for Sound and Air Performance.
- C All fans shall be certified to bear the AMCA Certified Ratings Program seal for FEI (Fan Energy Index).
- D For fans over 1.0 HP, the submittal shall have the fan efficiency index (FEI) clearly indicated. The FEI shall be as determined by AMCA 208-18.
- E Maintenance Data: Include instructions for lubrication, motor and drive replacement, spare parts list, and wiring diagrams.
- F Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
  - 1. See Section 01 60 00 - Product Requirements, for additional provisions.
  - 2. Extra Fan Belts: One set for each individual fan.

**1.04 QUALITY ASSURANCE**

- A Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.

**1.05 FIELD CONDITIONS**

- A Permanent ventilators may not be used for ventilation during construction.

**PART 2 PRODUCTS**

**2.01 MANUFACTURERS**

- A Greenheck
- B Loren Cook Company
- C PennBarry
- D Twin City Fan & Blower
- E Or Approved Equal

**2.02 POWER VENTILATORS - GENERAL**

- A Static and Dynamically Balanced: Comply with AMCA 204.
- B Performance Ratings: Comply with AMCA 210, bearing certified rating seal.
- C Sound Ratings: AMCA 301, tested to AMCA 300 and bearing AMCA Certified Sound Rating Seal.
- D Fabrication: Comply with AMCA 99.
- E UL Compliance: UL listed and labeled, designed, manufactured, and tested in accordance with UL 705.
- F Electrical Components: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.
- G Enclosed Safety Switches: Comply with NEMA 250.

- H Each fan shall bear a permanently affixed manufacture's nameplate containing the model number and individual serial number

**2.03 ROOF EXHAUSTERS**

- A Fan Unit: V-belt or direct driven as indicated, with spun aluminum housing; resilient mounted motor; 1/2 inch mesh, 0.62 inch thick aluminum wire birdscreen; square base to suit roof curb with continuous curb gaskets.
- B Wheel:
  - 1. Constructed of Aluminum or Composite
  - 2. Non-overloading, backward inclined centrifugal
  - 3. The wheel cone and fan inlet shall be matched and shall have precise running tolerances for maximum performance and operating efficiency.
- C Roof Curb: 20 inch high self-flashing of galvanized steel with continuously welded seams, built-in cant strips, insulation and curb bottom, and factory installed nailer strip.
- D Disconnect Switch: Factory wired, non-fusible, in housing for thermal overload protected motor and wall mounted solid state speed controller or EC motor, refer to fan schedule..
- E Backdraft Damper: Gravity actuated, aluminum multiple blade construction, felt edged with offset hinge pin, nylon bearings, blades linked.
- F Sheaves: Cast iron or steel, dynamically balanced, bored to fit shafts and keyed; variable and adjustable pitch motor sheave selected so required rpm is obtained with sheaves set at mid-position; fan shaft with self-aligning pre-lubricated ball bearings.

**2.04 CABINET EXHAUST FANS**

- A Centrifugal Fan Unit: V-belt or direct driven with galvanized steel housing lined with acoustic insulation, resilient mounted motor, gravity backdraft damper in discharge.
- B Disconnect Switch: Cord and plug in housing for thermal overload protected motor and wall mounted solid state speed controller or EC motor, refer to fan schedule..
- C Grille: Aluminum with baked white enamel finish.
- D Sheaves: Cast iron or steel, dynamically balanced, bored to fit shafts and keyed; variable and adjustable pitch motor sheaves selected so required rpm is obtained with sheaves set at mid-position; fan shaft with self-aligning pre-lubricated ball bearings.
- E Performance Ratings: As indicated on drawings.

**2.05 UPBLAST ROOF EXHAUSTERS**

- A Direct Drive Fan:
  - 1. Fan Wheel:
    - a. Type: Non-overloading, backward inclined centrifugal.
  - 2. Statically and dynamically balanced.
  - 3. Motors:
    - a. Open drip-proof (ODP).
    - b. Heavy duty ball bearing type.
    - c. Mount on vibration isolators or resilient cradle mounts, out of air stream.
    - d. Fully accessible for maintenance.
  - 4. Housing:
    - a. Construct of heavy gage aluminum including curb cap, windband, and motor compartment.
    - b. Rigid internal support structure.
    - c. One-piece fabricated or fully welded curb-cap base to windband for leak proof construction.
    - d. Construct drive frame assembly of heavy gauge steel, mounted on vibration isolators.
    - e. Provide breather tube for fresh air motor cooling and wiring.
- B Shafts and Bearings:
  - 1. Fan Shaft:
    - a. Ground and polished steel with anti-corrosive coating.
    - b. First critical speed at least 25 percent over maximum cataloged operating speed.
  - 2. Bearings:

- a. Permanently sealed or pillow block type.
  - b. Minimum L10 life in excess of 100,000 hours (equivalent to L50 average life of 500,000 hours), at maximum cataloged operating speed.
  - c. 100 percent factory tested.
- C Drive Assembly:
1. Belts, pulleys, and keys oversized for a minimum of 150 percent of driven horsepower.
  2. Belts: Static free and oil resistant.
  3. Fully machined cast iron type, keyed and securely attached to the wheel and motor shafts.
  4. Motor pulley adjustable for final system balancing.
  5. Readily accessible for maintenance.
- D Disconnect Switches:
1. Factory mounted and wired.
  2. Environment Type per NEMA 250: Unless otherwise indicated, as specified for the following installation locations:
    - a. Outdoor Locations: Type 3R.
  3. Finish for Painted Steel Enclosures: Provide manufacturer's standard or factory applied gray unless otherwise indicated.
  4. Positive electrical shutoff.
  5. Wired from fan motor to junction box installed within motor compartment.
- E Roof Curb: 20 inch high self-flashing of galvanized steel with continuously welded seams, built-in cant strips, insulation and curb bottom, and factory installed nailer strip.
- F Drain Trough: Allows for single-point drainage of water, grease, and other residues.

## **2.06 INLINE CENTRIFUGAL FANS**

- A Wheel:
1. Forward curved centrifugal wheel
  2. Constructed of galvanized steel or calcium carbonate filled polypropylene
  3. Statically and dynamically balanced in accordance to AMCA Standard 204-05
- B Housing:
1. Constructed of heavy gauge galvanized steel
  2. Interior shall be lined with 0.5 inches of acoustical insulation
- C Disconnect Switch: Cord and plug in housing for thermal overload protected motor and wall mounted solid state speed controller.
- D Spring Loaded Aluminum Backdraft Damper:
1. Prevents air from entering back into the building when fan is off
  2. Eliminates rattling or unwanted backdrafts

## **PART 3 EXECUTION**

### **3.01 INSTALLATION**

- A Install in accordance with manufacturer's instructions.
- B Secure roof exhausters with cadmium plated steel lag screws to roof curb.
- C Extend ducts to roof exhausters into roof curb. Counterflash duct to roof opening.
- D Hung Cabinet Fans:
1. Install fans with resilient mountings and flexible electrical leads; see Section 23 05 48.
  2. Install flexible connections specified in Section 23 33 00 between fan and ductwork. Ensure metal bands of connectors are parallel with minimum one inch flex between ductwork and fan while running.
- E Provide sheaves required for final air balance.
- F Install backdraft dampers on inlet to roof and wall exhausters.
- G Provide backdraft dampers on outlet from cabinet and ceiling exhauster fans and as indicated.

**END OF SECTION 23 34 23**

**SECTION 23 37 00**  
**AIR OUTLETS AND INLETS**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A Diffusers:
- B Slot ceiling diffusers.
- C Registers/grilles:
  - 1. Ceiling-mounted, exhaust and return register/grilles.
  - 2. Wall-mounted, supply register/grilles.
  - 3. Wall-mounted, exhaust and return register/grilles.
- D Duct-mounted supply and return registers/louvers.
- E Gravity ventilators.
- F Clothes Dryer Vents

**1.02 REFERENCE STANDARDS**

- A AMCA 550 - Test Method for High Velocity Wind Driven Rain Resistant Louvers; 2022.
- B ASHRAE Std 70 - Method of Testing the Performance of Air Outlets and Air Inlets; 2023.
- C ASTM B221 - Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes; 2021.
- D ASTM B221M - Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes (Metric); 2021.
- E SMACNA (ASMM) - Architectural Sheet Metal Manual; 2012.

**1.03 SUBMITTALS**

- A Product Data: Provide data for equipment required for this project. Review outlets and inlets as to size, finish, and type of mounting prior to submission. Submit schedule of outlets and inlets showing type, size, location, application, and noise level.
- B Provide performance data for each inlet and outlet model and size variation, indicating CFM range, throw data, noise data, and pressure drop.

**1.04 QUALITY ASSURANCE**

- A Test and rate air outlet and inlet performance in accordance with ASHRAE Std 70.
- B Louver shall comply with AMCA 540 and AMCA 550.
- C Louvers licensed to bear AMCA Certified Ratings Seal. Ratings based on tests and procedures performed in accordance with AMCA 500-L, AMCA 511 and AMCA 540 and comply with AMCA Certified Ratings Program. AMCA Certified Ratings Seal applies to air performance and water penetration ratings.
- D Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.

**PART 2 PRODUCTS**

**2.01 MANUFACTURERS**

- A Carnes, a division of Carnes Company Inc
- B Krueger
- C Metalaire, a brand of Metal Industries Inc
- D Nailor
- E Price Industries
- F Ruskin Company
- G Titus
- H Tuttle and Bailey
- I Or Approved Equal

**2.02 SQUARE CONE DIFFUSERS**

- A Type: Provide square, adjustable pattern, stamped, multi-core diffuser to discharge air in four way pattern.
- B Connections: Round.
- C Frame: Provide surface mount and inverted T-bar type. In plaster ceilings, provide plaster frame and ceiling frame.

D Fabrication: Aluminum with baked enamel finish.

E Color: As indicated.

**2.03 SQUARE PLAQUE DIFFUSERS**

A Type: Provide aluminum square plaque ceiling diffusers of sizes and mounting types designated by the Drawings and air distribution schedule.

B An inner plaque assembly shall be incorporated and shall drop no more than ¼ inch below the ceiling plane to assure proper air distribution performance.

C The inner plaque assembly shall be completely removable from the room side to allow for full access to any dampers or other ductwork components located near the diffuser neck.

D The diffuser shall integrate with all duct sizes shown on the plans without affecting the face size and appearance of the unit.

E The face panel shall have smooth edges and rounded corners to blend with the back cone.

F Frame: Provide surface mount and inverted T-bar type. In plaster ceilings, provide plaster frame and ceiling frame.

G The ceiling module size shall be as indicated on the Drawings.

**2.04 CEILING SLOT DIFFUSERS**

A Type: Continuous 1/2 inch, 3/4 inch, or 1 inch wide slot as scheduled, number of slots wide as scheduled, with adjustable vanes for left, right, or vertical discharge.

B Fabrication: Aluminum extrusions with factory baked enamel finish.

C Color: To be selected by Architect from manufacturer's standard range.

D Frame: 1-1/4 inch margin with support clips for T bar mounting and gasket, mitered end border.

E Plenum: Integral, galvanized steel, insulated.

**2.05 DUCT-MOUNTED SUPPLY AND RETURN REGISTERS/LOUVERS**

A Type: Duct-mounted, rectangular register for round-spiral duct with adjustable pivot-ended blades, end caps, built-in volume damper, and dual cover flanges to lay flush on duct surface regardless of diameter. Performance to match manufacturer's catalog data.

B Material: 22 gauge, 0.0299 inch aluminum.

1. Provide crossing spiral fitting-body of matching duct diameter.

**2.06 CEILING EXHAUST AND RETURN REGISTERS/GRILLES**

A Type: Streamlined blades, 3/4 inch minimum depth, 3/4 inch maximum spacing, with blades set at 45 degrees, vertical face.

B Frame: 1-1/4 inch margin with countersunk screw mounting.

C Fabrication: Steel with 20 gauge, 0.0359 inch minimum frames and 22 gauge, 0.0299 inch minimum blades, steel and aluminum with 20 gauge, 0.0359 inch minimum frame, or aluminum extrusions, with factory baked enamel finish.

D Color: As indicated.

E Damper: Integral, gang-operated, opposed blade type with removable key operator, operable from face where not individually connected to exhaust fans.

F Gymsnasiums: Provide front pivoted or welded in place blades, securely fastened to be immobile.

**2.07 WALL SUPPLY REGISTERS/GRILLES**

A Type: Streamlined and individually adjustable blades, 3/4 inch minimum depth, 3/4 inch maximum spacing with spring or other device to set blades, vertical face, double deflection.

B Frame: 1-1/4 inch margin with countersunk screw mounting and gasket.

C Fabrication: Steel with 20 gauge, 0.0359 inch minimum frames and 22 gauge, 0.0299 inch minimum blades, steel and aluminum with 20 gauge, 0.0359 inch minimum frame, or aluminum extrusions, with factory baked enamel finish.

D Color: As indicated.

E Damper: Integral, gang-operated opposed blade type with removable key operator, operable from face.

**2.08 WALL EXHAUST AND RETURN REGISTERS/GRILLES**

A Type: Streamlined blades, 3/4 inch minimum depth, 3/4 inch maximum spacing, with spring or other device to set blades, vertical face.

- B Frame: 1-1/4 inch margin with countersunk screw mounting.
- C Fabrication: Aluminum extrusions, with factory baked enamel finish.
- D Color: As indicated on the drawings.
- E Damper: Integral, gang-operated, opposed blade type with removable key operator, operable from face.

**2.09 DRYER VENT**

- A Manufacturers
  - 1. Seiho
  - 2. Or Approved Equal
- B Heavy duty aluminum construction with flapper backdraft damper
- C Size: 4" or 6" as scheduled or indicated on Drawings
- D Finish: Anodized

**2.10 GRAVITY VENTILATORS**

- A Hood Intake and Relief Gravity Ventilator:
  - 1. General:
    - a. Low silhouette for intake applications with natural gravity or negative pressure system(s).
    - b. Performance ratings and factory testing to be in accordance with AMCA 511 and AMCA 550.
    - c. Equipment to bear permanently affixed manufacturer's nameplate listing model and serial number.
    - d. High Wind Rated: Provide Miami-Dade NOA
  - 2. Hood and Base:
    - a. Material: Aluminum.
    - b. Hood Construction: Precision formed, arched panels with interlocking seams.
    - c. Vertical End Panels: Fully locked into hood end panels.
    - d. Curb Cap: Pre-punched mounting holes for installation.
  - 3. Birdscreen:
    - a. Fabricate in accordance with ASTM B221 (ASTM B221M).
    - b. Construction: 1/2 inch Aluminum mesh.
    - c. Horizontally mounted across hood intake area.
  - 4. Hood Support: Galvanized steel construction and fastened so hood can be removed completely from the base or hinged open.
  - 5. Options/Accessories:
    - a. Roof Curbs:
      - 1) Flat Roofs:
        - (a) Welded curb with 45 degree cant and wood nailer.
      - 2) Pitched Roofs: Welded, straight side curb with flashing flange and wood nailer.
      - 3) Material: Galvanized.
      - 4) Insulation Thickness: 2 inches.
- B Spun Aluminum Intake and Relief Gravity Ventilator:
  - 1. General:
    - a. Provide low silhouette configuration for intake applications with natural gravity or negative pressure system.
    - b. Performance ratings and factory testing to be in accordance with AMCA 511 and AMCA 550.
    - c. Equipment to bear permanently affixed manufacturer's nameplate listing model and serial number.
    - d. High Wind Rated: Provide Miami-Dade NOA
  - 2. Hood:
    - a. Internal structure constructed of galvanized steel.
  - 3. Birdscreen:
    - a. Fabricate in accordance with ASTM B221 (ASTM B221M).
    - b. Construction: 1/2 inch galvanized mesh.
    - c. Horizontally mounted across hood intake area.
  - 4. Housing:
    - a. Windband:



- 1) One piece spun aluminum construction with uniform, original material thickness throughout the housing.
- 2) Include integral rolled bead for strength.
5. Options/Accessories:
  - a. Roof Curbs:
    - 1) Flat Roofs:
      - (a) Welded curb with 45 degree cant and wood nailer.
    - 2) Pitched Roofs: Welded, straight side curb with flashing flange and wood nailer.
    - 3) Material: Aluminum.
    - 4) Insulation Thickness: 2 inches.

**PART 3 EXECUTION**

**3.01 INSTALLATION**

- A Install in accordance with manufacturer's instructions.
- B Comply with SMACNA (ASMM) for flashing/counter-flashing of roof penetrations and supports for roof curbs and roof mounted equipment.
- C Check location of outlets and inlets and make necessary adjustments in position to comply with architectural features, symmetry, and lighting arrangement.
- D Install diffusers to ductwork with air tight connection.
- E Provide balancing dampers on duct take-off to diffusers, and grilles and registers, despite whether dampers are specified as part of the diffuser, or grille and register assembly.
- F Paint ductwork visible behind air outlets and inlets matte black. Refer to Section 09 91 23.
- G Inspect areas to receive louvers. Notify the Architect of conditions that would adversely affect the installation or subsequent utilization of the louvers. Do not proceed with installation until unsatisfactory conditions are corrected.
- H Install louvers plumb, level, and in alignment with adjacent work.
- I The supporting structure shall be designed to accommodate the point loads transferred by the louvers when subject to the design wind loads. Coordinate with the General Contractor and Framing Contractor.

**END OF SECTION 23 37 00**

**SECTION 23 74 00**  
**ROOFTOP PACKAGED DX UNIT**

**PART 1 GENERAL**

**1.01 GENERAL DESCRIPTION**

- A This section includes the design, controls and installation requirements for packaged rooftop units / outdoor air handling units.

**1.02 REFERENCE STANDARDS**

- A AHRI Standard 920 (I-P) 2015 - Standard for Performance Rating of DX - Dedicated Outdoor Air System Units

**1.03 QUALITY ASSURANCE**

- A Packaged air-cooled condenser units shall be certified in accordance with ANSI/AHRI Standard 340/360 performance rating of commercial and industrial unitary air-conditioning and heat pump equipment.
- B Packaged air-cooled condenser units shall be certified in accordance with AHRI Standard 920 performance rating of DX Dedicated Outdoor Air System Units.
- C Unit shall be certified in accordance with UL Standard 1995/CSA C22.2 No. 236, Safety Standard for Heating and Cooling Equipment.
- D Unit and refrigeration system shall comply with ASHRAE 15, Safety Standard for Mechanical Refrigeration.
- E Unit Energy Efficiency Ratio (EER) shall be equal to or greater that prescribed by ASHRAE 90.1, Energy Efficient Design of New Buildings except Low-Rise Residential Buildings.
- F Unit shall be safety certified by ETL and ETL US listed. Unit nameplate shall include the ETL/ETL Canada label.

**1.04 SUBMITTALS**

- A Product Data: Literature shall be provided that indicates dimensions, operating and shipping weights, capacities, ratings, fan performance, filter information, factory supplied accessories, electrical characteristics and connection requirements. Installation, Operation, and Maintenance manual with startup requirements shall be provided.
- B Shop Drawings: Unit drawings shall be provided that indicate assembly, unit dimensions, construction details, clearances and connection details. Computer generated fan curves for each fan shall be submitted with specific design operation point noted. Wiring diagram shall be provided with details for both power and control systems and differentiate between factory installed and field installed wiring.

**1.05 COORDINATION**

- A If equipment is supplied by a manufacturer other than the one named, coordinate with the General Contractor and affected subcontractors to ensure the specified performance is met. This coordination shall include (but is not limited to) the following:
  1. Structural supports for units.
  2. Size and location of concrete bases/housekeeping pads
  3. Location of roof curbs, unit supports and roof penetrations
  4. Ductwork sizes and connection locations
  5. Piping size and connection/header locations
  6. Interference with existing or planned ductwork, piping and wiring
  7. Electrical power requirements and wire/conduit and over current protection sizes.
  8. Trap height requirements
- B The Mechanical Contractor shall be responsible for costs incurred by the General Contractor, Subcontractors, and Consulting Engineers to accommodate units furnished by a manufacturer other than manufacturer named as basis of design.

**1.06 DELIVERY, STORAGE, AND HANDLING**

- A Unit shall be shipped with doors screwed shut and outside air hood closed to prevent damage during transport and thereafter while in storage awaiting installation.
- B Follow Installation, Operation, and Maintenance manual instructions for rigging, moving, and unloading the unit at its final location.

- C Unit shall be stored in a clean, dry place protected from construction traffic in accordance with the Installation, Operation, and Maintenance manual.

**1.07 WARRANTY**

- A Manufacturer shall provide a limited “parts only” warranty for a period of 12 months from the date of equipment startup or 18 months from the date of original equipment shipment from the factory, whichever is less. Warranty shall cover material and workmanship that prove defective, within the specified warranty period, provided manufacturer’s written instructions for Installation, Operation, and maintenance have been followed. Warranty excludes parts associated with routine maintenance, such as belts and filters.

**PART 2 PRODUCTS**

**2.01 MANUFACTURERS:**

- A AAON
- B Addison
- C Greenheck
- D Tempmaster
- E Valent
- F Or Approved Equal
- G Substitute equipment may be considered for approval that includes at a minimum:
  - 1. R-454B refrigerant
  - 2. Variable capacity compressor with 15-100% capacity control
  - 3. Direct drive supply fans
  - 4. Double wall cabinet construction
  - 5. Insulation with a minimum R-value of 13.0
  - 6. Stainless steel drain pans

**2.02 ROOFTOP UNITS**

- A General Description
  - 1. Packaged rooftop unit shall include compressors, evaporator coils, filters, supply fans, dampers, air-cooled condenser coils, condenser fans, reheat coil, exhaust fans, and unit controls.
  - 2. Unit shall be factory assembled and tested including leak testing of the DX coils, pressure testing of the refrigeration circuit, and run testing of the completed unit. Run test report shall be supplied with the unit in the service compartment’s literature pocket.
  - 3. Unit shall have decals and tags to indicate lifting and rigging, service areas and caution areas for safety and to assist service personnel.
  - 4. Unit components shall be labeled, including refrigeration system components and electrical and controls components.
  - 5. Estimated sound power levels (dB) shall be shown on the unit ratings sheet.
  - 6. Installation, Operation, and Maintenance manual shall be supplied within the unit.
  - 7. Laminated color-coded wiring diagram shall match factory installed wiring and shall be affixed to the interior of the control compartment’s hinged access door.
  - 8. Unit nameplate shall be provided in two locations on the unit, affixed to the exterior of the unit and affixed to the interior of the control compartment’s hinged access door.
- B Performance
  - 1. Refer to Schedule on Drawings for equipment capacities, ambient conditions, etc.
  - 2. Unit performance shall be rated in accordance with AHRI 920. Manufacturer shall provide the Integrated Seasonal Moisture Removal Efficiency (ISMRE). Efficiency shall comply with ASHRAE 90.1-2016.
- C Construction
  - 1. All cabinet walls, access doors, and roof shall be fabricated of double wall, impact resistant, rigid polyurethane foam panels.
  - 2. Unit insulation shall have a minimum thermal resistance R-value of 13. Foam insulation shall have a minimum density of 2 pounds/cubic foot and shall be tested in accordance with ASTM D1929-11.

3. Unit construction shall be double wall with G90 galvanized steel on both sides and a thermal break. Double wall construction with a thermal break prevents moisture accumulation on the insulation, provides a cleanable interior, prevents heat transfer through the panel, and prevents exterior condensation on the panel.
  4. Unit shall be designed to reduce air leakage and infiltration through the cabinet. Cabinet leakage shall not exceed 1% of total airflow when tested at 3 times the minimum external static pressure provided in AHRI Standard 340/360. Panel deflection shall not exceed L/240 ratio at 125% of design static pressure, at a maximum 8 inches of positive or negative static pressure, to reduce air leakage. Deflection shall be measured at the midpoint of the panel height and width. Continuous sealing shall be included between panels and between access doors and openings to reduce air leakage. Piping and electrical conduit through cabinet panels shall include sealing to reduce air leakage.
  5. Roof of the air tunnel shall be sloped to provide complete drainage. Cabinet shall have rain break overhangs above access doors.
  6. Access to filters, dampers, cooling coils, reheat coil, exhaust fans, energy recovery wheels, compressors, and electrical and controls components shall be through hinged access doors with quarter turn, zinc cast, lockable handles. Full length stainless steel piano hinges shall be included on the doors.
  7. Exterior paint finish shall be capable of withstanding at least 2,500 hours, with no visible corrosive effects, when tested in a salt spray and fog atmosphere in accordance with ASTM B 117-95 test procedure.
  8. Units with cooling coils shall include double sloped 304 stainless steel drain pans.
  9. Unit shall be provided with horizontal discharge and return air openings. All openings through the base pan of the unit shall have upturned flanges of at least 1/2 inch in height around the opening.
  10. Unit shall include lifting lugs on the top of the unit.
- D Electrical
1. Unit shall be provided with factory installed and factory wired, non-fused disconnect switch.
  2. Unit shall be provided with a factory installed and factory wired 115V, 12 amp GFI outlet disconnect switch in the unit control panel.
  3. Unit shall be provided with phase and brown out protection which shuts down all motors in the unit if the electrical phases are more than 10% out of balance on voltage, the voltage is more than 10% under design voltage or on phase reversal.
- E Motorized Dampers
1. Frame shall be constructed of a 16 gage galvanized steel hat-channel.
  2. Blades shall be constructed of 16 gage galvanized steel strengthened by three longitudinal 1 inch deep "vee" grooves.
  3. Blades shall be symmetrical relative to its axle pivot point.
  4. Axle bearings shall be synthetic sleeve-type and rotate inside extruded holes in the damper frame.
  5. Blade seals shall be extruded vinyl permanently bonded to the appropriate blade edges.
  6. Frame shall include flexible stainless steel compression-type jamb seals.
  7. Modulating spring-return actuators shall be provided by the factory, installed on the damper, and wired to the control center. Each damper shall have a dedicated actuator. Single actuators with gear trains are not acceptable.
  8. Damper leakage shall be no more than 3 cfm/sq.ft. at 1 in.wg static pressure.
- F Supply Fans (VFD)
1. Unit shall include direct drive, unhooded, backward curved, plenum supply fans.
  2. Blowers and motors shall be dynamically balance and mounted on rubber isolators.
  3. Motors shall be premium efficiency ODP with ball bearings rated for 200,000 hours service with external lubrication points.
  4. Variable frequency drives shall be factory wired and mounted in the unit. Fan motors shall be premium efficiency.
  5. Fan wheel shall be tested in accordance to AMCA 210.
- G Supply Fans (EC Motors)

1. Fan assemblies shall be direct-drive without the use of belts or adjustable sheaves.
  2. Fan wheels shall be constructed of a high-performance composite material with airfoil blades.
  3. Fan wheel shall be tested in accordance to AMCA 210. Fan speed shall not exceed 2400 RPM.
  4. Fans are full width.
  5. Fans shall be rigidly mounted to structural base.
  6. Motor shall have an IP54 protection rating at a minimum and be electronically commutated (EC) with integral speed controller. VFDs combined with a permanent magnet motor is not an acceptable alternative due to size, weight, and complexity increases.
- H Cooling Coils
1. DX Evaporator Coils
    - a. Coil shall be rated in accordance to AHRI standards, designed to withstand 250 psig working pressure at 300 degrees F, and pressure tested to 600 psig.
    - b. Coils shall be designed for use with R-454B refrigerant and constructed of copper tubes with aluminum fins mechanically bonded to the tubes and galvanized steel end casings. Fin design shall be sine wave rippled.
    - c. Coils shall have interlaced circuitry and shall be standard capacity.
    - d. Coils shall have interlaced circuitry and shall be minimum 6 row high capacity.
    - e. Coils shall be hydrogen or helium leak tested.
    - f. Coils shall be furnished with factory installed expansion valves.
- I Gas Heating:
1. Unit shall be provided with AGA-certified, induced-draft, 3:1 or 6:1 or 5:1 or 10:1 turndown indirect gas furnace. Turndown as listed on schedule.
  2. Furnace assembly shall include the following items:
    - a. Electronic modulating gas valve.
    - b. Two-speed combustion fan.
    - c. Stainless steel heat exchanger.
  3. Contractor shall provide final gas regulator for each unit
- J Hot Gas Reheat Coil
1. Hot-gas reheat coil shall be separated from the evaporator coil by a minimum of 6" in the direction of airflow to prevent the re-evaporation of condensate, provide room for coil cleaning, and allow control system to monitor evaporator coil leaving dew point temperature.
  2. Coil shall be rated in accordance to AHRI standards, designed to withstand 250 psig working pressure at 300 degrees F, and pressure tested to 600 psig.
  3. Coil casing shall be constructed of 16 gage galvanized steel or 304 stainless steel.
  4. Coil tubes shall be constructed of 5/16" diameter, 0.012" thick seamless copper tubing.
  5. Coil fins shall be constructed of 0.0060" thick aluminum fins.
  6. Hot-gas reheat shall be controlled through a factory-supplied and controlled modulating 3-way valve.
  7. Coil shall be hydrogen or helium leak tested.
- K Refrigeration System
1. Unit shall be factory charged with R-454B refrigerant.
  2. Compressors shall be scroll type with thermal overload protection and carry a 5 year non-prorated warranty, from the date of original equipment shipment from the factory.
  3. Compressors shall be mounted in an isolated service compartment which can be accessed without affecting unit operation. Lockable hinged compressor access doors shall be fabricated of double wall, rigid polyurethane foam injected panels to prevent the transmission of noise outside the cabinet.
  4. Compressors shall be isolated from the base pan with the compressor manufacturer's recommended rubber vibration isolators, to reduce any transmission of noise from the compressors into the building area.
  5. Each refrigeration circuit shall be equipped with expansion valve type refrigerant flow control.
  6. Each refrigeration circuit shall be equipped with automatic reset low pressure and manual reset high pressure refrigerant safety controls, Schrader type service fittings on both the high pressure and low

pressure sides and a factory installed replaceable core liquid line filter driers.

7. Unit shall include a variable capacity scroll compressor on the lead refrigeration circuit which shall be capable of modulation from 10-100% of its capacity.
8. Lead refrigeration circuit shall be provided with hot gas reheat coil, modulating valves, electronic controller, supply air temperature sensor and a control signal terminal which allow the unit to have a dehumidification mode of operation, which includes supply air temperature control to prevent supply air temperature swings and overcooling of the space.

**L Condensers**

**1. Air-Cooled Condenser**

- a. Condenser fans shall be a vertical discharge, axial flow, direct drive fans.
- b. Coils shall be designed for use with R-454B refrigerant. Coils shall be multi-pass and fabricated from aluminum microchannel tubes.
- c. Outdoor coil shall be constructed of copper tubes with aluminum fins mechanically bonded to the tubes and aluminum end casings. Fin design shall be sine wave rippled.
- d. Coils shall be designed for a minimum of 10°F of refrigerant sub-cooling.
- e. Coils shall be hydrogen or helium leak tested.
- f. Condenser fans shall be high efficiency electrically commutated motor driven with factory installed head pressure control module. Condenser airflow shall continuously modulate based on head pressure and cooling operation shall be allowed down to 35°F with adjustable compressor lockout.
- g. Condenser fans shall be VFD driven variable speed for condenser head pressure control. Factory provided and factory programmed VFDs shall continuously modulate the fan air flow to maintain head pressure at acceptable levels. Cooling operation shall be allowed down to 35°F with adjustable compressor lockouts.

**M Filters**

1. Outdoor air hood shall have a aluminum mesh filter section.
2. Unit shall include 2 inch thick, pleated panel filters with an ASHRAE efficiency of 30% and MERV rating of 13, upstream of the cooling coil.
3. Unit shall include 0-100% economizer consisting of a motor operated outside air damper and return air damper assembly constructed of extruded aluminum, hollow core, airfoil blades with rubber edge seals and aluminum end seals. Damper blades shall be gear driven and designed to have no more than 20 cfm of leakage per sq ft. at 4 in. w.g. air pressure differential across the damper. Low leakage dampers shall be Class 2 AMCA certified, in accordance with AMCA Standard 511. Damper assembly shall be controlled by spring return enthalpy activated fully modulating actuator. Unit shall include outside air opening bird screen, outside air hood, and barometric relief dampers.
4. Economizer shall be furnished with return air CO2 override.

**N Controls**

**1. Factory Installed Controller**

- a. The unit shall come with a factory programmed and supplied controller that provide all programming and functionality for the unit to operate, including internal safeties.
- b. All sensors required for the operation of the unit shall be factory furnished. This includes outside air temperature and humidity sensors, supply air temperature and humidity sensors, coil suction pressure and temperature sensors, space temperature and humidity sensors, preheat discharge temperature sensor, and other sensors as required to implement the sequence of operations. Refer to sequence on Drawings.

**O Accessories**

1. Unit shall be provided with a smoke detector in the supply of the unit, wired to shut off the unit's control circuit.
2. Provide factory installed R-454B refrigerant Leak Detection Sensor:
  - a. A factory-installed A2L class gas sensor designed for R454B refrigerant detection shall be installed in the DX coil sections selected with R454B refrigerant. It shall utilize thermal

conductivity technology for quick and accurate leak detection and features automated self-calibration, self-diagnostics, immunity to poisoning and a 15-year life. The sensor shall come set with a 15% LFL alarm threshold with +/-2.5% accuracy at 68°F (and +/-5% accuracy across the rest of the operating range of -40°F - 175°F).

**2.03 CURBS**

- A Curbs shall to be fully gasketed between the curb top and unit bottom with the curb providing full perimeter support, cross structure support and air seal for the unit. Curb gasket shall be furnished within the control compartment of the rooftop unit to be mounted on the curb immediately before mounting of the rooftop unit.
- B Height of curb shall be at least the minimum required to accommodate the horizontal discharge openings.
- C Solid bottom curb shall be factory assembled and fully lined with 1 inch neoprene coated fiberglass insulation and include a wood nailer strip. Curb shall be adjustable up to 3/4 inch per foot to allow for sloped roof applications.

**PART 3 EXECUTION**

**3.01 INSTALLATION, OPERATION, AND MAINTENANCE**

- A Installation, Operation, and Maintenance manual shall be supplied with the unit.
- B Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- C Examine casing insulation materials and filter media before air-to-air energy recovery equipment installation. Reject insulation materials and filter media that do not comply, or are wet, moisture damaged, or mold damaged.
- D Install units with clearances for service and maintenance.
- E Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- F Installing contractor shall install unit, including field installed components, in accordance with Installation, Operation, and Maintenance manual instructions.
- G Start up and maintenance requirements shall be complied with to ensure safe and correct operation of the unit.

**3.02 OWNER TRAINING**

- A Location: Job site
- B An authorized manufacturer's representative shall conduct the training session.
- C Provide minimum four (4) hours training for six (6) people.
- D Provide video recording of the training session. Turn over video to Owner at the conclusion of the project.

**END OF SECTION 23 74 00**

**SECTION 23 81 26.13**  
**SMALL-CAPACITY SPLIT-SYSTEM AIR CONDITIONERS**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A Air-source heat pumps.
- B Air cooled condensing units.
- C Indoor air handling (fan and coil) units for ductless systems.
- D Controls.

**1.02 REFERENCE STANDARDS**

- A AHRI 210/240 - Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment; 2023.
- B AHRI 520 - Performance Rating of Positive Displacement Condensing Units; 2004.
- C ASHRAE Std 15 - Safety Standard for Refrigeration Systems; 2022, with Addendum (2024).
- D ASHRAE Std 23.1 - Methods for Performance Testing Positive Displacement Refrigerant Compressors and Condensing Units that Operate at Subcritical Pressures of the Refrigerant; 2019.
- E NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems; 2021.
- F NFPA 90B - Standard for the Installation of Warm Air Heating and Air-Conditioning Systems; 2021.
- G UL 207 - Standard for Refrigerant-Containing Components and Accessories, Nonelectrical; Current Edition, Including All Revisions.

**1.03 SUBMITTALS**

- A Product Data: Provide rated capacities, weights, accessories, electrical nameplate data, and wiring diagrams.
- B Shop Drawings: Indicate assembly, required clearances, and location and size of field connections.
- C Design Data: Indicate refrigerant pipe sizing.
- D Warranty: Submit manufacturers warranty and ensure forms have been filled out in Owner's name and registered with manufacturer.

**1.04 QUALITY ASSURANCE**

- A Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.

**1.05 WARRANTY**

- A Provide five year manufacturers warranty for compressors.

**PART 2 PRODUCTS**

**2.01 SYSTEM DESIGN**

- A Split-System Heating and Cooling Units: Self-contained, packaged, matched factory-engineered and assembled, pre-wired indoor and outdoor units; UL listed.
  - 1. Heating and Cooling: Air-source electric heat pump located in outdoor unit with evaporator.
  - 2. Provide refrigerant lines internal to units and between indoor and outdoor units, factory cleaned, dried, pressurized and sealed, with insulated suction line.
- B Performance Requirements: See Drawings for additional requirements.

**2.02 INDOOR AIR HANDLING UNITS FOR DUCTLESS SYSTEMS**

- A Manufacturer
  - 1. Carrier
  - 2. Daikin
  - 3. Fujitsu
  - 4. LG
  - 5. Mitsubishi
  - 6. Samsung
  - 7. Trane
  - 8. Or Approved Equal
- B Indoor Units: Self-contained, packaged, factory assembled, pre-wired unit consisting of cabinet, supply fan, evaporator coil, and controls; wired for single power connection with control transformer.



- C Evaporator Coils: Copper tube aluminum fin assembly, galvanized or polymer drain pan sloped in all directions to drain, drain connection, refrigerant piping connections, restricted distributor or thermostatic expansion valve.
  - 1. Construction and Ratings: In accordance with AHRI 210/240 and UL 207.
  - 2. Manufacturer: System manufacturer.
- D Remote Actuators:

**2.03 OUTDOOR UNITS**

- A Outdoor Units: Self-contained, packaged, pre-wired unit consisting of cabinet, with compressor and condenser.
  - 1. Comply with AHRI 210/240.
  - 2. Refrigerant: R-410A or R-454B.
  - 3. Cabinet: Galvanized steel with baked enamel finish, easily removed and secured access doors with safety interlock switches, glass fiber insulation with reflective liner.
  - 4. Construction and Ratings: In accordance with AHRI 210/240 with testing in accordance with ASHRAE Std 23.1 and UL 207.
- B Compressor: Hermetic, two speed 1800 and 3600 rpm, AHRI 520 resiliently mounted integral with condenser, with positive lubrication, crankcase heater, high pressure control, motor overload protection, service valves and drier. Provide time delay control to prevent short cycling and rapid speed changes.
- C Air Cooled Condenser: Aluminum fin and copper tube coil, AHRI 520 with direct drive axial propeller fan resiliently mounted, galvanized fan guard.
  - 1. Condenser Fans: Direct-drive propeller type.
- D Coil: Air-cooled, aluminum fins bonded to copper tubes.
- E Accessories: Filter drier, high pressure switch (manual reset), low pressure switch (automatic reset), service valves and gauge ports, thermometer well (in liquid line).
  - 1. Provide thermostatic expansion valves.
  - 2. Provide heat pump reversing valves.
- F Operating Controls:
  - 1. Control by room thermostat to maintain room temperature setting.
  - 2. Low Ambient Kit: Provide refrigerant pressure switch to cycle condenser fan on when condenser refrigerant pressure is above 285 psig and off when pressure drops below 140 psig for operation to 0 degrees F.

**2.04 ACCESSORY EQUIPMENT**

- A Room Thermostat: Wall-mounted, electric solid state microcomputer based room thermostat with remote sensor to maintain temperature setting; low-voltage; with following features:
  - 1. Automatic switching from heating to cooling.
  - 2. Preferential rate control to minimize overshoot and deviation from setpoint.
  - 3. Instant override of setpoint for continuous or timed period from one hour to 31 days.
  - 4. Short cycle protection.
  - 5. Programming based on every day of the week.
  - 6. Selection features including degree F or degree C display, 12 or 24 hour clock, keyboard disable, remote sensor, fan on-auto.
  - 7. Battery replacement without program loss.
  - 8. Thermostat Display:
    - a. Actual room temperature.
    - b. Programmed temperature.
    - c. System Mode Indication: Heating, Cooling, Fan Auto, Off, and On, Auto or On, Off.

**PART 3 EXECUTION**

**3.01 INSTALLATION**

- A Install in accordance with NFPA 90A and NFPA 90B.
- B Install refrigeration systems in accordance with ASHRAE Std 15.

- C Pipe drain from cooling coils to nearest floor drain or building exterior as shown on the Drawings.

**3.02 OWNER TRAINING**

- A Location: Job site
- B An authorized manufacturer's representative shall conduct the training session.
- C Provide minimum four (4) hours training for six (6) people.
- D Provide video recording of the training session. Turn over video to Owner at the conclusion of the project.

**END OF SECTION 23 81 26.13**

**SECTION 23 82 00**  
**CONVECTION HEATING AND COOLING UNITS**

**PART 1 GENERAL**

**1.01 SECTION INCLUDES**

- A Electric unit heaters.

**1.02 REFERENCE STANDARDS**

- A AHRI 410 - Forced-Circulation Air-Cooling and Air-Heating Coils; 2001, with Addenda (2011).

**1.03 SUBMITTALS**

- A Product Data: Provide typical catalog of information including arrangements.
- B Shop Drawings:
  - 1. Indicate cross sections of cabinets, grilles, bracing and reinforcing, and typical elevations.
  - 2. Indicate air coil and frame configurations, dimensions, materials, rows, connections, and rough-in dimensions.
  - 3. Submit schedules of equipment and enclosures typically indicating length and number of pieces of element and enclosure, corner pieces, end caps, cap strips, access doors, pilaster covers, and comparison of specified heat required to actual heat output provided.
  - 4. Indicate mechanical and electrical service locations and requirements.
- C Certificates: Certify that coils are tested and rated in accordance with AHRI 410.

**1.04 QUALITY ASSURANCE**

- A Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.
- B Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

**PART 2 PRODUCTS**

**2.01 ELECTRIC UNIT HEATERS**

- A Manufacturers:
  - 1. INDEECO (Industrial Engineering and Equipment Company)
  - 2. Modine Manufacturing Company
  - 3. Trane, a brand of Ingersoll Rand
  - 4. Markel
  - 5. REDD-I
  - 6. Raywall
  - 7. Or Approved Equal
- B Provide products listed, classified, and labeled by Underwriters Laboratories Inc. (UL), Intertek (ETL), or testing firm acceptable to Authority Having Jurisdiction as suitable for the purpose indicated.
- C Heating Element Assembly:
  - 1. Thermal safety cut-out within electric terminal box with automatically reset switch located near electric terminal box.
  - 2. Horizontal Projection Units:
    - a. Nickel chromium resistance wire surrounded with magnesium oxide and sheathed in steel, spiral-finned tubes.
    - b. High-mass, all steel tubular type, copper brazed, centrally located and installed in fixed element banks.
- D Housing:
  - 1. Suitable for ceiling or high altitude mount using provided hardware appendages.
  - 2. Horizontal Projection Units:
    - a. Construction materials to consist of heavy gauge steel with galvanized, polyester powder coat, or high gloss baked enamel finish.
    - b. Provide with threaded holes for threaded rod suspension.
    - c. Provisions for access to internal components for maintenance, adjustments, and repair.
- E Air Inlets and Outlets:

1. Inlets: Provide stamped louvers or protective grilles with fan blade guard.
  2. Outlets: Provide diffuser cones, directional louvers, or radial diffusers.
- F Fan: Factory balanced, direct drive, axial type with fan guard.
- G Motor: Totally enclosed, thermally protected, and provided with permanently lubricated bearings.
- H Controls:
1. 24-volt auxiliary relay.
  2. Terminal block for remote control.
  3. 2-speed fan switch.
  4. Built-in thermostat for wall mounted units. Remote low-voltage thermostat for suspended units.

**PART 3 EXECUTION**

**3.01 EXAMINATION**

- A Verify that surfaces are suitable for installation.

**3.02 INSTALLATION**

- A Install in accordance with manufacturer's recommendations.
- B All coils, fan coils, unit heaters, and other devices shall be fully accessible for cleaning and servicing. Contractor shall coordinate accessibility with other trades.
- C Unit Heaters:
1. Hang from building structure, with pipe hangers anchored to building, not from piping or electrical conduit.
  2. Mount as high as possible to maintain greatest headroom unless otherwise indicated.
- D Units with Electric Heating Elements:
1. Install as indicated including electrical devices furnished by manufacturer but not factory installed.

**3.03 CLEANING**

- A After construction and painting is completed, clean exposed surfaces of units.
- B Touch-up marred or scratched surfaces of factory-finished cabinets using finish materials furnished by the manufacturer.

**3.04 PROTECTION**

- A Provide finished cabinet units with protective covers during the balance of construction.

**END OF SECTION 23 82 00**