SECTION 230100 - GENERAL MECHANICAL REQUIREMENTS

PART 1 - GENERAL

1.01 SUMMARY

A. Division 23 includes Division 23 01 00 of the Specifications and Mechanical Drawings (HVAC). Elements of the Scope of Work include, but are not limited to, labor, materials, equipment, supplies, storage, transportation and all required permits, fees and licenses. Division 23 does not stand alone, but is part of the complete project and its Documents. Requirements of the General Conditions and Division 1 apply to all work in the Division.

B. Provide the necessary interface with other Divisions to provide a complete project. Carefully check the Documents of this Division with those Documents of other Divisions. Determine the requirements of any interfacing materials or equipment being furnished and/or installed by those Sections and Divisions, and provide proper installation and required interface.

C. No deviation from the Contract Documents shall be made without the written consent of the Architect and Engineer.

D. All Specifications and Drawings are to be considered together as the Contract Documents. Any work shown in one and not the other, or is implied by either, shall be provided to make a complete project. Should conflicts exist between the Specifications and Drawings or there is an item shown or noted for which is not clearly defined, immediately submit a request for clarification. Under no circumstance will conflicts between the Specifications and Drawings be grounds for additional cost to the Contract after the Contract is established.

E. The Drawings are schematic and are not intended to show the exact location of duct, piping, equipment, etc.

F. Dimensions and information regarding accurate locations of equipment, and structural limitations and finish shall be coordinated and verified with other Divisions of Work. Be prepared to furnish dimensions and information regarding the Work of this Division to other trades.

G. The right is reserved to relocate any device (receptacle, switch, fire alarm, audio/visual, junction box, outlet, etc.) a maximum of 10'-0" before it is permanently installed without incurring additional cost to the Contract.

1.02 REFERENCE STANDARDS

A. All work shall comply with the most recently revised versions of all local, state and federal codes, ordinances of the authority having jurisdiction, laws, rules and regulations. Any modifications required by any of the above shall be made without any additional cost to the Owner. Where

requirements between governing Codes and Regulations vary, the more restrictive provision shall apply.

B. Nothing contained in the Contract Documents shall be construed as authority or permission to disregard legal requirements and regulations. The Contractor shall thoroughly review the Documents and bring any such conflicts to the attention of the Architect and Engineer prior to Installation.

C. All materials, installation, and workmanship shall comply standards and/or codes of the following:
1. International Building Code – 2018 edition, with latest Georgia amendments
2. International Mechanical Code - 2018 edition, with latest Georgia amendments
3. International Plumbing Code - 2018 edition, with latest Georgia amendments
4. International Fuel Gas Code - 2018 edition, with latest Georgia amendments
5. International Fire Code - 2018 edition, with latest Georgia amendments
6. International Energy Conservation Code - 2015 edition, with latest Georgia amendments
7. National Electrical Code, 2020 edition
8. National Fire Protection Association
9. State of Georgia (ANSI 117.1) Handicap Code
10. ANSI - American National Standards Institute
11. ASTM - American Society of Testing and Materials
12. NEMA - National Electrical Manufacturer's Association
13. OSHA - Occupational Safety and Health Act
14. UL - Underwriter's Laboratories
15. ASHRAE - American Society of Heating and Air Conditioning Engineers
16. SMACNA - Sheet Metal and Air Conditioning Contractors' Nat'l Assoc.

D. All materials shall be new and shall bear the label of UL.

1.03 EXISTING CONDITIONS

A. Where work is to be performed in an existing facility, the contractor shall visit the site prior to bid and be familiar with all existing conditions. Special attention shall be given to work to be performed above an existing ceiling.

B. Where existing slabs are to be cut or core drilled, the contractor shall x-ray the existing slabs to avoid cutting or disrupting existing conduits, cables, plumbing or structural members.

C. HVAC systems, plumbing systems, and electrical service to the building shall not be interrupted without written consent of the building owner.

D. No allowance will be made for lack of knowledge of existing conditions.

E. At the completion of the project, all work under this Division shall be completely integrated with the existing systems and left in perfect operating condition.

F. Where work under this Division disrupts the continuity of any existing to remain electrical circuit or feeder, the Contractor shall repair/replace as necessary to return to a perfectly functional and safe operating condition.

G. Prior to any demolition or construction the Contractor shall have the existing conditions inspected by an EPA, OSHA certified asbestos abatement agency to identify the presence of asbestos. Should any asbestos be found it shall be brought to the immediate attention of the Architect and Owner and specifically identified in writing.

1.04 DEFINITIONS

A. Provide: to furnish, install and connect.

B. Furnish: to supply all materials, labor, equipment, testing apparatus, controls, tests, accessories and all other items customarily required for the proper and complete application.

C. Install: to join, unite, fasten, link, attach, set-up or connect together, complete, tested, and ready for normal satisfactory operation.

D. Engineer: the Engineer of record.

E. Contract Documents: the complete set of Specifications and Drawings of all Divisions.

F. Work: labor, materials, equipment, accessories, controls and other items required for a complete installation.

G. Concealed: embedded in masonry or other construction, installed in furred spaces, within double partitions or hung ceilings, in trenches, in crawl spaces or in enclosures.

H. Exposed: not installed underground or concealed.

I. Equal: equal in quality, workmanship, materials, weight, size, design and efficiency of the specified product, conforming with manufacturers.

J. Supply: to purchase, procure, acquire and deliver complete with related accessories.

K. Authority Having Jurisdiction (AHJ): applicable local, state and federal authorities having jurisdiction over any part of the Scope within this Division and other Divisions.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Manufacturer's names and catalog numbers specified in the Contract Documents are intended to describe the material and set the standard of quality. All bids shall be based on material specified. Request for approval of material not specified shall be considered if the request is in written form and submitted to the Architect no later than fourteen (14) days prior to the bid date. All requests shall conform to the provisions of the general and supplementary conditions.

B. When specific names are not stated, only the best available quality of material or equipment shall be submitted for review and used in the installation.

2.02 BASIS OF DESIGN

A. Where a product is designated as "BASIS OF DESIGN", the Contractor is notified that mechanical, electrical, structural, architectural, space conditions and/or other features of the overall project design have been based on the requirements of the "BASIS OF DESIGN" product.

B. Where a product is substituted for a "BASIS OF DESIGN" product, the Contractor shall notify the design team that changes in project design may be mandatory in order to permit use and installation of the substitute product. Shop drawing submittal for a substitute product shall include a complete schedule of changes in project design, if any, which must be made in order to permit use and installation of the substitute product. The Contractor shall be responsible for the coordination of all trades for use of the substituted product. The Contractor shall bear all expenses related to the use of a substitute product.

2.03 SHOP DRAWINGS AND PRODUCT DATA

A. The Contractor shall obtain complete shop drawings, product data and samples from the manufacturers, suppliers, vendors, and all Division 23 Subcontractors, for all materials and equipment as specified herein in various Sections of the Specifications, and shall submit data and details of such materials and equipment for review by the Architect and Engineer. Prior to submission of the shop drawings, product data and samples to the Architect and Engineer, the Contractor shall thoroughly review the shop drawings, product data and samples and certify they are in compliance with the Contract Drawings. Further, the Contractor shall check all materials and equipment upon their arrival on the Project site and verify their condition and compliance with the Contract Documents. Any Work which proceeds prior to receiving reviewed shop drawings shall be modified as required to comply with the Contract Documents and the shop drawings. A minimum period of ten (10) working days, exclusive of transmittal time, will be required in the Engineer's office each time a shop drawing, product data and/or sample is submitted or resubmitted for review. This time period shall be considered by the Contractor when scheduling his Work. The initial shop drawing review for equipment and

materials may be expedited through the mutual consent of the Contractor, Architect, Engineer, and Owner providing the Contractor agrees to submit complete, certified, documented, and coordinated shop drawings for review in accordance with the requirements of the Contract Documents.

B. The review of shop drawings, product data, and samples by the Architect and Engineer shall not relieve the Contractor of the responsibility for dimensions or errors that may be contained therein, or for deviations from requirements in the Contract Documents. It shall be clearly understood that the noting of some errors by the Engineer but overlooking others does not grant the Contractor permission to proceed in error.

C. All shop drawings and product data/submittals shall be submitted in compliance with the requirements of the general and supplementary conditions. No more than four (4) copies of submittal data will be reviewed. Any additional copies will be returned unmarked. The responsibility of copying review comments on any additional copies will rest solely with the Contractor.

D. All product data/submittals shall bear the name of the manufacturer to be used.

E. All shop drawings and submittals shall include a stamped indication signifying that the submittal has been reviewed for compliance with the Contract Documents by the Contractor. This stamped indication also represents the fact that the Contractor has checked this submittal for its interaction with all other Divisions and certifies by his signature or initials that all coordination has taken place. The stamp shall include the date, name of the Contracting Firm, the signature of the Contractor, certification of compliance and approval. This stamp shall be on the submittal before the Engineer will review it.

F. The Engineer will review an individual submittal not more than twice. If the submittal is rejected again on the second review, the Contractor will bare all responsibility for paying for the Engineer's time for additional reviews. Such payments to the Engineer shall be withheld from the next monthly pay application.

G. Shop drawings and/or product data shall be submitted for the following for review:

1. HVAC duct system layouts, including supply air, return air, exhaust air, and outside air. HVAC piping system layouts. These drawings must include associated equipment, drawn to scale based on submittals for that equipment, must be dimensioned, and must include duct, piping and equipment elevation tags (distance above finished floor to bottom).
   The Contractor is encouraged to develop their own shop drawings, without having have had the Engineer's CAD files (as previously stated, the Engineer's drawings are schematic/diagrammatic in nature). Should the Contractor insist on using the Engineer's CAD files in the procurement of shop

drawings, the Contractor must pay the Engineer $ 150.00 per sheet for the CAD files.
The Contractor shall give the Engineer a written release, acceptable to the Engineer, signed by a corporate officer of the Contractor. This release shall also include a copyright statement indicating that these drawings or electronic data contained will not be used on any other project. The release and payment for the files must be received PRIOR to delivery of the CAD files.

2. Equipment, including but not limited to: chillers, cooling towers, boilers, pumps, heat exchangers, rooftop units, split systems, fans, heaters, water-cooled self-contained units, water-source heat pumps, coils, air distribution devices (diffusers, etc.), air terminal units (PIU's, etc.), ductwork accessories, louvers, hoods, heat tracing, insulation, piping specialties, etc.

2.04 AS-BUILT DRAWINGS

A. The Contractor shall maintain on a daily basis at the Project site a complete set of "Record Drawings". The "Record Drawings" shall consist of a set of black-line or blue-line prints or AutoCAD files of the Contractor Coordination Drawings for this Division. The prints shall be marked or the AutoCAD file electronically updated to show the precise location of all work and equipment, and all changes and deviations in the work from that shown on the Contract Documents. This requirement shall not be construed as authorization for the Contractor to make changes in the layout or work without definite instructions from the Architect or Engineer. The continuously updated coordination drawings (shop drawings previously described) shall be used to produce the final "Record Drawings" which shall be delivered to the Owner in AutoCAD electronic format (CD) upon Project completion.

B. Record dimensions shall clearly and accurately delineate the work as installed; locations shall be suitably identified by at least two dimensions to permanent structures.

C. The Contractor and Subcontractor shall mark all "Record Drawings" on the drawings with a rubber stamp impression or an AutoCAD image that states such.

PART 3 - EXECUTION

3.01 INSTALLATION

A. The equipment selections used in the preparation of the Contract Documents will fit into the physical spaces provided and indicated, allowing ample room for access, servicing, removal and replacement of parts, etc. Adequate space shall be allowed for clearance in accordance with the Code requirements and the requirements of the local Authorities having jurisdiction, and the equipment manufacturer's recommendations.

B. In the preparation of Drawings, a reasonable effort to accommodate acceptable equipment manufacturer's space requirements has been made. However, since space requirements and equipment arrangement vary according to each manufacturer, the responsibility for initial access, maintenance access, code required access, and proper fit rests with the Contractor.

C. Physical dimensions and arrangements of equipment to be installed shall be subject to the Architect's and Engineer's review.

D. The General Contractor and all Subcontractors shall coordinate the installation of ductwork, conduit, busway, piping, cable trays, etc., installation with lighting fixtures, special ceiling construction, air distribution equipment, and the structure. Provide additional rises, drops and offsets as required. If after installed, new ductwork, conduit, busway, piping or cable is found to be in conflict with the architecture, structure, or other trade Work which is either existing or shown on the Contract Documents, the ductwork, conduit, busway, piping or cable shall be relocated without additional cost to the Owner.

E. No ductwork, piping, equipment, etc., shall be installed in the eight (8) inch high zone directly above the ceiling in tenant areas to allow for tenant build-out and flexibility unless otherwise specifically shown on the Drawings or prior written authorization is received from the Engineer.

F. Accessibility and Clearance:
   1. Mechanical equipment, ductwork, piping, etc. shall be installed in accessible locations, avoiding obstructions, preserving headroom, and keeping openings and passageways clear.
   2. Minor adjustments in the locations of equipment shall be made where necessary, providing such adjustments do not adversely affect functioning of the equipment.

G. Scaffolds and staging for installation of mechanical work shall be provided under the work of this Division.

3.02 STRUCTURAL FITTINGS

A. Furnish and install the necessary sleeves, inserts, hangers, anchor bolts, and related structural items. Install at the proper time.

B. Openings may have been indicated on the Architectural and Structural drawings. Should any additional openings or holes be required, the same shall be provided at no additional cost to the Owner.

C. Location: At a time in advance of the work, verify openings shown on the Architectural and Structural drawings, and coordinate any additional openings.

D. If the work of this Section requires modification of the Architectural or Structural drawings, furnish new instructions as to requirements for these openings. Submit for review and coordination to Architect.

E. Sleeves shall be supplied for mechanical piping passing through walls or slabs and shall be placed before concrete is poured.

F. Equipment supports for mechanical work shall be fastened to the structure by inserts, anchor bolts, bolting to drilled and tapped structural members, or be welded to the structure.
   1. Welding shall be done by the electric arc method with fully competent welders. Supporting members shall be shop coated with a suitable primer.
   2. Surfaces damaged by installation of supports shall be touched up with primer to match shop coat. Any drilling of structural members shall be approved by the Architect.

G. Flashing:
   1. Wherever ductwork and/or piping pass through the roof or outer walls, base flashing and counter-flashing shall be provided.
   2. Such flashing shall be properly installed by skilled workmen, and shall include grouting, mastic or tar application, or other means to insure a permanent, waterproof, neat and workmanlike installation.
   3. Insofar as possible, flashing shall comply with and be similar to requirements for flashing in General Construction Work.

H. Anchor bolts and inserts shall be galvanized and of adequate size and strength for installation of electrical work and shall be placed in forms before concrete is poured.
   1. Placement of bolts in bases shall be done under other Division. Furnish detail drawings, templates, and anchor bolts for bases to the General Contractor in time to avoid delaying work schedules.
   2. Expansion shields shall only be used with specific approval of the Architect. Wooden or soft metal plugs shall not be used.

I. Cutting and patching:
   1. All additional cutting, patching and reinforcement of construction of building, subject to review by the Architect, shall be performed under this Section.
   2. Refer to appropriate Division for requirements.

3.03 WEATHERPROOF EQUIPMENT

A. Mechanical devices or equipment located in damp, semi-exposed areas shall be weather-resistant. Enclosures shall comply with NEMA Type 3R requirements.

B. Air distribution devices located in damp areas outside shall be weather-resistant (aluminum, etc.).

3.04 CLEANING

A. Brush and clean work prior to concealing, painting and acceptance. Perform in stages if directed.

B. Painted exposed work soiled or damaged: Clean and repair to match adjoining work before final acceptance.

C. Remove dust and debris from inside and outside of material and equipment.

3.05 TESTS AND DEMONSTRATIONS

A. All systems shall be tested in the presence of the Owner or an Owner designated representative upon completion of the Work and demonstrates that the installation is in accordance with the Contract Documents.

B. All motors shall be checked and adjusted for correct direction of rotation.

C. Any work found not to be in compliance with the Contract documents shall be repaired or replaced without incurring additional cost to the Contract price.

D. Provide all instruction to the Owner on maintenance and operation of all systems and equipment provided under this Division.

3.06 WARRANTIES

A. The warranty period for all systems, equipment, components, work, etc. shall be no less than one (1) year, unless specified otherwise hereinafter and shall include at least one (1) full heating season and one (1) full cooling season. The warranty shall include parts and labor.

B. The Contractor shall, without cost to the Owner, remedy any defects within a reasonable time to be specified in notice from the Architect. In default thereof, the Owner may have such work done and charge all costs to the Contractor.

C. The start of the Contractor's warranty period, as defined in the General Conditions, shall commence on the issue of a "Certificate of Substantial Completion", by the Owner or the Owner's Representative for each item of material, equipment or system.

D. The Subcontractor shall confer with the General Contractor prior to the bid date concerning the project schedule and determine if there is a need to operate any items of equipment or systems for temporary heating and/or cooling or other reasons prior to "Substantial Completion". All required extended warranty costs for equipment, materials, and systems shall be included in the Subcontractor's bid.

END OF SECTION 230100

SECTION 230529 - HANGERS & SUPPORTS FOR HVAC PIPING & EQUIPMENT

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

A. The Conditions of the Contract and applicable requirements of Division 1, "General Requirements", and Section 23 01 00 "General Mechanical Requirements", govern this Section.

1.02 DESCRIPTION OF WORK

A. Work Included: Provide pipe hangers, supports, and required appurtenances as specified and indicated

1.03 QUALITY ASSURANCE

A. MSS Standard Compliance: Provide pipe hangers and supports of materials, design, and manufacture which comply with ANSI/MSS SP-58, SP-59, SP-89, and SP-90.

B. Acceptable Manufacturers: The model numbers listed in the Specification establish a level of quality and material. Subject to compliance with requirements, provide products and materials by the following:
   1. Anvil International,
   2. Fee and Mason,
   3. Central Iron Manufacturing Company, and
   4. F& S Manufacturing Company
   5. B-Line

PART 2 – PRODUCTS

2.01 PIPE HANGERS AND SUPPORTS:

A. General: Provide pipe hangers and supports as specified. Comply with local codes and standards for pipe and equipment support and anchorage. Pipe supports shall be of material that will prevent electrolytic action.

B. Inserts: Provide Anvil No. 282 inserts for concrete construction.

C. Piping in Multiple Parallel Runs: Provide Anvil No. 45 or No. 50 with Anvil No. 137 U-bolt pipe clamps or structural channels or angles with U-bolt clamps, supported as trapeze hangers where multiple parallel runs of piping are shown. Select and size members for weights to be carried and span dimensions between supports.

D. Piping in Single Runs: Provide Fee and Mason Fig. 239 or Anvil No. 260 clevis hanger.

E. Hanger Rod: Provide hanger rods of required length. Rod diameters shall be as listed in the following table. Rod diameters may be adjusted after consultation

with the Structural Engineer concerning the building framing system, the method of attachment to the structure and the support rod spacing.

Pipe Sizes	Rod Diameter
3/4" - 2"	3/8"
2-1/2" – 3	1/2"
4" – 5	5/8"
6"	3/4"
8" – 12"	7/8"
14" – 18"	1"

F. Riser Clamps: Provide Fee and Mason Figure 241 riser clamps. Riser clamps for copper tube shall be copper-plated.

G. Saddles and Shields:
1. Saddles for Horizontal Insulated Piping without Vapor Barrier: At each hanger or support on horizontal runs, provide Anvil No. 160 or Fee and Mason Figure 171, 1710, 1712, or 172 saddles, as applicable. Shields as described below may be used instead of the saddles. On heating water systems below 140°F (60°C), hangers may be sized for the pipe size and of a material compatible with the pipe. Where dissimilar materials are used, provide dielectric separation. Carry insulation over the hanger and seal where hanger is sized for pipe.
2. Shields for Horizontal Insulated Water Piping with Vapor Barrier: At each hanger or support for water piping, provide a half section of preformed 6 PCF density fiberglass or rigid calcium silicate, with jacket of adjacent insulation brought across unbroken, supported on semicircular 16 gauge shields. Shields for pipe 4" and smaller shall be 12" long; shields for pipe 5" to 8" shall be 18" long; and shields for larger pipe shall be 24" long.

H. Piping on Roof: Roof mounted pipe supports are discouraged. If roof supports are necessary, installation methods must be approved by the architect, engineer, general contractor and the Roofing Contractor.

PART 3 – EXECUTION

3.01 INSTALLATION:

A. Independent Support: Support fire sprinkler and standpipe piping independently of other piping in accordance with NFPA-approved methods and local codes and standards.

B. Provisions for Movement:
1. Movement: Install hangers and supports to allow controlled movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate the action of expansion joints, expansion loops, expansion bends, and similar units.
2. Load Distribution: Install hangers and supports so piping live and dead loading stresses from movement will not be transmitted to any pipe or connected equipment. Pipe supports shall properly transmit the weight of

the pipe and its contents to the building structure, or to independent posts, piers, or foundations.

3. Pipe Slopes: Install hangers and supports to provide the indicated pipe slopes so maximum pipe deflections allowed by ANSI B31 are not exceeded.

C. Insulated Piping: Comply with the following installation requirements:
   1. Clamps: Attach clamps, including spacers (if any), to piping with clamps projecting through the insulation; do not exceed pipe stresses allowed by ANSI B31.
   2. Shields: Where low-compressive-strength insulation of vapor barriers are indicated on cold, chilled, or heating water piping, install coated protective shields. For pipe 8" and over, install rigid calcium silicate insulation between saddles and pipe.

D. Spacing: Install hangers and supports in piping systems to remove stress from equipment flanges and rotating equipment. Space hangers and supports as shown in the following table. Rod spacing may be adjusted after consultation with the Structural Engineer concerning the building framing system, the method of attachment to the structure and the support rod diameters.

Trade Pipe Size	Maximum Spacing
1/2"	5'
3/4"	6'
1" and 1-1/4"	7'
1-1/2"	9'
2"	10'
2-1/2"	11'
3"	12'
4"	14'
5"	16'
6"	17'
8"	19'
10"	22'
12"	23'
14"	25'
16"	27'
18"	28'

E. Saddles: Where insulation without vapor barrier is indicated, install protection saddles, or use hangers as indicated in Paragraph 2.0/H.1.

F. Guides: Install pipe guides complying with the manufacturer's published product literature. Where not otherwise indicated, install pipe guides near expansion loops, expansion joints, and ball joints.

G. Anchors: Install anchors at the proper locations to prevent stresses from exceeding those permitted by ANSI B31 and to prevent the transfer of loading and stresses to connected equipment. Anchors shall include vibration isolation in accordance with the pipe support system specified. Where the piping system is floating, the anchors shall be termed restraints or braces.

1. Where expansion compensators are indicated, install anchors in accordance with the expansion unit manufacturers written instructions, to limit movement of piping and forces to the maximums recommended by the manufacturer of each unit.
2. Where not otherwise indicated, install anchors at the ends of principal pipe runs and at intermediate points in pipe runs between expansion loops and bends. Make provisions for preset of anchors as required accommodating both expansion and contraction of piping.

H. Leveling: Adjust hangers and supports and place grout as required under supports to bring piping to proper levels and elevations.

I. Hangers: Refer to Section 23 05 48, "Vibration Isolation", for additional information and support requirements. Pipe hangers made of wood, wire, or sheet iron shall not be permitted.

J. Riser Supports: Vertical piping shall be secured at sufficiently close intervals to keep the pipe in alignment and carry the weight of the pipe and contents.
1. Cast iron soil pipe shall be supported at the base and at each story level, but in no case at intervals greater than 10'.
2. Steel pipe shall be supported at the base and at no less than every other story level, but in no case at intervals greater than 25'.
3. Copper tube shall be supported at each story level, but in no case at intervals greater than 10'.
4. Plastic pipe shall be supported at mid point between floors and at ceiling to prevent movement, but in no case at intervals greater than 8'.

END OF SECTION 230529

SECTION 230548 - VIBRATION ISOLATION

PART 1 - GENERAL

1.01 SUMMARY

A. The General Provisions, Supplemental General Provisions, section 23 01 00, Division 1 Specifications and Special Provisions apply to all Work specified in this Section.

B. This section describes the basic materials and installation methods for the vibration isolation systems. Comply with other Division 23 sections and drawings as applicable. Refer to other divisions for coordination of work.

C. Furnish and install all components of the vibration isolation systems specified herein, as indicated on the drawings, and as required to provide complete and operating systems.

1.02 DESCRIPTION OF WORK

A. Work Included: Provide vibration isolation work as specified and indicated, including the following:
   1. Support isolation for motor-driven mechanical equipment
   2. Inertia base frames in conjunction with equipment isolation
   3. Support isolation of air-handling housings
   4. Isolation including support isolation for piping risers
   5. Support isolation of piping
   6. Flexible ductwork connections

1.03 QUALITY ASSURANCE

A. General: Except as otherwise indicated, obtain support isolation units from a single manufacturer.

B. Supervision: Manufacturer shall provide technical supervision of the installation of support isolation units produced by him and of associated inertia bases.

C. Manufacturers: Provide vibration isolation support units manufactured by one of the following or an approved equal: Amber-Booth, Vibrations Mounting and Controls, Inc., Korfund Dynamics Corporation, Consolidated Kinetics Corporation.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Chilled, Condenser and Heating Hot Water Pumps: Provide concrete inertia bases with structural steel pouring forms sized and reinforced as required for the intended service. Size bases to support the piping elbow supports and furnish with Type RSW recessed spring isolators properly sized

for one-inch static deflection. Mount springs on concrete bases 3-1/2" high. Inertia base is not required for pumps installed on slabs on grade.

B. Suspended Fans: Isolate with not less than four combination spring and rubber-in-shear vibration isolators.

C. Cooling Towers: Design and coordinate the structural supports with the Structural Engineer. Isolate towers with spring isolators with springs sized for 2" static deflection. Isolator housing to be hot-dipped galvanized springs to be neoprene-coated. Provide tie-down adjustment to prevent excessive movement when tower is drained. Towers located on grade do not require vibration isolation.

D. Fluid Cooler Mounted on Ground: System is internally isolated; no special vibration isolation is required.

E. Suspended Heat Pump Units: Unit shall be isolated with hanger and vibration isolation kit supplied by unit manufacturer or a vibration isolation manufacturer.

F. Suspended Fan & Coil Unit: Isolate with not less than four combination spring and rubber "in-shear" vibration isolators.

G. Flexible Pipe Connections at Cooling Tower: Isolate supply and return piping to the cooling tower with flanged rubber, spherical double-arch expansion joints.

H. Flexible Pipe Connections at Rotating Equipment: Isolate supply and return piping to each pump with braided metal hose connectors between pump and valve.

I. Flexible Ductwork Connections to Equipment: Install flexible connections between sheet metal ductwork and equipment or fan collar. Locate as close to fan as possible. Isolate the duct system from the equipment by at least 1".

J. Roof Mounted Air Handling Units: Provide housed spring type isolators with vertical limit stops. Provide with 1" deflection (0 to 500 rpm) or .75" deflection (501 and over rpm).

PART 3 - EXECUTION

3.01 ISOLATOR PERFORMANCE

A. General: Comply with the minimum static deflections recommended by the American Society of Heating, Refrigerating and Air Conditioning Engineers, including the definitions of critical and non-critical locations, for the selection and application of vibration isolation materials and units as indicated.

B. Manufacturer's Recommendations: Except as otherwise indicated, comply with manufacturer's instructions for selection and application of vibration isolation materials and units.

3.02 RELATED WORK EXAMINATION

A. Examination and Reporting: Installer of vibration isolation work shall observe the installation of other work related to and connected to vibration isolation work. After completion of other related work (but before equipment start-up), installer shall furnish a written report to the Contractor, with a copy to the Engineer, listing observed inadequacies for proper operation and performance of vibration isolation work.

B. Correction and Start-up: Do not start-up equipment until inadequacies have been corrected in a manner acceptable to the vibration isolation Installer.

3.03 EQUAL LOADING

A. General: Equipment installed on vibration isolating mountings shall be level after load is applied. Further vibration isolating mountings shall be selected and installed to compensate for unequal loading. Spring isolators with coils touching during equipment start-up or operation will not be acceptable.

END OF SECTION 230548

SECTION 230553 - HVAC EQUIPMENT AND PIPING IDENTIFICATION

PART 1 - GENERAL

1.01 SUMMARY

A. The General Provisions, Supplemental General Provisions, section 23 01 00, Division 1 Specifications and Special Provisions apply to all Work specified in this Section.

B. This section describes the basic materials and installation methods for the identification of equipment and piping. Comply with other Division 23 sections and drawings as applicable. Refer to other divisions for coordination of work.

C. Furnish and install all components of the identification of equipment and piping specified herein and/or as indicated on the drawings.

1.02 DESCRIPTION OF WORK

A. Work Included: Identification of mechanical equipment shall consist of equipment labeling, pipe marking, and valve tagging as specified hereinafter.

1. In general, all equipment shall be labeled. This shall include all central plant, air handling or air conditioning equipment, and other similar and miscellaneous equipment.
2. Pipe markings shall be applied to all piping.
3. Each valve shall be identified with a stamped tag. Valves and tagging shall be scheduled typewritten on 8 ½" x 11" paper, tabulating valve number, piping system, system abbreviation, location of valve (Room or area), and service (e.g. – 2nd Floor North Domestic Hot Water). The valve schedule shall be submitted to the Engineer for approval prior to ordering or installing valve tags. See Section 23 01 00, "General Mechanical Requirements" for information and requirements regarding Operation and Maintenance Manuals.
   Labels, tags, and markers shall comply with ANSI A13.1 and other applicable state and local standards for lettering size, colors, and length of color field.
4. Equipment and device identification specified in other sections shall be provided as a part of those requirements.

1.03 ACCEPTABLE MANUFACTURERS

A. Labels, markings, and tags shall be manufactured by W.H. Brady, Seton, Allen, or Industrial Safety Supply.

PART 2 - PRODUCTS

2.01 EQUIPMENT LABELING

A. Equipment labeling shall be one of the following, unless noted or specified otherwise:
   1. Permanently attached engraved brass or plastic laminated signs with 1" high lettering. Signs on exterior equipment shall be brass.
   2. Stencil painted identification, 2" high letters, with standard fiberboard stencils and standard black (or other appropriate color) exterior stencil enamel.

2.02 PIPE MARKINGS

A. On piping less than 6" diameter, install plastic semi-rigid snap-on type, manufacturer's standard pre-printed color-coded pipe markers extending fully around the pipe and insulation or pressure-sensitive vinyl pipe markers similar to the above. Pipe markings can also be applied with the stick type backing in lieu of he semi-rigid snap-on-type.

B. On piping and insulation 6" and greater diameter, full band as specified above or strip-type markers fastened to the pipe or insulation with laminated or bonded application or by color-coded plastic tape not less than 1 ½" wide, full circle at both ends of the marker. Pipe markings can also be applied with the stick type backing in lieu of the semi-rigid snap-on-type.

C. Arrows for direction of flow provided integral with the pipe marker or separate at each marker.

2.03 VALVE TAGS

A. Valve tags shall be polished brass or plastic laminate with solid brass S hook and chain. Tags shall be stamped or engraved with the appropriate abbreviation for the type of service (e.g. – CHW, HW), as well as the designated valve number.

B. A valve schedule is to be provided to the Owner. For each page of valve schedules, a glazed display frame, with screws for removable mounting on masonry walls. Provide frames of finished hardwood or extruded aluminum, with SSB-grade sheet glass.

PART 3 - EXECUTION

3.01 GENERAL

A. Identification labeling, marking, and tagging shall be applied after insulation and painting has been completed.

B. Coordinate names, abbreviations, and other designations used in mechanical identification work with corresponding designations shown,

specified, or scheduled on drawings. Prior to ordering any labels, markings, or tags, obtain the approval of the Engineer regarding names, abbreviations, etc.

C. The Plumbing, HVAC, and Fire Protection Contractors shall coordinate labeling, marking, and tagging to ensure consistent and coordinated identification. In existing buildings, utilize similar names, abbreviations, and other designations that are currently in use to remain consistent with existing identification.

D. Equipment labeling shall consist of unit designation as shown on the drawings. Exhaust fan labeling shall also indicate service or the room or area of service.

E. Pipe and ductwork markers shall be placed on piping and ductwork on 25' centers in mechanical rooms and concealed spaces. In locations where piping and ductwork is exposed, place markers on 50' centers. Flow directional arrows should be marked on the piping at taps from the main and riser.

F. Valve tags shall be placed on each valve except those intended for isolation of individual heat pumps or terminal units (e.g. - VAV boxes, fan coil units, unit heaters, etc.). Valve tag schedules shall be prepared as specified hereinbefore. Copies of one schedule shall be laminated in clear plastic and placed where directed by the Owner. Other sets shall be included in the Operating and Maintenance Manuals.

END OF SECTION 230553

SECTION 230593 - TESTING, ADJUSTING, AND BALANCING

PART 1 - GENERAL

1.01 SUMMARY

A. The General Provisions, Supplemental General Provisions, section 23 01 00, Division 1 Specifications and Special Provisions apply to all Work specified in this Section.

B. This section describes the basic materials and installation methods for the testing, adjusting, and balancing of HVAC systems. Comply with other Division 23 sections and drawings as applicable. Refer to other divisions for coordination of work.

C. Provide testing, adjusting, and balancing specified herein, as indicated on the drawings, and as required to provide complete and operating systems.

1.02 DESCRIPTION OF WORK

A. Work Included:
1. All air and water systems shall be tested, adjusted, and balanced to optimize operating and comfort conditions. Record test data as outlined hereinafter and submit for review and approval. Systems shall be fully tested and balanced prior to Building commissioning and acceptance.
2. Conduct tests as specified herein, and as required by authorities having jurisdiction, including Local Inspection Department or Construction Manger.
3. Repair or replace defects discovered or resulting from the required tests to a like new condition.
4. All tenant finish air balancing will be by the tenant finish contractor. All air and water moving equipment installed under the shell building contracts will be balanced by the shell contractor.

1.03 QUALITY ASSURANCE

A. Personnel: Submit evidence to show that the personnel who will actually balance the systems are qualified. Evidence showing that the personnel have passed the tests required by the Associated Air Balance Council (AABC) or the National Environmental Balancing Bureau (NEBB) will be sufficient.

PART 2 - PRODUCTS

Not applicable.

PART 3 - EXECUTION

3.01 TEST DATA

A. General: Record test data after balancing has been completed and deliver recorded data to the Engineer for review and evaluation. Should deficiencies or

discrepancies be found, repeat balancing procedures to achieve correct test data results. Certify the test and balancing data as being true and correct over the Contractor's signature. Execute the Certification by an authorized officer if the contracting firm is a corporation, by a partner if the firm is a partnership, by the firm's owner if the firm is a sole proprietorship, or by the authorized representative if the firm is a joint venture. Include a copy of the approved test and balancing data in the Owner's Manual.

B. Test Forms: Record and submit test and balancing data on forms similar to those of the AABC or NEBB.

3.02 CALIBRATION TEST

A. Submit evidence to show that the balancing devices are properly calibrated before proceeding with system balancing.

3.03 PRELIMINARY AIR TESTING

A. General: Preliminary air tests shall be performed before duct work or equipment is enclosed in walls, floors, ceilings, chases, or in any other way concealed from view. Tests may be conducted on individual systems. Submit notification when systems are ready for preliminary air tests. Condenser water shall not be required for preliminary air tests. Make necessary arrangements to energize fan motors for the tests. Where possible, conduct the tests before the application of exterior duct insulation and installation of grilles or diffusers. Remove section of duct to allow design airflow at design static pressure where necessary.

B. Tests: Demonstrate that there is no excessive leakage of the duct work by visual inspection, that fans are operating at essentially the correct speed, that motors will not overload, and that equipment delivers design cfm. Correct any deficiencies found. Repeat preliminary air tests until tests have proven satisfactory.

C. Inspection: Inspection and acceptance of the Work shall, in addition to the foregoing requirements, be subject to the following conditions:
   1. Instruments: Test instruments, devices, and similar items, their accuracy and the methods by which instruments are employed, shall be approved by AABC or NEBB for use at the job site.

3.04 PRESSURE TESTING FOR SMOKE CONTROL SYSTEMS

A. General: Pressure tests shall be performed before duct work or equipment is enclosed in walls, floors, ceilings, chases, or in any other way concealed from view. Pressure tests shall be conducted on all individual systems. Submit notification when systems are ready for pressure tests and all testing methods and results shall be documented.

B. Tests: Demonstrate that leakage does not exceed 5% of the design airflow for each system (Smoke Exhaust, Make-up Air, Stairwell Pressurization, Atrium Exhaust, etc.) when tested at a minimum of 1.5 times the scheduled static pressure. Correct any deficiencies found. Repeat pressure tests until tests have proven satisfactory.

3.05 PRESSURE TESTING FOR DUCTS 3" W.G. AND HIGHER

A. At least 25% of the duct shall be tested and shown to have a rate of air leakage (CL) less than or equal to 4.0 as determined by the following equation:

$$CL = F/P^{0.65}$$

Where:

F = The measure leakage rate in CFM per 100 square feet of duct surface
P = The static pressure of the test

3.06 FINAL AIR BALANCE

A. General: When tests have been completed and systems are complete and ready for operation, perform the following steps of final air balance and record the results.

B. Motors: Verify correct rotation of rotating equipment. Verify that properly sized thermal heater elements are installed in starters. Verify that properly sized duel-element fuses, where specified, are installed in disconnect switches.

C. Filters: Check air filters or filter media. Balance system only with clean filters or filter media.

D. Airflow at Each Unit: Read and record return and/or outside air, supply air cfm, and temperature at each fan and blower.

E. Water flow at Each Unit: Set thermostat for full cooling and for full heating loads. Measure and record supply and return water flow at each cooling/heating coil.

F. Coil Temperatures: Set thermostat for full cooling and for full heating loads. Read and record entering and leaving dry bulb and wet bulb temperatures at each cooling and heating coil.

G. Outlet Airflow: Adjust each air exhaust inlet and supply diffuser, register, and grille to within 10% of design air cfm. Dampers in diffusers (if specified) may be used for only 10% adjustment from full open airflow. Include terminal points of air supply and points of exhaust.

H. Surgical Centers: Operating room supply diffusers shall be balanced within 25 to 35 CFM per square foot. Pressure offsets as listed in the drawings shall be maintained.

END OF SECTION 230593

SECTION 230700 - HVAC INSULATION

PART 1 - GENERAL

1.01 SUMMARY

A. The General Provisions, Supplemental General Provisions, section 23 01 00, Division 1 Specifications and Special Provisions apply to all Work specified in this Section.

B. This section describes the basic materials and installation methods for the insulation of HVAC and Plumbing piping, duct, and equipment. Comply with other Division 23 sections and drawings as applicable. Refer to other divisions for coordination of work.

C. Furnish and install all components of the insulation system specified herein, as indicated on the drawings, and as required to provide complete and operating systems.

1.02 QUALITY ASSURANCE

A. Manufacturer: Approved manufacturers are Armstrong, Calsite, Cell-U-Foarm Corp, Ceelco, Certainteed Corp, Dow Chemical Company, Forrest Mfg Co, Foster / Chilers, Gemco, Johns Manville, Knauf Fiberglass, Midwest Fastners, Owens Corning Fiberglass, Pittsburg Corning Fiberglass, Rubatex, Trymer, and Venture Tape.

B. All insulation, jacket and adhesive shall have a fire and smoke hazard ratings as tested under ASTM E 84, NFPA 255, and UL 723 not exceeding:

Flame Spread:	25
Fuel Contributed:	50
Smoke Developed:	50

Exceptions: Type B Insulation and PVC Fitting Covers

1.03 SUBMITTALS

A. Per Section 23 01 00.

B. Product Data
1. Type A Insulation
2. Type B Insulation
3. Type C Insulation
4. Type D Insulation
5. Type E Insulation
6. Type F Insulation
7. Type G Insulation
8. Vinyl Lacquer Paint for Type B Insulation
9. Metal Jacket

1.04 DEFINITIONS

A. The phrase "Storm Drainage Conductor" refers to that portion of the storm drain interior to the building, between the roof drain body and where the pipe goes below grade.

B. The word "plenum" shall mean a ceiling space or mechanical room used for the transfer of conditioned return and/or outside air.

PART 2 - PRODUCTS

2.01 PIPING INSULATION

A. Type A – Fiberglass (indoor)
1. One Piece glass fiber, rigid molded sectional pipe covering with factory applied aluminum foil and white craft paper flame retardant vapor barrier jacket, conforming to ASTM C547, Class II, Mineral Fiber Preformed Pipe Insulation.
2. Thermal Conductivity (k) equals approximately 0.23 (BTU/HR., SF., Degree F, IN) at 75 °F.
3. Similar to Johns Manville Corp "Micro Lox 650 AP T", or approved equal.

B. Type B - Closed Cell (indoor)
1. Closed cell, flexible foamed plastic conforming to ASTM C534, "Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form." Insulation shall be suitable for a temperature range from –40 degrees F to 220 degrees F.
2. Conductivity (k) equals approximately 0.27 (BTUHR., SF., Degree F, IN) at 75 °F.
3. Similar to Armstrong "Armaflex", or approved equal.

C. Type C – Polyisocyanurate (outdoor)
1. Prefabricated 2 lb./cu.ft. density polyisocyanurate insulation with waterproof mastic and glass fiber jacket finished with an aluminum jacket with waterproof silicone caulk joints.
2. Conductivity (k) equals approximately 0.14 (BTUHR., SF., degrees F, IN) at 75 °F.
3. Insulation shall be applied per manufacturer's recommendations. Joint sealants and coatings shall be as approved by the insulation manufacturer for the intended application and service temperature range.
4. Jacketing shall be an all service jacket with 1 mm aluminum foil on pipe insulation and FSK jacket on board stock applied by the manufacturer to ASTMC-1136. Jacket shall have integral flap for sealing joint.
5. Similar to Trymer 9501, or approved equal.

2.02 EQUIPMENT INSULATION

A. Type Dh - Fiberglass Board (Hot Equipment)
1. Semi-rigid intermediate service fibrous glass board for operating temperatures greater than 850 degrees F.

2. Conductivity (k) equals approximately 0.23 (BTU/HR., SF., degrees F, IN) at 75 °F. Minimum density of 4.25 lb / cu ft.
3. Similar to Johns Manville Corp "Spin Glass", or approved equal.

B. Type Dc - Foamed Plastic (Cold Equipment)
1. Foamed plastic sheet suitable for operating temperatures between –40 degrees F and 22- degrees F.
2. Conductivity (k) equals approximately 0.27 (BTU/HR., SF., Degree F, IN) at 75 °F.
3. Similar to Armstrong "Armaflex", or approved equal.

C. Type E
1. Calcium silicate block conforming to ASTM C 553, Type I (1200 degrees F. max), asbestos free.
2. Conductivity (k) equals approximately 0.42 (BTU IN/HR., SF., degree F) per inch thickness at 200 °F.
3. Similar to Calsilite, or approved equal.

2.03 DUCTWORK INSULATION

A. Type F – Duct Wrap
1. Duct insulation shall be 2" thick, minimum 3/4 lb. density fiberglass with an FSKL aluminum foil jacket, reinforced with fiberglass scrim.
2. Conductivity (k) equals approximately 0.24 (BTUHR., SF., degrees F, IN) at 75 °F.
3. Integral UL rated vapor barrier of:
   a. Aluminum foil reinforced with fiberglass scrim laminated to 30-lb. kraft paper.
   b. Class I white vinyl 0.004 inch thick, where specified.
4. Similar to Johns Manville Corp "Microlite", or approved equal.

B. Type G - Duct Liner
1. ASTM C1071, Type II, Grade 2, R-6, 1-1/2" thickness, 1.5 lb. Density for low pressure ductwork and 3.0 lb density for medium pressure ductwork, bonded mat of glass fiber coated with black fire resistant and microbial resistant coating, complying with TIMS AHC 101. Moisture adsorption shall not be greater than 0.5% moisture by volume when exposed to moisture-laden air at 120°F and 96% RH, per ASTM C553. Insulation shall be Schuller "Permacote Linacoustic" R-300, "Aeroflex Ductliner" as manufactured by Owens Corning Fiberglass Corp. or "Ultralite with Certa Edge" by Certainteed Corp. or equal by Knauf Fiberglass.
2. Duct liner adhesive shall comply with ASTM C916 "Specifications for Adhesives for Duct Thermal Insulation".
3. Liner Fasteners: Mechanical or weld secured fasteners for duct liner where finish of duct is not exposed. For exposed ductwork, except in mechanical rooms, provide adhesively secured fasteners. Position fasteners are recommended by SMACNA.

4. Minimum Sound Absorption coefficients shall be:

	125	250	500	1000	2000	4000
Coefficient	0.34	0.42	0.47	0.64	0.80	0.79

Attenuation*	3	5	12	24	21	17

* Attenuation in dB per 10 lineal feet, per ASTM E477

2.04 METAL JACKET

A. Smooth aluminum jacket 0.016 inch thick.

B. Integral polykraft or poly-surlyn moisture barrier.

C. Banded locking joints with field applied silicone weatherproof sealant.

D. Similar to Johns Manville Corp, or approved equal.

2.05 INSULATION ACCESSORIES

A. The following accessories shall be used in the application of the thermal insulations specified under this Section:
   1. PVC Fittings Covers: similar to Johns Manville Corp "Zeston", or approved equal.
   2. Pressure Sensitive polyester film tape to secure pipe insulation up to 12" outside diameter: Similar to 3M 30-80, or approved equal.
   3. Vapor Seal Mastic: Similar to Childers CP-35, or approved equal.
   4. Lagging Adhesive: Similar to Childers CP-52, or approved equal.
   5. Wire: 16 gauge soft stainless steel.
   6. Insulation Bonding Adhesive (To Metal): Similar to Childers CP-82, or approved equal.
   7. Insulating and Finishing Cement: Similar to Insulco Smooth Kote, or approved equal.
   8. Mechanical Fasteners - Welded or adhered pins with speed clip washers: Similar to Gemco Midwest Fasteners, or approved equal.
   9. Bands for Equipment:
      a. Outside diameter of insulation is less than 24 inch: 1/2 inch x 0.020-inch (25 ga.) stainless steel.
      b. Where diameter is 36 inches or larger: 3/4 inch x 0.020 inch.
   10. Bands for Piping: 1/2 inch x 0.020-inch stainless steel.
   11. Wire Mesh: 1 inch by 20-gage stainless steel hexagonal wire netting.

PART 3 - EXECUTION

3.01 INSULATION APPLICABILITY

A. Heat Pump loop piping (tempered): No insulation required (except where exposed to freezing temperatures—see exterior piping for condenser water below for this condition).

B. Interior Hot Water, Chilled Water, and Condenser Water - Type A insulation required:

Insulation Thickness (in)	Pipe Sizes (in)
1	up to 1-1/4

1-1/2	1-1/2 to 3
2	4 and up

C. Exterior Hot Water, Chilled Water, and Condenser Water – Type C insulation required:

Insulation Thickness (in)	Pipe Sizes (in)
1	up to 2-1/2
2	3 and up

D. Condensate Drains (except in plenums and fire partitions/floors) – Type B insulation required:

Insulation Thickness (in)	Pipe Sizes (in)
½	all

E. Condensate Drains (inside plenums and fire partitions/floors) – Type A insulation required:

Insulation Thickness (in)	Pipe Sizes (in)
1/2	up to 1
3/4	1-1/4 and up

F. Horizontal storm leaders, roof drain bodies, and underside of drains receiving condensate from cooling coils – Type F insulation required:

Insulation Thickness (in)	Pipe Sizes (in)
2	all

G. Horizontal waste piping from electric water coolers – Type A insulation required:

Insulation Thickness (in)	Pipe Sizes (in)
1/2	all

H. Refrigerant Suction (and Liquid where required by system and/or manufacturer) Lines & Valves (except in plenums and fire partitions/floors) – Type B

Insulation Thickness (in)	Pipe Sizes (in)
1	all

I. Refrigerant Suction (and Liquid where required by system and/or manufacturer)Lines & Valves (in plenums and fire partitions/floors), and hot gas bypass piping – Type A insulation required:

Insulation Thickness (in)	Pipe Sizes (in)
1	all

J. Outdoor cooling tower make-up water – Type C insulation required:

Insulation Thickness (in)	Pipe Sizes (in)
2	all

K. Boiler stack, breeching and converter – Type E insulation required:

Insulation Thickness (in)	Pipe Sizes (in)
4	all

L. Emergency Generator Exhaust Piping and Muffler – Type E insulation required:

Insulation Thickness (in)	Pipe Sizes (in)
4	all

M. Medium Pressure Supply Ducts – Type F insulation required

Insulation Thickness (in)	Duct Sizes (in)
2	all

N. Low Pressure Supply Ducts – Type F insulation required

Insulation Thickness (in)	Duct Sizes (in)
2	all

O. Outside air ductwork: No insulation required (except when air is pre-cooled below dew point of air surrounding duct).

P. Domestic Water Heaters shall be factory insulated.

Q. Cold equipment – Type Dc insulation required, minimum 1/2". Consult with equipment manufacturer as thickness may vary depending on service application and equipment manufacturer installation recommendations.

R. Hot equipment – Type Dh insulation required, minimum 2". Consult with equipment manufacturer as thickness may vary depending on service application and equipment manufacturer installation recommendations.
Notes:

a. Exhaust ductwork, stairwell pressurization and dedicated smoke evacuation ductwork is not insulated, unless otherwise noted.
b. Exposed supply and return ductwork will be double wall, internally lined.
c. All duct connected to equipment without compressors must be internally lined with Type G duct liner for a distance not less than 5 feet from the equipment connection.
d. All duct connected to equipment that contains compressors must be internally lined with Type G duct liner for a distance not less than 10 feet from the equipment connection.
e. The above thicknesses are the minimum required. All local codes and local energy codes shall be complied with.
f. All piping exposed to outdoors shall be insulated. All piping subject to freezing shall be provided with heat tracing. Coordinate insulation with heat trace cable and controls.
g. Insulation types and thickness are a minimum standard. Each application shall be carefully considered and insulation product type and thickness

shall be appropriate for each specific application. Submit all insulation products with verification of their service intent.

h. Insulation may be omitted on condenser water piping located within mechanical rooms.

3.02 PIPING INSULATION GENERAL REQUIREMENTS

A. Preparation
1. Do not apply insulation until piping has been leak tested.
2. All surfaces to be insulated shall be dry and free of loose scale, rust, dirt, oil or water.

B. Application:
1. Insulation shall be installed in a smooth, clean workmanlike manner. Joints shall be tight and finished smooth without fish-mouths.
2. Insulation shall fit tightly against the surface to which it is applied to prevent air circulation between the insulation and the pipe or equipment to which it is applied.
3. Insulation applied to cold piping or equipment shall be completely vapor sealed, free of pinholes or other openings.
4. Do not use wet insulation materials.
5. All longitudinal joints on vertical pipe runs shall be staggered.
6. Apply insulation so as to permit expansion or contraction of pipelines without causing damage to insulation or surface finish.
7. Do not apply mastic or adhesive until all previous applications of mastic and adhesives have thoroughly dried.
8. No bands or staples shall be provided on covering.
9. The adhesive used in connection with all covering work shall contain an approved vermin and rodent proof ingredient.
10. Provide 24-gauge sheet-metal saddle between the pipe hanger/support and the exterior of the insulation. Saddle length shall be the same as insulation inserts.

C. Application at Fittings:
1. Insulation of flanges and flanged fittings shall overlap adjacent pipe covering at least 1 inch. Valves shall be insulated up to the gland only.
2. Pipeline strainers shall be insulated in such a manner as to permit removal of strainer basket without disturbing insulation of the strainer body.
3. Insulation adjacent to un-insulated flanges shall be tapered back and neatly finished so as to allow access to and removal of bolts without injury to covering.

3.03 TYPE A INSTALLATION

A. Tightly butt together sections of insulation on pipe runs sealing longitudinal seams of jacket with a self-sealing adhesive. Seal end joints with 4-inch wide straps of matching vapor barrier tape. Seal off ends of insulation with vapor seal mastic at valves, fittings and flanges. No further finish required. Mastic shall extend onto the bare pipe and over the insulation O.D.

B. PVC fitting jackets shall be used when they are available for the particular application. When molded or routed coverings are not available, the coverings

shall be fabricated in the field similar to equipment insulation. Molded or routed fitting covers are highly recommended. Order PVC pre-curled.

C. Cold Piping:
1. Cover valves, fittings and flanges with insulation having the same thickness as adjacent pipe covering, securing in place reforming tape up to 12" O.D. and ½" wide SST bands on larger O.D. Apply a PVC jacket and seal joints with PVC cement (solvent welding).

D. Hot Piping:
1. Covers shall overlap the pipe insulation by the thickness of the insulation or 2" min. Cover valves, fittings and flanges with insulation similar to the adjacent pipe covering, securing in place with reforming tape up to 12" O.D. and ½" wide SST bands on larger O.D. Apply a PVC jacket and tape end joints to adjacent pipe insulation.
2. Do not use PVC fitting jackets where the surface of the insulation is above 150 degrees F.

E. Exterior Piping:
1. Exterior above grade water piping shall be finished with a weatherproof jacket and an aluminum jacket. Lap and seal joints as per manufacturer's instructions. Place laps to shed water.

3.04 TYPE B INSTALLATION

A. Type B insulation shall be slipped on the pipe prior to connection, and the butt joints shall be sealed. Where the slip on technique is not possible, the insulation shall be carefully slit and applied to the pipe.

B. All joints shall be completely butt sealed with the manufacturer's recommended adhesive.

C. Do not apply Type B insulation in multiple layers.

D. Type B insulation shall not be used in plenums nor firewall penetrations.

E. This Contractor shall paint Type B insulation exterior to the building with two coats of a vinyl acrylic paint recommended by the insulation manufacturer for protection against ultraviolet degradation and shall be flexible with no cracking. It is recommended in high humid areas to coat the insulation with a vapor barrier mastic to .037 min. DFT.

3.05 TYPE C INSTALLATION

A. Exterior
1. Butter joints of insulation with non-setting adhesive. Secure with factory applied Self-Seal laps. Installation shall be as per manufacturer's guidelines.
2. Finish shall be factory applied All Service Jackets. All fittings shall be finished with vapor seal mastic reinforced with white glass mesh. Minimum 0.037 thick DFT of mastic.

3. Piping exposed in machine rooms shall be finished with vapor seal mastic and open weave membrane 10 x 10.
4. Piping exposed to weather shall be finished with all service jacket and additional finish of 0.16 thick aluminum jacket. Aluminum jacket shall be secured with stainless bands located on maximum centers of 12 inches and at the overlap. No screws or pop rivets shall be used.
5. Fittings and valves shall be finished with vapor seal mastic, reinforced with minimum 0.037" DFT of mastic, glass mesh and aluminum preformed fitting covers.

3.06 TYPE D AND E INSTALLATION

A. Equipment Insulation Application:
1. Apply insulation to fit as closely as possible to equipment.
2. Stagger joints where possible.
3. Bevel insulation around nameplates, ASME stamp and access plates.
4. Insulation on equipment that must be opened periodically shall be constructed so insulation can be removed and replaced without damage.
5. Do not install Type E insulation on aluminum surfaces or with aluminum jacket.

B. Hot Equipment:
1. Install 3/4-inch expanded metal over equipment with standing ribs or seams prior to applying insulation to eliminate ribs or seams penetrating through the insulation.
2. Secure the insulation with steel bands spaced on 12-inch centers.
3. Where required, use welded studs, clips or angles as anchors for wire or bands on flat surfaces.
4. Seal joints with insulating cement.
5. Over the insulation stretch 1-inch hexagonal mesh wire and lace the edges together.
6. Apply a 1/4-inch thick coat of finishing cement and trowel smooth.
7. Smooth insulation with lagging adhesive, cover with glass cloth and a final coat of lagging adhesive.
8. On small equipment where it is not practical, omit the wire mesh and finishing cement on Type D insulation.

C. Cold Equipment
1. Cover irregular surfaces with a smoothing coat of insulating cement.
2. Secure insulation with wire or with stainless bands spaced on 12-inch centers.
3. Seal joints with vapor seal mastic.
4. Embed a layer of glass into a 1/16-inch coating of vapor seal mastic. Then coat the outside of the glass cloth with a 1/16-inch coating of vapor seal mastic.

D. Roof Drain Bodies
1. Insulate similar to cold equipment.
2. Insulated boxes around roof drain bodies are not acceptable.

3.07 TYPE F INSTALLATION

A. Ductwork Insulation Application:
1. Apply insulation tightly and smoothly to duct.
2. Secure insulation on the bottom of ducts and plenums and on the sides of plenums and other places where the insulation will sag and max 3" from any corner.
3. Impale insulation over pins or anchors located not more than 18 inches apart and hold in place with washers and clips.
4. Cut off protruding pin after clips are secured and seal with 2-mil. aluminum foil backed pressure sensitive tape.
5. Apply insulation with joints tightly butted.
6. Seal all ductwork joints, punctures and fittings with a mastic type sealant containing a vapor barrier.
7. Cover all breaks, joints, punctures and voids with a vapor seal mastic and cover with a vapor barrier material identical to vapor barrier on the insulation, where gaps exceed 2".
8. Bevel insulation around nameplates, access plates and doors.
9. Insulation shall be continuous through walls and floors except at fire dampers.

3.08 TYPE G INSTALLATION

A. Internal Lining Insulation Application:
1. Apply where specified herein.
2. Apply liner in accordance with SMACNA Duct Liner Application Standard, later edition.
3. Provide metal liner for the sound lining. Metal liner to be 24 gauge galvanized sheet metal with perforation of 3/32" diameter holes on 3/16" center. Properly fasten liner to the duct so that liner does not sag or vibrate.

3.09 METAL JACKET INSTALLATION

A. Cover all piping insulation exposed to the exterior with metal jacket as specified herein.

3.10 FLEX DUCT

A. Flexible ductwork runouts to diffusers and grilles shall be wrapped in fiberglass insulation and sheathed in reinforced, metallized polyester jacket. Minimum insulated value of R=6.0.

3.11 HANGERS

A. Continue insulation through pipe hangers. Provide either rigid insulation inserts or sheet metal inserts at all outside pipe hangers. Provide rigid insulation inserts for piping operating below 60 °F. and sheet metal inserts for piping above 60 °F.

B. Provide rigid insulation (on non-insulated piping) or sheet metal inserts (on insulated piping) between the pipe and pipe hanger - shall be of a thickness

equal to the adjoining insulation and shall be provided with vapor barrier where required. Insulation insert shall not be less than the following lengths:

1/2" to 2 1/2" pipe size	10 Inches Long
3" to 6" pipe size	12 Inches Long
8" to 10" pipe size	16 Inches Long
12" and over	22 Inches Long

C. Inserts for cold piping shall have a vapor barrier facing of the same material as the adjacent pipe insulation. Seal inserts into insulation with vapor seal mastic.

D. Sheet metal inserts shall be of steel sheet. Gauge shall conform to manufacturer's recommendation for pipe size. Sheet metal inserts shall have insulation filler of the same material as the adjacent pipe insulation.

3.12 PIPE SLEEVES

A. Pipe insulation and vapor barrier shall be continuous through sleeves in walls and floors.

B. Type B insulation shall not be used in sleeves through firewalls or fire rated (2-hour) floor systems. Use Type A or Type C through the sleeve instead and vapor seal the joint between the two insulations.

C. Provide 26 gauge galvanized steel or 0.020 inch aluminum jacket over insulation on pipe passing through sleeves where sealant is required.

D. Where penetrating interior walls, extend the metal jacket 2 inches out either side of the wall and secure each end with a metal band compressing the insulation slightly.

E. Where penetrating floors, extend the metal jacket 2 inches below the floor and 5 inches above the floor. Secure with metal bands.

END OF SECTION 230700

SECTION 23 23 00 - REFRIGERANT PIPING

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

A. The conditions of the contract and applicable requirements of Division 1, "General Requirements", and Section 23 01 00, "Basic Mechanical Requirements", govern this Section.

1.02 DESCRIPTION OF WORK

A. Work Included: Refrigerant piping including suction, liquid, discharge and condenser drain piping between compressors, evaporators, condensers and receivers for direct expansion air conditioning and refrigeration systems.

B. Work of Other Sections: Section 23 05 29, "Hangers & Supports for HVAC Piping & Equipment", Section 23 07 00 , "HVAC Insulation"

1.03 QUALITY ASSURANCE

A. Provide piping as described by ANSI B31.5, Refrigeration Piping and ASTM B75, Seamless Copper Tube.

B. Provide fittings as described by ANSI B17.22, Wrought Copper and Bronze Solder-Joint Pressure Fittings and SAE J513F, Refrigeration Tube Fittings.

C. Comply with material and installation requirements of ASHRAE 15, Safety Code for Mechanical Refrigeration.

D. Comply with material and installation requirements of:
1. ARI 710, Liquid-Line Dryers
2. ARI 750, Thermostatic Refrigerant Expansion Valves
3. ARI 730, Flow-Capacity Rating and Application of Suction-Line Filters and Filter Dryers
4. ARI 495, Refrigerant Liquid Receivers
5. ARI 770, Refrigerant Pressure Regulating Valves
6. UL 207, Refrigerant Containing Components and Accessories, Non-electrical

PART 2 – PRODUCTS

2.01 MATERIAL

A. Pipe
1. Seamless Copper Tube, Hard Drawn
   a. All sizes are to be type ACR ASTM B75 or Type K or L ASTM B88

B. Fittings
1. Ells, Tees, Couplings, Caps, Reducers –

a. Wrought copper or wrought bronze with silver soder, ASTM B16.22

2.02 EQUIPMENT

A. Provide refrigerant specialties of sizes, types, ratings and capacities required to comply with installation requirements.

B. Refrigerant Valves:
1. Globe Shutoff Valves:
   a. Cast iron, packed, back seating type with winged seal cap.
   b. 300°F temperature rating, 300 psi working pressure.
2. Check Valves:
   a. Cast iron, accessible internal parts.
   b. 300°F temperature rating, 300 psi working pressure.
3. 2-Way Solenoid Valve:
   a. Forged brass or steel, normally closed, Teflon valve seat.
   b. NEMA 1 solenoid enclosure, 24 volt, 60 Hz., UL-listed, ½" conduit adapter.
   c. 300°F temperature rating, 500 psi working pressure.
   d. Provide manual operator to open valve.

C. Refrigerant Strainers
1. Straight line or angle line type.
2. Brass shell and end connections.
3. 100 mesh, stainless steel screen.
4. UL-listed.
5. 430 psi working pressure.

D. Moisture – Liquid Indicator:
1. Copper plated steel with solder connections.
2. Paper indicator element held under sight glass.
3. UL-listed.
4. Rated working pressure 430 psi..

E. Filter – Dryers (Sealed Core):
1. Steel shell.
2. Molded desiccant core.
3. Solder or flare connections.
4. UL-listed.
5. 500 psi working pressure.

F. Filter – Dryers (Replaceable Core):
1. Steel Shell with bolted end plate.
2. Replaceable molded desiccant core.
3. Solder or pipe connections.
4. UL-listed.
5. 500 psi working pressure.

G. Evaporator Pressure Regulator:
1. Steel body.
2. Pressure operated, adjustable pressure regulator.

3. Solder connections.

H. Thermostatic Expansion Valve:
1. Brass body and stainless steel diaphragm.
2. Externally adjustable.
3. External pressure equalizer.
4. Removable inlet strainer.
5. Flare connections.
6. Strap-on bulb with 5' of tubing.

I. Receiver:
1. Copper shell with brazed points and fusible relief plug.
2. 450 psi working pressure
3. Flare connections.

PART 3 – EXECUTION

3.01 EXAMINATION

A. Examine areas and conditions under which refrigerant piping is to be installed.

B. Do not proceed with work until satisfactory conditions are present.

3.02 INSTALLATION OF REFRIGERANT PIPING AND SPECIALTIES

A. Install refrigerant piping in accordance with piping and equipment manufacturer's recommendations.

B. Install refrigerant piping with 1/8" per foot (1%) downward slope in direction of oil return to compressor.

C. Provide oil traps and double risers where required to provide oil return.

D. Clean refrigerant piping by swabbing with dry lint-free cloth, followed by refrigerant oil soaked swab.

E. Remove excess oil by swabbing with cloth soaked in high flash point petroleum solvent, squeezed dry.

F. Bleed dry nitrogen through refrigerant piping during brazing operations.

G. Install refrigerant valves in accordance with manufacturer's instructions.

H. Remove accessible internal parts before soldering or brazing, replace after joints are completed.

I. Install solenoid valves with stem pointing upwards.

J. Install accessories in locations accessible for service.

K. Adjust evaporator pressure regulators, if required, for proper evaporator pressure.

L. Install filter drier cores after leak test but before evacuation.

M. Insulate quantity of lines as required by equipment manufacturer requirements and literature.

3.03 EQUIPMENT CONNECTIONS

A. Connect refrigerant piping to mechanical equipment according to equipment manufacturer's instructions.

3.04 DEHYDRATION AND CHARGING SYSTEM

A. After testing and acceptance of installation, evacuate refrigerant system with vacuum pump until 35°F temperature is reached on vacuum dehydration indicator.

B. During evacuation, apply heat to pockets, elbows, and low spots in piping.

C. Maintain vacuum on system for minimum of 5 hours after closing valve between vacuum pump and system.

D. Break vacuum with refrigerant gas, allow pressure to build up to 2 psi.

E. Complete charging system using new filter dryer core in charging line.

F. Provide full operating charge.

END OF SECTION

SECTION 233000 - DUCTWORK

PART 1 - GENERAL

1.01 SUMMARY

A. The General Provisions, Supplemental General Provisions, section 23 01 00, Division 1 Specifications and Special Provisions apply to all Work specified in this Section.

B. This section describes the basic materials and installation methods for the duct systems. Comply with other Division 23 sections and drawings as applicable. Refer to other divisions for coordination of work.

C. Furnish and install all components of the duct systems specified herein, as indicated on the drawings, and as required to provide complete and operating systems.

1.02 DESCRIPTION OF WORK

A. Work Included:
   1. Provide sheet metal ductwork as specified herein.

B. Types: The types of ductwork specified in this Section include, but are not necessarily limited to the following:
   1. Air conditioning cooling and/or heating supply and return air systems
   2. Outdoor air supply systems
   3. Mechanical exhaust systems
   4. Air relief systems
   5. Kitchen exhaust systems
   6. Boiler breeching and boiler flue

C. Supply Air Ductwork Downstream of Heat Pumps: Ductwork shall be sheet metal designed for velocities up to 1,500 fpm or a friction rate of 0.10 inches water column per 100 feet of duct, whichever is most stringent. The ductwork shall meet the latest SMACNA Standards for construction and stiffening based on the maximum pressure in the ductwork. Ductwork shall be 1" W.C. pressure class.

D. VAV Supply Air Ductwork Upstream of Terminal Units (round or flat oval): Ductwork shall be sheet metal designed for velocities up to 2,800 fpm. The ductwork shall meet the latest SMACNA Standards for construction and stiffening based on the maximum pressure in the ductwork. Ductwork shall be 3" W.C. pressure class.

E. VAV Supply Air Ductwork Upstream of Terminal Units (rectangular): Ductwork shall be sheet metal designed for velocities up to 2,300 fpm. The ductwork shall meet the latest SMACNA Standards for construction and stiffening based on the maximum pressure in the ductwork. Ductwork shall be 3" W.C. pressure class.

F. Supply Air Ductwork Downstream of Terminal Units: Ductwork shall be sheet metal ductwork designed for velocities up to 1,500 fpm or a friction rate of 0.10 inches water column per 100 feet of duct, whichever is most stringent. The ductwork shall

meet the latest SMACNA Standards for construction and stiffening based on the maximum pressure in the ductwork. Ductwork shall be 1" W.C. pressure class.

G. Outside Air Ductwork (fan forced): Ductwork shall be sheet metal ductwork designed for velocities up to 2,500 fpm. The ductwork shall meet the latest SMACNA Standards for construction and stiffening based on the maximum pressure in the ductwork. Ductwork shall be 1" W.C. pressure class.

H. Outside Air Ductwork (passive): Ductwork shall be sheet metal ductwork designed for velocities up to 1,000 fpm. The ductwork shall meet the latest SMACNA Standards for construction and stiffening based on the maximum pressure in the ductwork.

I. Garage Supply and Exhaust Ductwork: Ductwork shall be sheet metal ductwork designed for velocities up to 2,500 fpm. The ductwork shall meet the latest SMACNA Standards for construction and stiffening based on the maximum pressure in the ductwork.

J. Stairwell Pressurization Ductwork: Ductwork shall be sheet metal ductwork designed for velocities up to 3,000 fpm. The ductwork shall meet the latest SMACNA Standards for construction and stiffening based on the maximum pressure in the ductwork.

K. Restroom and General Exhaust Ductwork: Ductwork shall be sheet metal ductwork designed for velocities up to 1,500 fpm. The ductwork shall meet the latest SMACNA Standards for construction and stiffening based on the maximum pressure in the ductwork. Ductwork shall be 1" W.C. pressure class.

L. Smoke Exhaust and Relief Air Ductwork: Ductwork shall be sheet metal ductwork designed for velocities up to 3,000 fpm. The ductwork shall meet the latest SMACNA Standards for construction and stiffening based on the maximum pressure in the ductwork. Ductwork shall be rated for the temperature ranges of the fire as required by the local authority having jurisdiction.

M. Grease exhaust ductwork shall be designed for velocities up to 2,500 FPM. The ductwork shall meet the latest SMACNA standards for construction and stiffening based on the maximum pressure in the ductwork. Grease exhaust duct material and installation shall meet the requirements of NFPA 96 and shall be either 16 GA black carbon steel or 18 GA stainless steel, sloping at a minimum of ¼" / foot back toward the hood. All grease exhaust duct shall be welded and leak-tested. Cleanouts should be provided at least every 12 feet and at each change in direction.

N. Flexible Ductwork: Ductwork connections to HVAC terminal units and air devices shall be made with flexible ductwork connection where shown on the Drawings. Additional connections may be made using flexible ductwork at the Contractors opinion, where approved in writing, in advance, by the Engineer. Insulated value of Flexible duct shall be R-6 or greater.

O. Breeching and Flue: Breeching and flue for [boilers] [and] [water heaters] shall be Type "B" flue. [Breeching and flue shall be insulated as specified in Section 23 07 00.]

P. Ductwork Insulation: Refer to section 23 07 00, "HVAC Insulation", for duct insulation.

Q. Ductwork Accessories: Refer to Section 23 33 00, "Ductwork Accessories", for accessories and specialties related to ductwork systems and installation.

1.03 QUALITY ASSURANCE

A. Design and Installation Standards:
1. SMACNA HVAC Duct Construction Standards, latest edition.
2. ASHRAE Standards: Comply with American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE 70-72) , Method of Testing for Rating the air flow performance of outlets and inlets.
3. ADC Standard 1062R2, Air Diffusing Equipment Test Code.
4. AMCA Standard 210, Test Code for Air Moving Devices.
5. NFPA 90-A, Standard for the Installation of Air Conditioning and Ventilating Systems, 2002 edition.

B. Fire and Smoke Rating Test Standards: ASTM E84, NFPA 255 and UL 723.

1.04 SUBMITTALS

A. Shop Drawings: Submit dimensioned layouts of ductwork showing both the accurately scaled ductwork and its relation to space enclosure. Show modifications of indicated requirements, made to conform to local shop practice and how those modifications ensure that the free area, materials, and weights are not reduced. The shop drawings must be submitted at ¼" = 1'-0" or larger scale and shall include all equipment connected to the duct systems, drawn to scale, based on the equipment submittals. All ductwork and equipment must indicate bottom elevations, referenced to finished floor below (bottom of duct = X'-Y" AFF, e.g.)

PART 2 - PRODUCTS

2.01 DUCTWORK MATERIALS

A. Exposed Ductwork Materials: Where ductwork is indicated to be exposed to view in occupied spaces, provide materials which are free from visual imperfections including pitting, seam marks, roller marks, oil canning, stains, discolorations, and other imperfections, including those which would impair painting.

B. Gauges, Rectangular Ductwork: Fabricate galvanized steel ductwork from the minimum gauges for sizes up to the corresponding maximum long-side dimensions as indicated in SMACNA Duct Construction Standards.

C. Gauges, Round Ductwork: Fabricate lock-form quality galvanized steel ductwork from the minimum gauges for diameters up to the corresponding maximum dimensions as indicated in SMACNA Duct Construction Standards.

D. Fiberglass Duct board: Fiberglass duct board is NOT an acceptable means of air transport.

2.02 MISCELLANEOUS DUCT MATERIALS

A. General: Provide miscellaneous materials and products of the types and sizes indicated and where not otherwise indicated, provide type and size required to comply with ductwork system requirements including proper connection of ductwork and equipment.

B. Duct Sealant: Provide non-hardening, non-migrating mastic or liquid elastic sealant (type applicable for the fabrication/installation detail) as compounded and recommended by the manufacturer specifically for sealing joints and seams in ductwork.

C. Ductwork Support Materials: Except as otherwise indicated, provide hot-dipped galvanized steel fasteners, anchors, rods, straps, trim, and angles for support of ductwork.

D. Duct Liner Adhesive: Comply with ASC-A-7001 by The Adhesive and Sealant Council, Inc. (per SMACNA standards).

E. Duct Liner Fasteners: Comply with SMACNA.

F. Flexible Ductwork: Insulated flexible ductwork shall be Atco Type UPC #036 or UPC #031. Approved equal flexible ductwork by Certainteed Corporation, Flexaust Company, Genflex or Owens-Corning Fiberglass will be acceptable. Provide either 45 degree angle taps with manual volume dampers or "spin-in" taps with manual volume dampers at main duct tap as shown on Drawings. Provide with a minimum R-Value of 6.0 or R-Value of 8.0 when installed in unconditioned spaces.

2.03 BOILER FLUE AND BREECHING

A. Flues: Flues for boilers shall comply with NFPA requirements for Type "A" boiler flue. A UL factory-fabricated stack rated for such duty may be used or a stack fabricated of not less than 16 gauge steel, welded and insulated as specified under Section 23 07 00, "System Insulation", of these Specifications, including terminal caps may be used.

PART 3 - EXECUTION

3.01 GENERAL REQUIREMENTS

A. Standards: Round and rectangular sheet metal ductwork shall be constructed in accordance with SMACNA "HVAC Duct Constructions Standards", latest Edition, ASHRAE Guide and Data Book, "Handbook of Fundamentals", latest edition, specifically Chapter 25 and NFPA Standard 90-A, "Standard for the Installation of Air Conditioning and Ventilating Systems".

B. All ductwork required for the heating, ventilating and air conditioning systems shall be constructed and erected in a first class workmanlike manner. This work

shall be guaranteed for a period of one year from and after the date of acceptance of the job against noise, chatter, whistling, vibration, and free from pulsation under all conditions of operation.

C. The interior surface of all ductwork shall be smooth with no parts projecting into the air stream unless specified to do so. All seams and joints shall be external. The inside of all ductwork shall be thoroughly cleaned and all fans operated to remove any debris prior to connection of air devices.

D. All holes in ducts for damper rods and other necessary devices shall be either drilled or machine punched (not pin punched), and shall not be any larger than necessary. All duct openings shall be provided with sheet metal caps if the openings are to be left unconnected for any length of time.

E. Where ducts, exposed to view (including equipment rooms), pass through walls, floors or ceilings, furnish and install sheet metal collars around the duct.

F. Sheet metal plenums shall be constructed and reinforced in accordance with SMACNA standards. Where plenums are connected to louvers, the plenum bottom shall be sloped to drain to the louver.

G. Ductwork which is exposed to weather shall have soldered joints and seams and shall be painted with a suitable epoxy coating. In lieu of solder joints, the use of duct-mate or TDC manufactured flanges are acceptable.

3.02 COORDINATION

A. Prior to submitting ductwork shop drawings, the Division 23 Contractor shall fully coordinate the routing and height of all ductwork with all other trades and with ceiling heights, lighting fixtures and building construction.

3.03 GENERAL DUCTWORK FABRICATION

A. Duct Gauge and Reinforcing:
   1. Rectangular Ductwork: Minimum metal gauges and reinforcement shall be in accordance with SMACNA HVAC Duct Construction Standards (SDCS) Tables 1-3 through 1-13. Minimum aluminum gauges and reinforcement shall be in accordance with SDCS Tables 1-14 through 1-16. Reinforcing shall be installed per SDCS Fig. 1-9 through 1-12.
   2. Round Ductwork: Minimum metal gauges for longitudinal and spiral seam round ductwork shall be in accordance with SDCS Table 3-2. Minimum aluminum gauges for longitudinal and spiral seam round ductwork shall be in accordance with SDCS Table 3-3. Longitudinal seam ductwork larger than 12" diameter shall not be permitted unless welded seams are used.
   3. Cross-breaking: Cross-break or transverse bead all flat surfaces which are more than 12" wide. Transverse beading shall be on 12" centers and shall be a minimum of 1/8" deep at the center of the bead and 3/8" wide at the base of the bead.
   4. Minimum Gauges: The metal gauges listed in the SDCS for round and rectangular ductwork are the minimum recommended. It shall be the

Contractor's responsibility to select a metal gauge heavy enough to withstand the physical abuse of installation.

B. Duct Joints And Seams:

1. General: Make all joints airtight. The distance between transverse joints on any size duct shall not exceed 5'.
2. Rectangular Ductwork: Transverse joints and longitudinal seams in ductwork shall be constructed in accordance with SDCS Fig. 1-4 and 1-5. Drive slips may be used on rectangular ductwork on short sides only, up to 18" maximum. Gauge of drive slips shall be at least as heavy as ductwork on which they are installed. Bend drive slips over at least 3/4" at corners. Corner closures shall be in accordance with SDCS Fig. 1-13 through 1-18. All longitudinal seams shall be "Pittsburgh Lock" or button punch snap lock at corner seams and grooved seam or seam welded in sides between corners, in accordance with SDCS Fig. 1-5. At the Contractor's option, transverse joints may be transverse duct flange joints or Ductmate EP12/11 prefabricated galvanized "Ductmate" sections. The proposed gasket material, flange, corner piece and Ductmate details shall be submitted for approval.
3. Round Ductwork: Transverse joints for round ductwork shall be beaded sleeve type constructed in accordance with SDCS Fig. 3-2, properly secured and sealed. Draw bands shall not be used on round ductwork. Longitudinal and spiral seams shall be constructed in accordance with SDCS Fig. 3-1.
4. Ductwork Sealing: Seal all longitudinal and transverse ductwork joints and seams using SMACNA ductwork sealant to provide positive seal.

C. Connections and Take-offs:

1. Rectangular Ductwork: Parallel flow branches shall be constructed using radius elbow take-offs in accordance with SDCS Fig. 2-7. Branch duct connections shall be 45 degree entry expanded taps constructed in accordance with SDCS Fig. 2-8. Duct-mounted coil connections shall be constructed in accordance with SDCS Fig. 2-11.
2. Round Ductwork: Connections and takeoffs shall be made using 90 degree conical taps, 45 degree lateral taps or wye fittings constructed in accordance with SDCS Fig. 3-4 and 3-5. Use of 90 degree tees shall not be allowed.
3. Spin-in Fittings: Spin-in fittings may be used for duct taps to air supply and exhaust devices and shall include quadrant dampers even though a volume damper may be specified for the air device. Spin-in fittings shall be sealed at the duct tap with a gasket and compression fit or sealed with duct sealant. The location of spin-in fittings in the ducts shall be determined after terminal units are hung and the location of the light fixtures is known so as to minimize flexible duct lengths and sharp bends. Spin-ins shall be installed with their damper axis parallel to airflow. A minimum of 18" must be provided between fittings.
4. Flexible Joints In Ductwork: Provide flexible connections where ductwork connects to air-handling units, fans, and similar powered equipment items and where required for expansion and contraction of the ductwork or the building structure. A minimum of one inch (1") slack shall be provided in all flexible connection to insure vibration isolation. Flexible joints are not

required where equipment is connected with flexible duct. Flexible connections shall be rigidly connected to metal work on each side and shall be airtight. Bond flanges of flexible duct connectors to ducts and housings to provide airtight connections. Seal seams and penetrations to prevent air leakage.

D. Elbows and Tees:
   1. Rectangular Ductwork: Provide radius or square elbows in ductwork, where shown on the Drawings. Where radius elbows are shown, radius elbows must be provided. Where square elbows are shown, square or radius elbows may be provided, at the Contractor's option. Elbows shall be constructed in accordance with SDCS Fig. 2-2. Turning vanes are required in all square elbows of 46 degrees or greater angle. Turning vanes are not required in radius elbows. Turning vanes shall be single vane type without a trailing edge and shall be constructed and installed in accordance with SDCS Fig. 2-3 and 2-4.
   2. Round Ductwork: Provide radius elbows of the stamped or segmented type constructed in accordance with SDCS Fig. 3-3. Segmented elbows shall have a minimum of three segments for 45 degree elbows and five segments for 90 degree elbows.

E. Offsets and Transitions: Where duct width increases, maximum angle of slope shall be 20 degrees (one inch (1") in 2.7"). Where duct width decreases, maximum angle of slope shall be 30 degrees (one inch (1") in 1.7"). Offsets and transitions shall be constructed in accordance with SDCS Fig. 2-9 and 2-10.

F. Air Device Connections: Make connections to air devices and fabricate air device plenums as detailed on the Drawings and in accordance with SDCS Fig. 2-16 through 2-18.

3.04. DUCTLINER

A. General: The liner shall be applied to the inside of the duct with heavy density side to the air stream and shall be secured in the duct with adhesive, completely coating the clean sheet metal. All joints in the insulation shall be "buttered" and firmly butted tightly to the adjoining liner using fireproof adhesive. Where a cut is made for duct taps, etc., the raw edge shall be accurately and evenly cut and shall be thoroughly coated with fireproof adhesive. On ducts over 24" in width or depth, the liner shall be further secured with mechanical fasteners. The fasteners shall be A.J. Gerrard Company pronged straps, or approved equal, secured to the ducts by fireproof adhesive. The clips shall be 18" maximum spacing and shall be pointed up with fireproof adhesive. Liner shall be accurately cut and ends thoroughly coated with fireproof adhesive so that when the duct section is installed, the liner shall make a firmly butted and tightly sealed joint. Where ducts are lined exterior insulation will not be needed unless otherwise noted, except that the two insulations shall lap not less than 24". Ductliner for velocities over 2,000 fpm shall be as specified except a perforated metal liner shall be used over ductliner for securement, in lieu of fasteners. Ductliner installation and fasteners shall comply with SDCS Fig. 2-22 through 2-25.

3.05 DUCTWORK INSTALLATION

A. General: Assemble and install ductwork in accordance with recognized industry practices which will achieve airtight and noiseless systems, capable of performing each indicated service. Install each run with a minimum of joints. Align ductwork accurately at connections, within 1/8" misalignment tolerance and with internal surfaces smooth. Support ducts rigidly with suitable ties, braces, hangers, and anchors of the type which will hold ducts true-to-shape and prevent buckling. System leakage shall be the lesser of SMACNA Class B leakage calculation or 5% of total system CFM.

B. Inserts: Install concrete inserts for support of ductwork in coordination with formwork, as required to avoid delays in the work.

C. Completion: Complete fabrication of work at the project as necessary to match shop-fabricated work and accommodate installation requirements.

D. Run Location: Locate ductwork runs, except as otherwise indicated, vertically and horizontally and avoid diagonal runs wherever possible. Locate runs as indicated by diagrams, grams, details, and notations or, if not otherwise indicated, run ductwork in the shortest route which does not obstruct usable space or block access for servicing the building and its equipment.

Hold ducts close to walls, overhead construction, columns, and other structural and permanent-enclosure elements of the building. Limit clearance to 0.5" where furring is shown for enclosure or concealment of ducts, but allow for insulation thickness, if any. Where possible, locate insulated ductwork to assure 1.0" clearance of insulation. Wherever possible in finished and occupied spaces, conceal ductwork from view, by locating in mechanical shafts, hollow wall construction or above suspended ceilings. Do not encase horizontal runs in solid partitions, except as specifically shown. Coordinate the layout with suspended ceiling and lighting layouts and similar finished work.

E. Coordination: Coordinate duct installation with installation of accessories, dampers, coil frames, equipment, controls, and other associated work of the ductwork system.

F. Hangers and Supports:
1. General: All ductwork supports shall be per Section IV of the SMACNA "HVAC Duct Construction Standards - First Edition" with all supports directly anchored to the building structure. Supports shall be on maximum 8'-0" centers with additional supports as required to prevent sagging.
2. Attachment to Structure: Provide hanger attachment to the building structure as specified in Section 15100, "Basic Materials and Methods", and in accordance with SDCS Fig. 4-1 through 4-3.
3. Hangers: Hangers shall be strap or rod sized in accordance with SDCS Table 4-1 and 4-2. Strap hanger attachment to rectangular duct shall consist of a turning strap under the duct a minimum of one inch (1") and securing the strap with one screw into the bottom of the duct and one screw to the side of the duct. Rectangular duct supported on trapeze hangers shall be attached to the trapeze. Round duct attachments shall be constructed in accordance with SDCS Fig. 4-4.

4. Horizontal Ducts: Ducts larger than 50" in their greatest dimension shall be supported by means of hanger rods bolted to angle iron or half round trapeze hangers. Duct shall have at least one pair of supports 8'-0" on centers according to the following:

Angle Length	Angle	Rod Diameter
4'-0"	1-1/2" x 1-1/2" x 1/8"	1/4"
6'-0"	1-1/2" x 1-1/2" x 1/8"	1/4"
8'-0"	2" x 2" x 1/8"	5/16"
10'-0"	3" x 3" x 1/8"	3/8"

5. Vertical Ducts: Ducts shall be supported where they pass through the floor lines with 1-1/2" x 1-1/2" x 1/4" angles for ducts up to 60". Above 60", the angles must be increased in strength and sized on an individual basis considering space requirements.

G. Flexible Ductwork:
1. General: Flexible ductwork shall be provided as shown on Drawings. Flexible ducts shall be installed in a fully extended condition free of sags and kinks, using only the minimum length required to make the connection, subject to the maximum lengths herein and below. Bends in any length of flexible duct shall not exceed 45 degrees for HVAC terminal unit connections or 135 degrees for air device connections and shall not exceed that recommended by the flexible ductwork manufacturer. Unless otherwise shown on the Drawings, the length of any one run of flexible ductwork shall not exceed 2 feet to terminal units or 6 feet to air devices.
2. Supports: Where flexible duct extension exceeds 48", horizontally, a support shall be provided. Duct shall be suspended on 48" centers with a minimum two inch (2") wide flat banding material. Refer to SDCS Fig. 3-9 and 3-10 and Page 3-17 for additional requirements.
3. Terminal Unit Flexible Duct Connections: The terminal ends of the duct core shall be secured by stainless steel worm gear type clamps. The fittings on terminal units and on sheet metal duct shall be coated with sealant, then the flexible duct core slipped over duct and the clamp tightened, and the connections shall be sealed with duct sealant. Insulation of flexible duct shall be slipped over connection to point where insulation abuts terminal unit or insulation on duct and attached with self-locking nylon straps. The insulation connections shall then be sealed using foil duct tape to provide vapor barrier. Refer to SDCS Page 3-13 and 3-15 for additional requirements.
4. Air Device Flexible Duct Connections: All joints and connections shall be made by turning back the insulation and securing the inner liner with self-locking nylon straps and sealing with two wraps of duct tape. The insulation shall then be placed over the joint, attached with a self-locking nylon strap and sealed on the exterior with an approved foil duct tape. Refer to SDCS Page 3-13 and 3-15 for additional requirements.

H. Duct Mounted Devices:
1. Install duct mounted sensors and control devices furnished under Section 23 09 00, "Building Controls". Provide access doors at each duct mounted control device. Coordinate location of devices and installation requirements with the Section 23 09 00Contractor.

2. Install duct type smoke detectors furnished under Division 26. Provide access doors at each sampling tube assembly. Coordinate location of detectors and installation requirements with Division 26.
3. Provide duct test ports in ductwork as required to properly balance all air systems. Test ports shall be located per ANSI/ASHRAE Standard III to allow accurate pitot-tube traverse measurements in ductwork.

3.06 FLUE AND BREECHING

A. General: Install flues and breeching in accordance with the flue manufacturer's recommendations and in accordance with SDCS Fig. 2-20.

3.07 CLEANING AND PROTECTION

A. General: Clean ductwork internally, section-by-section of dust and debris as it is installed. Clean external surfaces of foreign substances which might cause corrosive deterioration of the metal or, where ductwork is to be painted, might interfere with painting or cause paint damage.

B. Repairs: Strip protective paper from stainless ductwork surfaces and repair finish or replace ductwork portion wherever it has been damaged.

C. Temporary Closure: At ends of ducts which are not connected to equipment or air distribution devices at the time of ductwork installation, provide temporary closure of polyethylene film or other covering which will prevent the entrance of dust and debris until such time that connections are to be completed.

END OF SECTION 233000

SECTION 233300 - DUCTWORK ACCESSORIES

PART 1 - GENERAL

1.01 SUMMARY

A. The General Provisions, Supplemental General Provisions, section 23 01 00, Division 1 Specifications and Special Provisions apply to all Work specified in this Section.

B. This section describes the basic materials and installation methods for the ductwork accesories. Comply with other Division 23 sections and drawings as applicable. Refer to other divisions for coordination of work.

C. Furnish and install all components of the duct systems specified herein, as indicated on the drawings, and as required to provide complete and operating systems.

1.02 DESCRIPTION OF WORK

A. Work Included: Provide ductwork accessories as required for the project including the following:
1. Extractors,
2. Turning vanes,
3. Monitors,
4. Splitter dampers,
5. Access doors,
6. Straightening grids
7. Fire dampers.

1.03 QUALITY ASSURANCE

A. SMACNA Compliance: Comply with applicable portions of Sheet Metal and Air Conditioning Contractors' National Association (SMACNA) Duct Construction Standards (latest edition).

B. ASHRAE Standards: Comply with American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc. (ASHRAE) recommendations pertaining to construction of ductwork accessories.

1.04 SUBMITTALS

A. Shop Drawings: Show modifications of indicated requirements, if applicable, made to conform to local shop practice and show how these modifications ensure that the materials and weights are not reduced and that the fabricated units are equivalent to the specified requirements in every significant way.

PART 2 - PRODUCTS

2.01 DUCTWORK ACCESSORIES, FABRICATION AND MATERIALS

A. General: Provide ductwork accessories that comply with the Section 23 30 00, "Ductwork", and other applicable product requirements of ductwork materials noted in this Section.

2.02 FLEXIBLE CONNECTIONS

A. General: Flexible connections shall be UL-labeled, 30 ounces glass fabric-lined with insulation and coated on both sides with neoprene, complete with attachment accessories, "Vent-Glass" by Vent-Fabrics, Inc. or approved equal.

2.03 DUCTWORK HARDWARE

A. General: Damper operators for concealed inaccessible ductwork shall be Young Regulator Company, Catalog No. 700 or No. 315, as shown. Non-insulated accessible ductwork shall be Young Regulator Company, Catalog No. 433. Accessible insulated ductwork shall be Young Regulator Company, Catalog No. 443. Approved equal units by Duo-Dyne or Vent Fabrics, Inc. will be acceptable.

2.04 DIRECTIONAL, VOLUME CONTROL, AND FIRE DAMPERS

A. General: Provide all direction and volume control and fire dampers shown or noted on Drawings. All damper control devices shall be installed so as to be fully concealed in finished rooms and spaces.

B. Dampers:
1. Splitter Dampers: Splitter dampers shall be not less than 16 gauge. Splitter dampers shall be 1-1/2 times the width of narrowest duct leaving split, except not less than 12" long and shall have not more than 1/4" less height than duct in which it is installed. Splitter dampers having area less than 2.25 square feet shall be adjusted by means of a locking quadrant mounted on end of shaft. Splitter dampers having larger area shall be adjusted by means of one or more push rods in accordance with Figure 2-5, SMACNA "Low Velocity Duct Construction Standards".
2. Extractors: Provide extractors of the size and type required, with hex-key operated adjustable blades, and with gang operated galvanized steel blades on one-inch centers.
3. Taps: Where rectangular take-offs of branches from main ducts are used with 45 degree entry, provide manual volume regulators with lockable operators and nylon bushings on both sides of damper blade rod. Manual volume damper shall have standoff when duct system type is insulated.
4. Round Taps: Where taps to main ducts or their branches are made, provide 45 degree angle taps or 90 degree spin-in taps with manual volume dampers with nylon bushings on both sides of damper blade rod. Manual volume damper shall have standoff when duct system type is insulated.
5. Multi-leaf Dampers: Where multi-leaf dampers are required, provide opposed blade-type in accordance with Figure 2-12, SMACNA "Low Velocity Duct Construction Standards".

C. Fire Dampers: Provide fire dampers at duct penetrations of floors, smoke partitions, fire walls, and where required by the applicable building codes or

authority having jurisdiction. Fire dampers shall comply with state and local codes, be inspected and approved by an approved inspection agency and be labeled at the factory in accordance with Uniform Building Code Standard 43, Section 43.714.

1. Provide one-hour rated dampers where penetrations are in required one-hour fire rated assemblies.
2. Provide 1-1/2 hour rated dampers where penetrations are in required 2-hour fire rated assemblies.
3. Provide 3 hour rated dampers where penetrations are in required 4-hour fire rated assemblies; 4-hour occupancy separating walls are accepted.
4. Fire Dampers shall be type 'B' with shutter located outside of the airstream unless otherwise noted or detailed.

D. Fire Smoke Dampers: Provide fire smoke dampers at duct penetrations of floors, smoke partitions, shaft walls and where required by the applicable building codes. Fire smoke dampers shall comply with state codes, be inspected and approved by an approved inspection agency and be labeled at the factory in accordance with UL 555S.

1. Provide one-hour rated dampers where penetrations are in required one-hour fire smoke rated assemblies.
2. Provide 1-1/2 hour rated dampers where penetrations are in required 2-hour fire smoke rated assemblies.
3. Provide fire smoke dampers with duct mounted smoke detector located within 5' of the damper and wired to fire alarm.
4. Coordinate damper power with fire alarm Construction Professional.
5. Fire smoke dampers shall be provided with rated access doors/panels for review and inspection of dampers.

2.05 FLASHING AND COUNTER-FLASHING

A. General: Flashing and counter-flashing shall be as specified in other Divisions of these Specifications.

2.06 DUCT ACCESS DOORS

A. General: Provide hinged duct access doors, gasketed and with insulation where ductwork is indicated to be insulated. Provide construction per SMACNA Standards. Access doors shall be at least 15" x 15".

B. Inspection Plates: Provide inspection plates as required. Provide a minimum opening of 4" x 4" with a 6" x 6" cover plate. The cover plate shall be one gauge heavier than the ductwork, gasketed and secured with a minimum of eight sheetmetal screws.

2.07 MISCELLANEOUS DUCTWORK MATERIALS

A. General: Provide miscellaneous materials for ductwork accessories, including hinges, refrigerator latches, sash locks, bolts and wing nuts, gaskets and pitot tubes as recommended by the ductwork accessories manufacturer for the application indicated.

2.08 TURNING VANES

A. Construct turning vanes in accordance with SMACNA Standards (current edition).

PART 3 - EXECUTION

3.01 INSTALLATION

A. Access Doors: Install access doors so that the doors open against the system air pressure wherever feasible and that their latches are operable from either side, except where the duct is too small to be entered. Provide access to each fire damper link to permit resetting. Comply with the applicable building codes or authority having jurisdiction and NFPA 96.

B. Inspection Plates: Install plates at each primary zone damper and where otherwise required for inspection of operable mechanisms within the duct systems.

C. Multileaf Dampers: Install multileaf volume dampers in each zone duct of multizone units and as otherwise required for balancing.

D. Splitter Dampers: Install splitter dampers at all divisions of ductwork for proper air pattern control.

E. Turning Vanes:
1. Install turning vanes for all rectangular mitered elbows. Install turning vanes in accordance with SMACNA Standards.
2. Turning vanes for Ducts with air velocity less than 2500 FPM: Use single wall type vanes for ducts having width equal to or less than 12 inches.
3. Use double wall type vanes for (2" radius, 2–1/8" spacing) for ducts having widths greater than 12 inches.
4. If duct sizes change in a mitered elbow, use single wall type vanes with a trailing edge extension.
5. Turing vanes for Ducts with air velocity greater than 2500 FPM: Use double wall type vanes (4-1/2" radius, 3-1/4" spacing).

3.02 TESTING

A. General: Check installed ductwork accessories for required operation and leak-proof performance during the system's operational test. Repair or replace faulty accessories, as required to obtain proper operation and leak-proof performance.

END OF SECTION 233300

SECTION 233400 - FANS AND HOODS

PART 1 - GENERAL

1.01 SUMMARY

A. The General Provisions, Supplemental General Provisions, section 23 01 00, Division 1 Specifications and Special Provisions apply to all Work specified in this Section.

B. This section describes the basic materials and installation methods for the fan and hood systems. Comply with other Division 23 sections and drawings as applicable. Refer to other divisions for coordination of work.

C. Furnish and install all components of the fan and hood systems specified herein, as indicated on the drawings, and as required to provide complete and operating systems.

1.02 DESCRIPTION OF WORK

A. Work Included: Provide U.L. listed fans and ventilators as required by code and as specified.

1.03 QUALITY ASSURANCE

A. Basis of design is Greenheck. Other acceptable manufacturers are ACME, Broan, Buffalo, Carnes, Cook, Penn, and Woods.

PART 2 - PRODUCTS

2.01 PRODUCT REQUIREMENTS

A. Ratings: Fans shall be licensed to bear the AMCA certified ratings seal. Ratings of fans shall be based on 70°F and 29.92" of Hg atmospheric pressure. Air handling equipment shall be sized in conformance with applicable codes and good engineering practice. Roof-mounted units shall be located in coordination with the Architect to ensure proper sight lines.

B. Construction: Fan construction shall be in accordance with AMCA classes of construction for the intended duty. Fan wheels, shafts, and drives shall be statically and dynamically balanced at the factory as a unit. Balance reports shall be factory-certified to the Construction Manger.

C. Drives: Provide drives with a minimum belt horsepower capacity of 120% of the motor nameplate horsepower.

D. Motor Sheaves: Motor sheaves shall be Browning Type, MVP, or approved equal, adjustable type with double-locking feature. Motor sheaves shall be selected for the rated fan rpm and shall be adjustable to as close as 10% above and below the rated fan speed.

E. Fan Sheaves: Provide adjustable or nonadjustable sheaves with removable machined bushings. Sheaves shall be machined on surfaces. Sheaves with over three grooves shall be dynamically balanced and the manufacturer shall so designate on each sheave. Fan sheaves with three grooves or less shall be statically balanced and weights required for balancing shall be welded to the sheaves. Manufacturers shall be Browning, Eaton, Yale, Towne, Dodge Manufacturing Company, or Fort Worth Steel and Machinery Company.

F. Belts: Provide standard "V-groove" belts suitable for the service intended with the required capacities. The belts shall be closely matched and tagged prior to delivery to the job site. If the belts do not appear to be properly matched during operation, they shall be rechecked and, if necessary, replaced. Belts shall be as manufactured by Gates, Durkee-Atwood, Goodyear, Browning, or Uniroyal.

G. Bearings: Provide SKF, Sealmaster, Timken, or Fafnir externally or internally-mounted, grease-lubricated, self-aligning ball bearings. Bearings shall have grease type zerk fittings.

H. Motor Mount: Motors shall be mounted on an adjustable base rigidly supported on the fan and shall have extended shaft to accommodate the adjustable pitch sheave.

2.02 CEILING EXHAUST FANS

A. General: Provide direct driven ceiling exhaust fans as required. Fan shall be acoustically insulated and have a maximum sound level rating as scheduled.

B. Motor: Motor shall be suitably grounded and mounted on rubber-in-shear vibration isolators and speeds shall not exceed that scheduled.

C. Accessories:
1. Provide totally noise-free, integral back draft damper, with no metal to metal contact.
2. Inlet grille shall be white molded plastic with egg-crate or perforated shape and provide 85% free open area.
3. Provide terminal box on the housing with cord, plug, and receptacle inside the housing.

PART 3 - EXECUTION

3.01 VENTILATION AND EXHAUST FANS

A. General: Ventilating and exhaust fans not having integral vibration isolation shall be mounted on or suspended by vibration isolators as specified under Section 23 05 48. Where ductwork is connected to fans, Contractor shall provide UL labeled flexible duct connections.

B. Curbs: Factory-fabricated roof curbs, caps, and similar items, shall be supplied and installed by Mechanical Contractor. Coordinate installation with Roofing Contractor.

3.02 SYSTEMS

A. Refer to Section 23 05 53, "Mechanical Identification" for applicable painting, nameplate, and labeling requirements.

B. Placement of fans and noise levels generated by the fans shall be taken into consideration. Refer to specification 23 34 00 for additional information.

END OF SECTION 233400

SECTION 233700 - REGISTERS, GRILLES, AND DIFFUSERS

PART 1 - GENERAL

1.01 SUMMARY

A. The General Provisions, Supplemental General Provisions, section 23 01 00, Division 1 Specifications and Special Provisions apply to all Work specified in this Section.

B. This section describes the basic materials and installation methods for the registers, grilles, and diffusers. Comply with other Division 23 sections and drawings as applicable. Refer to other divisions for coordination of work.

C. Furnish and install all components of the registers, grilles, and diffusers specified herein, as indicated on the drawings, and as required to provide complete and operating systems.

1.02 DESCRIPTION OF WORK

A. Work Included: Provide air outlets and inlets as required for the finished or non-tenant areas of the project including the following:
1. Ceiling air registers, grilles, diffusers
2. Wall mounted registers and grilles
3. Linear lay-in slot diffusers
4. Architectural linear diffusers

1.03 QUALITY ASSURANCE

A. Basis of design is Titus. Other acceptable manufacturers are Krueger, Anemostat, Carnes, Metal Aire, Price, Nailor or Tuttle & Bailey.

B. NFPA Compliance: Comply with NFPA 90, as applicable to air diffuser construction and installation.

C. Air Distribution Equipment: Maximum space temperature variation shall not exceed 2°F through the conditioned area from 2' above the floor to 7' above the floor. The air outlets shall be selected by the manufacturer to suit the volume, throw, and noise level criteria described in these Specifications, and maintain maximum terminal velocities of 50 fpm, unless otherwise indicated.

PART 2 - PRODUCTS

2.01 AIR OUTLETS AND INLETS

A. General: Provide air outlets and inlets of the size, shape, and type, constructed of materials and components, and with finishes as required. Apply corrosion resistant treatment to surfaces prior to applying prime coat.

B. Ceiling Diffusers: Provide diffusers with corrosion resistant treated surfaces and finished in baked enamel unless otherwise required. Where applicable, provide adapters with diffusers to permit connection to round supply duct.

C. Registers and Grilles:
   1. General: Provide registers that contain a key-operated multi-louvered opposed blade damper operable from the face side.
   2. Supply Air Register: Provide supply air registers of the double deflection type.
   3. Return Air Grilles and Return Air Registers: Provide grilles and registers as required.

D. Supply Linear Diffuser:
   1. Provide supply linear diffuser with length and width as required. The supply diffuser shall be installed above the ceiling and located as indicated on the Architectural and Mechanical Drawings.
   2. The diffuser shall be designed, tested, and constructed in a manner so as to comply with the performance criteria and sound level requirements specified elsewhere in these Specifications. Plenum shall be constructed of at least 24 gauge galvanized steel and shall be reinforced as required. The air volume, length and duct connection size shall be as required. Coordinate the attachment, support, and similar features of the supply plenum with the ceiling Subcontractor.
   3. The plenum shall be painted flat black on interior surfaces and the exposed surfaces as viewed from below the ceiling system shall be painted flat black.

PART 3 - EXECUTION

3.01 INSTALLATION

A. General: Install air outlets and inlets in accordance with manufacturer's written instructions and recognized industry practices to ensure that products serve intended functions.

B. Duct Connection to Diffuser:
   1. Where flexible duct is connected to ceiling diffusers, the contractor shall use one of these three methods:
      a. Insulated flexible duct with Titus FlexRight flexible duct support, UL listed, to form duct elbow.
      b. A sheet metal elbow, externally insulated.
      c. Insulated flexible metal duct consisting of flexible metal core of corrugated aluminum with external insulation.
   2. In all cases duct connection/elbow shall be made with a bend that has not less than one duct diameter centerline radial.

C. Coordination: Coordinate with other trades, including ductwork, and ductwork accessories, as necessary to interface air outlets and inlets properly with other work.

3.02 FIELD CONTROL QUALITY CONTROL

A. Test installed devices to demonstrate satisfactory compliance with specified and indicated requirements.

END OF SECTION 233700

SECTION 237400 - PACKAGED DX CONSTANT VOLUME ROOFTOP UNITS

PART 1 - GENERAL

1.01 SUMMARY

A. The General Provisions, Supplemental General Provisions, section 23 01 00, Division 1 Specifications and Special Provisions apply to all Work specified in this Section.

B. This section describes the basic materials and installation methods for the rooftop unit system. Comply with other Division 23 sections and drawings as applicable. Refer to other divisions for coordination of work.

C. Furnish and install all components of the roof top units specified herein, as indicated on the drawings, and as required to provide complete and operating systems.

1.02 DESCRIPTION OF WORK

A. Work Included: Provide roof top constant air volume air-conditioning system, complete with controls and accessories as specified. Roof curbs are furnished under this section. Coordinate installation of curbs with Roofing Contractor.

B. Units shall be self-contained, rooftop curb-mounted, single package type. The rooftop units shall be completely factory assembled as a unitary package complete with operating controls and shall be completely piped, internally wired and fully charged with R-410 refrigerant. Only one electrical power connection shall be required.

1.03 QUALITY ASSURANCE

A. Equipment shall be installed and wired in accordance with applicable local and national codes.

B. Unit shall conform to the requirements and specifications of NFPA, and applicable local, state, and national codes.

C. Units shall be warranted by manufacturer with full factory warranty on materials and workmanship for one year from date of start-up, or the date of beneficial use, whichever is later.

D. Manufacturer shall provide a minimum five year material warranty on compressor.

1.04 SUBMITTALS

A. Shop drawings submittals shall include, but are not limited to, the following:
   1. Unit cut-sheets clearly showing all features, accessories, dimensions, weights, and capacities.
   2. Written instructions for equipment installation.

3. Wiring and piping diagrams and connection locations.
4. Performance certifications and test results.
5. Warranty information.
6. Additional information as required in Section 23 01 00.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. The "Basis of Design" is Daikin. Other acceptable manufacturers are:
   1. AAON
   2. Carrier
   3. Trane

2.02 ROOFTOP UNITS

A. General
   1. Factory assembled, single piece heating and cooling unit.
   2. Contained within unit enclosure shall be all factory wiring, piping, refrigerant charge operating oil charge, dual refrigerant circuits, microprocessor based control system and associated hardware.

B. Unit Cabinet
   1. Unit cabinet shall be constructed of heavy gauge galvanized steel with a weather resistant baked enamel finish tested in accordance with ASTM B117.
   2. Cabinet panels shall be hinged or removable for easy servicing and shall provide a water tight seal. All panels and covers shall be insulated with ½ inch, one pound density matt faced, fire resistant, permanent, odorless, fiber glass insulation.
   3. Lifting lugs shall be factory installed to facilitate overhead rigging.
   4. Unit shall be equipped with factory-supplied condensate drain connection for evaporator coil.

C. Fans
   1. Evaporator Fan
      a. Fans shall be forward curved, centrifugal, belt driven single or double wheel and mounted on a common shaft with adjustable motor sheaves. Fan shall be statically and dynamically balanced and tested in the factory. Fan shall not pass through its first critical speed to meet its scheduled performance. The fan and motor assembly shall be mounted on a common base. For units with motor sizes greater than five (5) HP, the entire assembly shall be internally isolated from the rest of the unit with double deflection vibration isolators. Motors shall be thermally protected.
   2. Condenser Fan
      a. Outdoor fans shall be of the direct driven propeller type statically and dynamically balanced in the factory and be protected by a wire guard.

b. Outdoor fans shall discharge air vertically upward and shall have permanently lubricated bearings and thermal overload protection.

D. Compressors
1. Two semi-hermetic or scroll type with unloading capability. Units larger than 25 tons shall be capable of at least four stages of loading.
2. Factory mounted on spring vibration isolators.
3. Equipped with factory-installed crankcase heater, high and low pressure control, outdoor ambient protection, height motor temperature cut-out, compressor sump heat, three phase overload protection, and anti-cycle timer.

E. Coils
1. Evaporator and condenser coils shall have aluminum plate fins mechanically bonded to seamless copper tubes with all joints brazed. The coils shall be leak tested at the factory to 200 psig and pressure tested to 450 psig.
2. Coils shall be intertwined circuited to provide two independent refrigeration system.

F. Electric Heating Section
1. Electric heating sections shall be furnished with nickel-chromium open coil resistance heating elements with each element protected by an automatic reset high-limit thermostat and manual reset high- limit thermostat for the primary and secondary over-current/thermal protection. Controls shall provide for multiple stage start-up and operation. Electric module shall be UL listed.

G. Refrigerant Components
1. Refrigerant circuit components shall include: Filter dryers, liquid line sight glasses, compressor discharge valves, liquid line service valves and thermal expansion valves.

H. Filter Section
1. Standard filter section shall consist of low velocity, disposable two inch thick glass fiber filters in commercially available sizes. Filters shall be not less than 30% efficient when tested in accordance with ASHRAE Standards. Temporary filer media shall be provide throughout the course of construction and shall be changed as required to maintain proper unit operation and filtration. Provide new set of filters when building is turned over to the Owner.

I. Controls, Safeties and Diagnostics
1. Controls: Controls shall be accomplished through use of factory installed, microprocessor based control system and associated electronic and electrical hardware. For building with BAS systems, all required control capability and alarm monitoring shall be made available via a compatible interface with the BAS system.
2. Compressor safeties: Compressors shall be equipped with the following protections:

a. Over temperature (shuts down compressor).
b. Over current (shut down individual compressor).
c. Crankcase heaters.
d. Ground fault (shuts down individual compressor).
e. High-pressure switch (shuts down individual compressor, automatic reset type).
f. Low pressure switch (shuts down compressor, automatic reset type).

3. Heating Section Safeties: Heating Section shall be equipped with the following protections:
   a. Loss of airflow switch.
   b. Temperature limit switches.
   c. Flame rollout switches. (gas heating only)
   d. Centrifugal switch mounted on each induced draft fan motor. (gas heating only)
   e. Automatically reset high-limit over-current/thermal protection. (electric heating only)
   f. Manually reset high-limit over-current/thermal protection. (electric heating only)
4. Interlocks shall be made to the duct-mounted smoke detectors in each units supply and return ductwork to shut the unit off and fully close the return air dampers to prevent migration of smoke upon its detection.

J. Operating Characteristics:
1. Unit shall be capable of starting and running at 115°F ambient outdoor temperature per maximum load criteria of ARI Standard 360.
2. Compressor with standard controls shall be capable of operation down to 0°F ambient outdoor temperature.
3. Provides multistage mechanical cooling capability.
4. Unit shall be factory equipped with shutoff valve and tubing to maintain capacity control at minimal cooling loads.

K. Electrical Requirements: All unit power wiring shall enter cabinet at single location.

L. Motors
1. Compressor motors shall be cooled by suction gas passing through motor winding and shall have internal thermal overload protection.
2. Indoor blower poly-phase motor bearing shall be of ball bearing type.
3. Outdoor totally enclosed motors shall have permanently lubricated sealed ball bearing and inherent automatic reset thermal overload protection.
4. Each poly-phase compressor and indoor fan motor shall be protected against over-current and single phasing conditions. Protection devices shall be manual reset type.

M. Accessories to include:
1. Integrated Economizer: For units 7.5 tons and greater, enthalpy controlled integrated type consisting of dampers, motors and linkages, and potentiometer in conjunction with control system to provide primary

cooling using outdoor air, enthalpy permitting, supplemented with mechanical cooling when necessary.

a. Dampers shall be low-leakage type, not to exceed one percent leakage at one inch water gauge pressure differential when fully closed.
b. Linkages shall have spring return feature which shuts dampers upon power interruption or unit shutdown.
c. Capable of introducing up to 100% outside air.
d. Exhaust/Return Air Fan, capable of 100% of maximum economizer supply air flow, shall be forward-curved centrifugal belt type only with fixed pitch pulley drive with optional factory installed inlet vanes or variable speed drive for capacity control Fan shall be controlled by building pressure sensor for active pressure control. Pressure sensor shall be installed in a location representative of the overall building pressure.

2. Barometric relief damper package: (Exhaust fan to be used on units over 20 tons)
   a. Package shall relieve internal pressure and consist of damper assembly, hoods, damper screen, seal strip and required hardwire.
   b. Damper assembly shall close due to gravity upon unit shutoff.
   c. Unit mounted down-flow units only.
3. Roof Curb:
   a. Each unit shall be provided with a full perimeter roof curb. The roof curb shall be of the same manufacturer as the unit, shall support the unit and provide a watertight enclosure to protect ductwork and utility services. Curb design shall comply with National Roofing Contractors Association requirements. Gaskets must be provided at supply/return air openings. Channel shall be provided allowing for adjustment of return air opening location to match the building structural frame indicated.

PART 3 - EXECUTION

3.01 START-UP

A. A factory certified trained service technician shall supervise the installation of equipment and start-up.

B. A factory certified service technician shall fully instruct Owner's personnel in the operation and maintenance of units.

3.02 INSTALLATION

A. Roof Top Air Unit
   1. Install units on roof curbs furnished by unit manufacturer and in accordance with manufacturer's installation instructions.
   2. For rooftop units of 50 tons or greater, provide isolation rails for vibration isolation and install sound attenuation materials inside the roof curb to dampen noise transfer from unit to occupied space. Coordinate added weight with structural engineer.

3. The rigging and setting of the units shall be in accordance with the unit manufacturer's recommendations.
4. All penetrations through unit are to be in factory provided chases. No penetrations through the condensate pan, etc. are permitted.

END OF SECTION 237400

SECTION 23 81 26 - AIR COOLED SPLIT SYSTEM AIR CONDITIONING UNITS

PART 1 - GENERAL

1.01 SUMMARY

A. The General Provisions, Supplemental General Provisions, section 23 01 00, Division 1 Specifications and Special Provisions apply to all Work specified in this Section.

B. This section describes the basic materials and installation methods for the air cooled split system units. Comply with other Division 23 sections and drawings as applicable. Refer to other divisions for coordination of work.

C. Furnish and install all components of the split system units specified herein, as indicated on the drawings, and as required to provide complete and operating systems.

1.02 DESCRIPTION OF WORK

A. Work Included: Provide a UL listed split system air-conditioning unit work including, but not limited to, the furnishing and installation of an indoor evaporator unit, an air-cooled condensing unit, filters, [electric heat section,] thermostat, accessories and other controls as required by local, state, and other applicable codes.

1.03 QUALITY ASSURANCE

A. Manufacturer: "Basis of Design" is Trane. Acceptable alternate manufacturers:

1. Carrier
2. Lennox
3. Daikin

B. Certification: Provide manufacturer's certification of compliance with ARI Standard 210.

1.04 SUBMITTALS

A. Shop drawings submittals shall include, but are not limited to, the following:

1. Unit cut-sheets clearly showing all features, accessories, dimensions, weights and capacities.
2. Written instructions for equipment to installation.
3. Wiring and piping diagrams and connection locations.
4. Performance certifications and test results.
5. Warranty information.
6. Additional information as required in Section 23 01 00.

1.05 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Deliver split system air conditioning units and accessories in factory-fabricated water-resistant wrapping.

B. Handle split system air conditioning units and accessories carefully to avoid damage to material components, enclosure and finish.

C. Store split system air conditioning units and accessories in a clean, dry space and protect from the weather.

PART 2 - PRODUCTS

2.01 MATERIALS

A. General: Except as otherwise indicated, provide split system air-conditioning unit manufacturer's standard materials and components as indicated by his product information, designed and constructed as recommended by the manufacturer and as required for a complete installation.

B. Evaporator Units:

1. General: Provide DX fan coil units of the size and capacity scheduled on the Drawings. All units shall be UL approved and rated in accordance with AIR Industry Standard 441.
2. Basic Unit: Units shall be fabricated of 18 gauge galvanized steel. The fan and motor assembly shall be easily removable for service. Units shall have 1" supply and return duct collars.
3. Cabinet: Cabinets shall be horizontal enclosed type and shall have 18 gauge steel panels acoustically and thermally insulated with 1/2" coated glass fiber insulation meeting NFPA-90A requirements. Exposed panels shall be bonderized and finished with a baked primer and a finish coat of enamel.
4. Coils: DX cooling coils shall have copper tubes with aluminum fins, mechanically bonded to the tubes. Coils for use with single compressor condensing units shall be single circuit and coils for use with dual compressor condensing units shall have two full-face refrigerant circuits. A factory installed thermal expansion valve shall be provided for each circuit. "A" coils shall be factory leak tested at 225 psi air under water. Coils shall have a maximum of 12 fins per inch. Coil air pressure drop shall not exceed scheduled maximum.
5. Electric Heat: Electric heating elements shall be integrally mounted and shall have voltage and capacity as scheduled. Heater elements shall be constructed of heavy-duty nickel chromium wire. Heaters shall be complete with magnetic contactor and all required controls and safeties.
6. Motors: Motors shall be 3-speed, high efficiency, permanent split capacitor type with thermal overload protection. Maximum motor horsepower, input wattage shall not exceed that schedule.

7. Junction Box: Units shall have a factory installed junction box with the fan motor and heating coil wired to the junction box.
8. Fans: Fans shall be of the centrifugal, forward-curved type. Fan wheels shall be statically and dynamically balanced. Fan wheels and housings shall be galvanized steel.
9. Drain Pan: Pans shall be fabricated of 18 gauge galvanized steel lined on the interior surfaces with 1/2" fire retardant closed cell foam. A 7/8" OD sweat fitting shall be provided for primary drain connection. A 1/2" OD overflow secondary drain connection shall be provided. Units shall be provided with a pan extension under the piping area.
10. Filters: Filter shall be 1" throwaway of woven glass fiber and shall be installed in each unit. RA opening shall be a [rear] [bottom] mounted grill or duct connection as shown on the drawings. Three sets of filters shall be supplied for each fan coil units. One set shall be installed at initial unit startup after all ductwork has been blowout and shall be used during balancing and testing, the second set shall be installed at the time of substantial completion and the third set shall be turned over to the Owner. Any additional filter sets required during the construction period shall be the responsibility of the Contractor.
11. Certification: All fan coil unit performance data shall be certified in accordance with AIR 441-70. Units shall be sound-tested and rated in accordance with ARI- 443-70.
12. Unit Controls: Controls shall include a magnetic fan contractor, terminal strip, heater contactor and controls, and all other required controls. All controls shall be factory wired and tested.

C. Air-cooled Condensing Units:

1. General: Provide air cooled condensing units of the size, type, capacity and arrangement as shown and scheduled on the Drawings. Condensing units shall be assembled on a heavy-gauge integral steel base. Units shall be weatherproofed and include hermetic compressor(s), condensing coils, fans and motors, controls and holding charge of R-32/R-454B. Units shall have a control box access panel and removable end panels that allow access to all major components and controls.
2. Unit Frame: Frame shall be a welded assembly of heavy gauge zinc-coated, galvanized steel. Drainage holes shall be provided as required. Exterior surfaces shall be cleaned, phosphatized and coated with an epoxy resin primer and finished with an enamel finish.
3. Refrigeration Circuits: Units up to 7-1/2 tons shall have single compressors with a single compressor. Units 10 tons and larger shall have dual compressors and dual refrigerant circuits for use with a dual circuit cooling coil. Each refrigeration circuit shall have an integral sub-cooling circuit.
4. Compressors: Each compressor shall be a direct-drive hermetic type with centrifugal oil pump; two-point lubrication for each bearing and connecting rod; crankcase heater and well; high strength, ring-type suction and discharge valves; large gas passages and minimum clearance volumes; and rubber-in-shear isolators; and a thermostatically controlled crankcase heater.

5. Compressor Motors: Each compressor motor shall be suction gas-cooled and have a voltage utilization range of plus or minus 10 percent of nameplate voltage. Internal temperature and current-sensitive motor overloads shall protect compressors under loss of charge and other abnormal operating conditions.
6. Condenser Fans: Fans shall be vertical discharge, direct-drive type, statically and dynamically balanced, with aluminum blades and zinc-plated steel hubs. Motors shall have permanently lubricated ball bearings, built-in current and thermal overload protection and weather-tight slingers over bearings. The fan motors shall be mounted in rubber isolators. Corrosion resistant fan grills shall be provided.
7. Condenser Coils: Condenser coils shall be aluminum fins mechanically bonded to seamless copper tubing. Sub-cooling circuit(s) shall be provided as standard for each refrigeration circuit. Coils shall be factory pressure and leak-tested to 425 psig air pressure. Corrosion resistant metal grilles for coil protection shall be provided.
8. Controls: Unit controls shall include a fused 24-volt control power transformer, magnetic contactors for each compressor, cooling low ambient fan switches, high pressure cut-out(s), low pressure cut-out(s) and reset relays. Unit completely factory-wired with necessary controls and terminal block for connection of field control power wiring. An anti-recycle timer shall be provided. Provide low ambient controls, as scheduled.
9. Refrigerant/Oil Charge: Units shall be shipped from the factory with a sufficient charge of refrigerant and oil for the complete system when used with pre-charged refrigerant lines.
10. Refrigerant Line Connections: Connections shall be either compression or sweat type. Brass liquid and suction line service valves, gauge/charging ports in the liquid line and a sight glass in the liquid line shall be provided.
11. Low Ambient Operation: Units shall include head pressure controller dampers, fan speed control or hot gas bypass as required to allow starting and operation down to 0°F.
12. Warranty: The manufacturer's one year parts and labor and five year extended (non pro-rated) compressor warranty shall be provided.

PART 3 – EXECUTION

3.01 INSTALLATION

A. General: Install each computer room air conditioning system in accordance with manufacturer's instructions, the NEC, and applicable local codes and ordinances. Test installed system for compliance with these Specifications. Rework as required and as directed to ensure that specified and indicated requirements are met and that installed systems function as intended.

B. Mounting: Provide foundation, platforms, and hangers required for proper installation of equipment.

C. Fans: Install fans to operate without noticeable vibration or noise after installation.

D. Guards: Arrange belt guards to permit accessible tachometer readings, oiling, and testing with guards in position.

E. Refrigerant Piping: Install, test, evacuate and charge refrigerant piping per the manufacturer's recommendations and as specified in Section 23 23 00, "Refrigerant Piping". Technician performing this work shall be certified and shall utilize proper refrigerant reclaim procedures.

F. Identification: Refer to Section 23 05 53, "Equipment and Piping Identification", for applicable painting, nameplate, and labeling requirements. Nameplates on units in finished areas shall be installed inside the unit cover and the unit manufacturers labeling system shall be used for exposed labeling of units.

END OF SECTION

SECTION 238129 - DUCTLESS AIR-COOLED SPLIT SYSTEM AIR CONDITIONING UNITS

PART 1 – GENERAL

1.1 SYSTEM DESCRIPTION

A. The Heat Pump system shall be a ductless split system with Variable Speed Inverter Compressor technology. The system shall consist of a horizontal discharge, single phase outdoor unit, a matched capacity indoor section that shall be equipped with a wired wall-mounted, wireless wall-mounted or wireless handheld remote controller.

Manufacturers are: Daikin, Trane, Mitsubishi, York, Carrier.

1.2 QUALITY ASSURANCE

A. The units shall be tested by a Nationally Recognized Testing Laboratory (NRTL) and shall bear the ETL label.

B. All wiring shall be in accordance with the National Electrical Code (N.E.C.) and local codes as required.

C. The units shall be rated in accordance with Air-conditioning, Heating, and Refrigeration Institute's (AHRI) Standard 240 and bear the ARI Certification label.

D. The units shall be manufactured in a facility registered to ISO 9001 and ISO 14001, which is a set of standards applying to environmental protection set by the International Standard Organization (ISO).

E. A dry air holding charge shall be provided in the indoor section.

F. The outdoor unit shall be pre-charged with R-410a refrigerant for 100 feet (20 meters) of refrigerant tubing.

1.3 DELIVERY, STORAGE AND HANDLING

A. Unit shall be stored and handled according to the manufacturer's recommendations.

B. The controller shall be shipped separately and shall be able to withstand 105°F storage temperatures and 95% relative humidity without adverse effect.

PART 2 – WARRANTY

2.1 The units shall have a manufacturer's parts and defects warranty for a period one (1) year from date of installation. The compressor shall have a warranty of five (5) years from date of installation. If, during this period, any part should fail to function properly due to defects in workmanship or material, it shall be replaced or repaired at the discretion of the manufacturer. This warranty does not include labor.

PART 3 - OUTDOOR UNIT DESIGN

3.1

A. The outdoor unit shall be compatible with the four different types of indoor units (ceiling suspending, ducted, wall mounted and four way recessed ceiling cassette). The connected indoor unit shall be of the same capacity as the outdoor unit.

B. The outdoor unit shall be equipped with an electronic control board that interfaces with the indoor unit to perform all necessary operation functions.

C. The outdoor unit shall be capable of cooling operation down to 0°F (-18°C) ambient temperature.

D. The outdoor unit shall be able to operate with a maximum height difference of 100 feet (30 meters) between indoor and outdoor units.

E. System shall operate at up to a maximum refrigerant tubing length of 100 feet (30 meters) for the 18,000 and 165 feet (50 meters) for the 24,000, 30,000, 36,000, and 42,000 BTU/h units between indoor and outdoor units without the need for line size changes, traps or additional oil.

F. The outdoor unit shall be completely factory assembled, piped, and wired. Each unit must be test run at the factory.

3.2 CABINET

A. The casing shall be constructed from galvanized steel plate, finished with an electrostatically applied, thermally fused acrylic or polyester powder coating for corrosion protection.

B. Mounting feet shall be provided and shall be welded to the base of the cabinet and be of sufficient size to afford reliable equipment mount and stability.

C. Easy access shall be afforded to all serviceable parts by means of removable panel sections.

D. The fan grill shall be of ~~ABS~~ plastic.

E. Cabinet mounting and construction shall be sufficient to withstand 155 MPH wind speed conditions for use in Hurricane condition areas. Mounting, base support, and other installation to meet Hurricane Code Conditions shall be by others.

3.3 FAN

A. Models shall be furnished with a DC fan motor.

B. The fan blade(s) shall be of aerodynamic design for quiet operation, and the fan motor bearings shall be permanently lubricated.

C. The outdoor unit shall have horizontal discharge airflow. The fan shall be mounted in front of the coil, pulling air across it from the rear and dispelling it through the front. The fan shall be provided with a raised guard to prevent external contact with moving parts.

3.4 COIL

A. The L shaped condenser coil shall be of copper tubing with flat aluminum fins to reduce debris build up and allow maximum airflow. The coil shall be protected with an integral metal guard.

B. Refrigerant flow from the condenser shall be controlled by means of an electronic linear expansion valve (LEV) metering device. The LEV shall be control by a microprocessor controlled step motor.

C. All refrigerant lines between outdoor and indoor units shall be of annealed, refrigeration grade copper tubing, ARC Type, meeting ASTM B280 requirements, individually insulated in twin-tube, flexible, closed-cell, CFC-free (ozone depletion potential of zero), elastomeric material for the insulation of refrigerant pipes and tubes with thermal conductivity equal to or better than 0.27 BTU-inch/hour per Sq Ft / °F, a water vapor transmission equal to or better than 0.08 Perm-inch and superior fire ratings such that insulation will not contribute significantly to fire and up to 1" thick insulation shall have a - Flame-Spread Index of less than 25 and a Smoke-development Index of less than 50 as tested by ASTM E 84 and CAN / ULC S-102.

3.5 COMPRESSOR

A. The compressor shall be a DC twin-rotor rotary compressor with Variable Speed Inverter Drive Technology. The compressor for model 3.6 Tons and greater shall be a Frame Compliant Scroll compressor with Variable Speed Inverter Drive Technology.

B. The compressor shall be driven by inverter circuit to control compressor speed. The compressor speed shall dynamically vary to match the room load for significantly increasing the efficiency of the system which shall result in significant energy savings.

C. To prevent liquid from accumulating in the compressor during the off cycle, a minimal amount of current shall be automatically, intermittently applied to the compressor motor windings to maintain sufficient heat to vaporize any refrigerant. No crankcase heater is to be used.

D. The outdoor unit shall have an accumulator and high pressure safety switch. The compressor shall be mounted to avoid the transmission of vibration.

3.6 ELECTRICAL

A. The electrical power of the unit shall be 208 volts or 230 volts, single phase, 60 hertz. The unit shall be capable of satisfactory operation within voltage limits of 187 volts to 253 volts.

B. Power for the indoor unit shall be supplied from the outdoor unit via Controller.

C. The outdoor unit shall be controlled by the microprocessor located in the indoor unit.

3.7 OPERATING RANGE:

Operating Range		Indoor Air Intake Temperature	Outdoor Air Intake Temperature
Cooling	Maximum	D.B. 95°F (35°C) W.B. 71°F (21.7°C)	D.B. 115°F (46°C)
	Minimum	D.B. 67°F (19.4°C) W.B. 57°F (13.9°C)	D.B. 0°F (-18°C)*
Heating	Maximum	D.B. 80°F (26.7°C) W.B. 67°F (19.4°C)	D.B. 70°F (21.1°C) W.B. 59°F (15°C)
	Minimum	D.B. 70°F (21.1°C) W.B. 60°F (15.6°C)	D.B. 12°F (-11.1°C) W.B. 10°F (-12.2°C)

* Requires wind baffle – without wind baffle: D.B. 23°F (-5°C)

A. Unit shall be able to provide 100% capacity when operating at 0°F outdoor air temperature and a wind baffle is used.

PART 4 - INDOOR UNIT SELECTION AND SPECIFICATION

4.1

A. WALL MOUNTED TYPE

The indoor unit shall be factory assembled, wired and tested. Contained within the unit hall be all factory wiring and internal piping, control circuit board and fan motor. The unit, in conjunction with the wired wall-mounted, wireless wall-mounted or wireless handheld controller, shall have a self-diagnostic function, 3-minute time delay mechanism, an auto restart function, and a test run switch. Indoor unit and refrigerant pipes shall be purged with dry air before shipment from the factory.

B. UNIT CABINET

The cabinet shall be formed from high strength molded plastic with smooth finish, flat front panel design with access for filter. Cabinet color shall be white. The unit shall be wall mounted by means of a factory supplied, pre-drilled, mounting plate.

C. FAN

The indoor unit fan shall be high performance, double inlet, forward curve, direct drive sirocco fan with a single motor. The fans shall be statically and dynamically balanced and run on a motor with permanently lubricated bearings. The indoor fan shall be capable of multiple speeds. The fan shall have a selectable Auto fan setting that will adjust the fan speed based on the difference between controller set-point and space temperature.

D. VANE

There shall be a motorized horizontal vane to automatically direct air flow in a horizontal and downward direction for uniform air distribution. The horizontal vane shall significantly decrease downward air resistance for lower sound levels, and shall close the outlet port when operation is stopped. There shall also be a set of vertical vanes to provide horizontal swing airflow movement.

E. FILTER

Return air shall be filtered by means of an easily removable washable filter.

F. COIL

The evaporator coil shall be of nonferrous construction with pre-coated aluminum strake fins on copper tubing. The multi-angled heat exchanger shall have a modified fin shape that reduces air resistance for a smoother, quieter airflow. All tube joints shall be brazed with PhosCopper or silver alloy. The coils shall be pressure tested at the factory. A condensate pan and drain shall be provided under the coil. An optional drain pan level switch (DPLS1), designed to connect to the control board, shall be provided if required, and installed on the condensate pan to prevent condensate from overflowing. A condensate mini-pump shall be provided to provide a means of condensate disposal when a gravity drain is not available.

G. ELECTRICAL

The electrical power of the unit shall be 208 volts or 230 volts, 1 phase, 60 hertz. The system shall be capable of satisfactory operation within voltage limits of 187 volts to 253 volts. The power to the indoor unit shall be supplied from the outdoor unit.

H. PERFORMANCE

Each system shall perform in accordance to the ratings shown in the table below. Cooling performance shall be based on 80°F DB, 67°F WB (26.7°C DB, 19.4°C WB) for the indoor unit and 95°F DB, 75°F WB (35°C DB, 29.3°C WB) for the outdoor unit. Heating performance shall be based on 70°F DB, 60°F WB (21.1°C DB, 15.6°C WB) for the indoor unit and 47°F DB, 15°F WB (8.3°C DB, 6.1°C WB) for the outdoor unit.

I. SYSTEM CONTROL

The control system shall consist of a minimum of two (2) microprocessors, one on each indoor and outdoor unit, interconnected by a single non-polar two-wire cable. The microprocessor located in the indoor unit shall have the capability of monitoring return air temperature and indoor coil temperature, receiving and processing commands from a wireless or wired controller, providing emergency operation and controlling the outdoor unit. The control signal between the indoor and outdoor unit shall be pulse signal 24 volts DC. Indoor units shall have the ability to control supplemental heat via connector CN152 and a 12 VDC output.

J. The indoor unit control board shall have auxiliary control contact connectors to provide:

Function / Model	
CN-2L – Lossnay Control	X
CN-24(152) Back-up Heat	X
CN-32 – Remote Switch	X
CN-51 – Central Control	X
CN-105 – IT Terminal	X

X = Included

K. Remote Controllers

1. Wired Remote Controller

The Wired Remote Controller shall be an LCD display. The Controller shall support a selection from multiple languages for display information. There shall be a built-in weekly timer. The controller shall consist of an On/Off button, Increase/Decrease Set Temperature buttons, a Cool/Auto/Fan/Dry mode selector, a Timer Menu button, a Timer On/Off button, Set Time buttons, a Fan Speed selector, a Ventilation button, a Test Run button, and a Check Mode button. The controller shall have a built-in temperature sensor. Temperature shall be displayed in either Fahrenheit (°F) or Celsius (°C), and Temperature changes shall be by increments of 1°F (0.5°C).

The control voltage from the wired controller to the indoor unit shall be 12/24 volts, DC. Field wiring shall run directly from the indoor unit to the wall mounted controller with no splices. Up to two wired controllers shall be able to be used to control one unit.

The basic functions are:

Wired Remote Controller	
Item	Description
ON/OFF	
Operation Mode	Run and stop operation
Temperature Setting (Range and modes depend on connected unit model)	Switches between Cool/Dry/Auto/Fan/Heat.
Fan Speed Setting (Range and modes depend on connected unit model)	Sets the setpoint temperature in the following range Cool/Dry: 67°F-87°F Heat: 63°F-83°F Auto: 67°F-83°F
Error	ON/OFF/Temperature setting. The time can be set by the 1-minute interval.
Auto Lock Out Function	When an error is currently occurring on an air conditioner unit, the afflicted unit and the error code are displayed
	Setting/releasing of simplified locking for remote control buttons can be performed. • Locking of all buttons Locking of all buttons except ON/OFF button

END OF SECTION 238129

SECTION 238200 - ELECTRIC HEATERS

PART 1 – GENERAL

1.01 SUMMARY

A. The General Provisions, Supplemental General Provisions, section 23 01 00, Division 1 Specifications and Special Provisions apply to all Work specified in this Section.

B. This section describes the basic materials and installation methods for the electric heaters. Comply with other Division 23 sections and drawings as applicable. Refer to other divisions for coordination of work.

C. Furnish and install all components of the electric heaters specified herein, as indicated on the drawings, and as required to provide complete and operating systems.

1.02 DESCRIPTION OF WORK:

A. Work Included: Provide electric heating and cooling units, as specified, which may include:

1. Electric unit heaters
2. Additional information as required in Section 23 01 00.

1.03 QUALITY ASSURANCE:

A. The complete assembly, not just components, shall be approved as a unit by Underwriters' Laboratories, Inc. (UL) and shall bear the UL label, where required by code. Equipment shall be installed and wired in accordance with applicable local and national codes.

1.04 SUBMITTALS:

A. Shop drawings submittals shall include, but are not limited to, the following:

1. Unit cutsheets clearly showing all features, accessories, dimensions, weights and capacities.
2. Complete color samples for selection.
3. Written instructions for equipment to installation.
4. Wiring and piping diagrams and connection locations.
5. Performance certifications and test results.
6. Warranty Information.
7. Additional information as required in Section 23 01 00.

PART 2 – PRODUCTS

2.01 MANUFACTURERS:

A. Chromalox

B. Indeeco

C. QMark

D. Berko

E. Brasch

F. Markel

G. Electric Heaters, Inc.

H. Nailor

I. Tutco

J. Warren

2.02 EQUIPMENT:

A. [Electric Unit Heaters (EUH):]

1. As manufactured by QMark.
2. Other acceptable manufacturers: Brasch, Chromalox, Markel
3. Cabinet shall be 18 gauge dip formed steel.
4. Paint of phosphate undercoat or corrosion resistance and finished in neutral gray, baked enamel.
5. Heating element shall be corrosion-resistant fin tube with reset thermal overload protection, magnetic contactor for remote control.
6. Remote thermostat shall be line voltage SPST with temperature range of
7. 40°F to 70°F, wall mounted.
8. Fan shall be dynamically balanced with totally enclosed continuous duty sleeve bearings, with built-in thermal overload protection.
9. Capacities and electrical characteristics: Scheduled on drawings.

PART 3 – EXECUTION

3.01 INSTALLATION:

A. Install units in accordance with manufacturer's instructions.

B. Install units where indicated on drawings.

C. Provide supports, for pedestal type wall fin per manufacturer's recommendations.

END OF SECTION 238200