MEPNN Supplier Scouting Opportunity Synopsis

Section 1: General Information

Scouting Number	2025-334
Item to be Scouted	BABA Compliant Vibration Isolation Mount
Days to be scouted	30
Response Due By	10/10/2025
Description	BABA Compliant: Vibration Isolation: Mount compressor and condenser units on rubber pads with 2

Section 2: Technical Information

Type of supplier being sought	Other
Details	BABAA-compliant self-certified manufacturers
Reason	BABA
Describe the manufacturing processes (elaborate to provide as much detail as possible)	Domestic components in each of the BABAA compliant manufactured products must exceed 55% of the total component cost and be assembled in the United States.
Provide dimensions / size / tolerances / performance specifications for the item	See attached specs and mechanical schedule for more information.
List required materials needed to make the product, including materials of product components	See attached specs and mechanical schedule for more information.
Are there applicable certification requirements?	Yes
Details	Build America, Buy America Act (BABAA) compliant
Are there applicable regulations?	Yes
Details	Must be able to submit BABAA manufactured product self-certification manufactured product letter that details a compliant product.
Are there any other stndards, requirements, etc.?	No
Additional Technical Comments	See attached specs and mechanical schedule for more information.

Section 4: Business Information

Estimated potential business volume	TBD post selection. Cost should be the best available, and cannot increase the project cost by 25%.
Estimated target price / unit cost information (if unavailable explain)	TBD post selection. Cost should be the best available, and cannot increase the project cost by 25%.
When is it needed by?	Q1 2026
Describe packaging requirements	Must arrive undamaged
Where will this item be shipped?	Colorado

Additional Comments

Is there other information you would like to include?	Nationwide Search Provide written documentation in response to the Supplier Scouting request of being a current Build America Buy America Act compliant Vibration Isolation Mount manufacturer with experience in manufacturing the system components, meeting the product performance requirements. Information on BABAA compliance requirements can be found at the Made in America Office link https://www.madeinamerica.gov/.

1.9 FIELD MEASUREMENTS

A. Verify field measurements prior to fabrication.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Structural Steel: ASTM A 36/A 36M, “Carbon Structural Steel,” 2001, steel plates, shapes, and bars, black and galvanized.

B. Bolts and Nuts: ASME B18.10 or ASTM A 183, “Track Bolts and Nuts,” 2000, steel, hex-head, track bolts and nuts.

C. Washers: ASTM F 844, “Standard Specification for Washers, Steel, Plain (Flat), Unhardened for General Use,” steel, plain, flat washers.

D. Grout: ASTM C 1107, Grade B, “Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink),” nonshrink, nonmetallic.

1. Characteristics include post-hardening, volume-adjusting, dry, hydraulic-cement-type grout that is nonstaining, noncorrosive, nongaseous and is recommended for both interior and exterior applications.
2. Design Mix: 5000-psi (34.5MPa), 28-day compressive strength.
3. Water: Potable.
4. Packaging: Premixed and factory-packaged.

2.2 VIBRATION ISOLATION MOUNT TYPES

A. General

1. Metal parts of vibration isolation units installed out-of-doors shall be hot-dip galvanized, cadmium- plated or Neoprene-coated after fabrication. Galvanizing shall meet ASTM 144 “Salt Spray Test Standards and Federal Test Standard.”
2. Isolator types are scheduled to establish minimum standards. Optionally, labor-saving accessories can be an integral part of isolators supplied to provide initial lift of equipment to operating height, hold piping at fixed elevations during installation and initial system filling operations, and similar installation advantages. Accessories shall not degrade vibration isolation system.

B. Unit FSN (Floor Spring and Neoprene) (Type 3)

1. Spring isolators shall be free standing and laterally stable without any housing and complete with a molded neoprene cup or 1/4" (6mm) neoprene acoustical friction pad between the base plate and the support. All mountings shall have leveling bolts that must be rigidly bolted to the equipment. Spring diameters shall be no less than 0.8 of the compressed height of the spring at rated load. Springs shall have a minimum additional travel to solid equal to 50% of the rated deflection. Submittals shall include spring diameters, deflection, compressed spring height and solid spring height. Mountings shall be Model FDS as manufactured by Kinetics Noise Control or

type SLF as manufactured by Mason Industries, Inc., or comparable acceptable product.

C. Unit HSN (Hanger Spring and Neoprene) (Type 3)

1. Hangers shall consist of rigid steel frames containing minimum 1 1/4" thick neoprene or pre-compressed elastomer coated fiberglass elements at the top and a steel spring with general characteristics as in specification 5 seated in an optional steel washer reinforced neoprene cup on the bottom. The neoprene element and the optional cup shall have neoprene bushings projecting through the steel box. To maintain stability the boxes shall not be articulated as clevis hangers nor the neoprene element stacked on top of the spring. Spring diameters and hanger box lower hole sizes shall be large enough to permit the hanger rod to swing through a 30 degree E arc from side to side before contacting the rod bushing and short circuiting the spring. Submittals shall include a hanger drawing showing the 30 degree E capability. Hangers shall be Model SRH or SFH as manufactured by Kinetics Noise Control or type 30N as manufactured by Mason Industries, Inc., or comparable acceptable product.

2.3 RESILIENT PENETRATION SLEEVE/SEAL

A. Unit RPS-A (Resilient Penetration Sleeve/Seal)

1. The horizontal thrust restraint shall consist of a spring element in series with a neoprene molded cup as described in specification 5 with the same deflection as specified for the mountings or hangers. The spring element shall be designed so it can be preset for thrust at the factory and adjusted in the field to allow for a maximum of 1/4" (6mm) movement at start and stop. The assembly shall be furnished with 1 rod and angle brackets for attachment to both the equipment and the ductwork or the equipment and the structure. Horizontal restraints shall be attached at the centerline of thrust and symmetrical on either side of the unit. Horizontal thrust restraints shall be type WBI/WBD as manufactured by Mason Industries, Inc.

2.4 FLEXIBLE DUCT CONNECTIONS

A. Flexible duct connections shall be fabricated from Neoprene, loaded vinyl or canvas. Clear space between connected parts shall be a minimum of three inches and connection shall have 1.5" minimum of slack material.

2.5 FLEXIBLE ELECTRICAL CONNECTION

A. Unit FEC-A (Flexible Electrical Connection Type A):

1. Flexible electrical coupling shall be prefabricated units incorporating flexible watertight outer jacket, grounding strap, plastic inner sleeve to maintain smooth wire way and end hubs with standard tapered electrical threads to fit standard threaded, rigid metal conduit.
2. Unit FEC-A shall be as specified in section “Raceways and Boxes for Electrical Systems” for liquid tight flexible metal conduit.

B. Unit FEC-B (Flexible Electrical Connection Type B):

1. Flexible electrical couplings shall be field-fabricated using minimum 2 ft length of flexible conduit or cable installed in grossly slack "U" shape.
2. Unite FEC-B shall be as specified in section “Raceways and Boxes for Electrical Systems” for flexible metal conduit.

2.6 RESTRAINTS

A. Thrust Restraint

1. Thrust restraints shall consist of spring element in series with Neoprene pad.
2. Thrust restraint shall be designed to have same deflection as specified for isolators supporting equipment generating thrust.
3. Spring element shall be contained within steel frame and be designed to be factory-preset for thrust and be field-adjustable to allow for maximum of 1/4" movement during starting or stopping of equipment.
4. Furnish assembly complete with rods and angle brackets for attachment to both equipment generating thrust and adjacent fixed structural anchor.
5. Thrust restraint shall be Model HSR as manufactured by Kinetics Noise Control or Mason Industries Type WB, or comparable acceptable product.

2.7 GROMMETS

A. Grommets shall be either custom made by combining Neoprene washer and sleeve, or be Isogrommets as manufactured by MBIS, Inc., or be Series W by Barry Controls.

B. Neoprene shall be between 40 and 50 durometer.

C. Grommets shall be specially formed to prevent fastening bolts from directly contacting isolator base plate.

2.8 ACOUSTICAL SEALANT

A. Sealants for acoustical purposes shall be one of following non-setting sealants:

1. Acoustical sealant ..... D.A.P.
2. BR-96 ..... Pecra
3. Acoustical sealant ..... Tremco
4. Acoustical sealant ..... U.S.G.

2.9 VIBRATION ISOLATION SCHEDULE

			Slab on Grade			Up to 30 Ft. Floor Span			Greater Than 30’ Floor Span		
Fans (Not Within Equipment)	Horsepower/ Other	RPM	Base Typ	Isolator Type	Minimum Deflectio	Base Typ	Isolator Type	Minimum Deflection, IN.	Base Typ	Isolator Type	Minimum Deflecti

			e		n, IN.	e			e		onIN.
Inline Centrifugal, Cabinet, Ceiling	All	All	A	3	0.75	A	3	1.50	A	3	1.50

			Slab on Grade			Up to 30 Ft. Floor Span			Greater Than 30' Floor Span		
Miscellaneous Equipment	Horsepower/ Other	RPM	Base Type	Isolator Type	Minimum Deflection, IN.	Base Type	Isolator Type	Minimum Deflection, IN.	Base Type	Isolator Type	Minimum DeflectionIN.
Water-Source Heat Pump Units, Outdoor Air Source Heat Pump Units, Indoor Air Handling Units, 100% Outdoor Air Units, and other Miscellaneous Motor Driven Equipment	All	All	A	3	0.75	A	3	0.75	A	3	1.50

PART 3 - EXECUTION

3.1 INSTALLATION OF VIBRATION ISOLATION EQUIPMENT

A. General

1. Locations of vibration isolation equipment shall be selected for ease of inspection and adjustment as well as for proper operation.
2. Installation of vibration isolation equipment shall be in accordance with manufacturer's written instructions.

B. Isolation Mounts

1. Squarely align vibration isolators above or below mounting points of supported equipment.
2. Isolators for equipment with bases shall be located on sides of bases, which are parallel to equipment shaft unless this is not possible because of physical constraints.
3. If housekeeping pad is provided, isolators shall bear on housekeeping pad and isolator base plate shall rest entirely on pad. Maintain at least ten bolt diameters from isolator anchors to edge of pad.

4. Hanger rods for vibration isolated support shall be connected to structural beams or joists; not from floor slab between beams and joists. Provide intermediate support members as necessary.
5. Position vibration isolation hanger elements as high as possible in hanger rod assembly but not in contact with building structure, and so that hanger housing may rotate full 360 degrees about rod axis without contacting any object.
6. Parallel-running pipes may be hung together on trapeze, which is isolated from building. Isolator deflections must be largest determined by provisions for pipe isolation. Do not mix isolated and non-isolated pipes on same trapeze.
7. No pipes or equipment shall be supported from other pipes or equipment.
8. Resiliently-isolated pipes shall not contact rigid building structure or equipment.
9. Installed and operating heights of vibration-isolated equipment mounted on Unit FSN isolators shall be identical. Limit stops shall be out of contact during normal operation.
10. Adjust leveling bolts and hanger rod bolts so isolated equipment is level and in proper alignment with connecting ducts or pipes.

C. Bases

1. No equipment unit shall bear directly on vibration isolators unless its own frame is suitably rigid to span between isolators and such direct support is approved by equipment manufacturer. This provision shall apply whether or not base frame is specified or indicated on drawings. If base frame is required for unit because of equipment manufacturer's requirements and is not specifically called for, base frame recommended by equipment manufacturer shall be provided at no additional expense.
2. Unless otherwise indicated, provide minimum operating clearance of 1.5" between inertia bases or structural steel frames and concrete housekeeping pad on floor beneath equipment. Position isolator mounting brackets so that required clearance is maintained. Check clearance space to ensure that no construction debris has been left to short-circuit or restrict proper operation of vibration isolation system.

D. Flexible Duct Connections

1. Sheet metal ducts or plenum openings shall be squarely aligned with fan discharge, fan intake or adjacent duct section prior to installation of flexible connection, so that clear length is approximately equal all way around perimeter. Flexible duct connections shall not be installed until this provision is met.
2. Fan or adjacent duct section shall be able to move 1" in any direction without causing metal to metal contact or stretching flexible connection taut.

E. Thrust Restraints

1. Attach thrust restraints at centerline of thrust and symmetrically on each side of equipment generating thrust for fans with a static pressure of 2” water column or more.
2. Adjust restraints to limit equipment movement to specified limit.

F. Resilient Penetration Sleeve/Seals

1. Penetration seals shall maintain airtight seal around penetrating element and shall

prevent contact of penetrating element and building structure. Fit sleeve tightly to building construction and with acoustical sealant seal airtight on both sides of construction penetrated.

3.2 APPLICATIONS FOR VIBRATION CONTROLS

A. Major Equipment

1. Unless otherwise shown or specified, major floor-mounted equipment shall be set on housekeeping type concrete pads. See architectural or structural drawings for details.
2. Flexible duct connections shall be installed at fan unit intakes, fan unit discharges, and wherever else shown on drawings.
3. Electrical connections to vibration-isolated equipment exposed to weather shall be unit FEC-A.
4. Electrical connections to vibration-isolated equipment located indoors shall be unit FEC-B.
5. Thrust Restraints shall be installed on equipment as called for in schedule on drawings or specified hereunder.

B. Miscellaneous Mechanical Equipment

1. Miscellaneous pieces of mechanical equipment such as domestic water heaters, expansion tanks, etc. shall be vibration-isolated from building structure by Unit FN isolators unless their position in piping system requires higher degrees of isolation as called for under pipe isolation requirements.

C. Pipes

1. Closed loop supply and return piping and refrigerant piping within mechanical rooms or within 50 ft total pipe length (whichever is longer) of connected vibration-isolated equipment (water-source heat pumps, air source heat pumps, etc.), and all of above piping that is 6" or larger, shall be isolated from building structure by vibration mounts, resilient pipe guides, and resilient penetration sleeve/seals.
2. Isolators for first three support points adjacent to connected equipment shall achieve half of specified static deflection of isolators supporting connected equipment. When required static deflection of these pipe isolators is greater than 0.50," Unit FSN or HSN isolators, (whichever is applicable for mounting condition) shall be used.
3. Where lateral support of pipe risers is required within specified limits, use resilient lateral supports.
4. Pipes within specified limits that penetrate building construction shall be isolated from building structure by (Unit RPS-A or Unit RPS-B) resilient penetrating sleeve/seals.

3.3 ADJUSTING

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

B. Adjust for pipe alignment and final equipment connections. Flexible connections shall not be

used for adjustment of alignment.

END OF SECTION

Division 23 - HVAC

SECTION 230553 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section, and all sections of Division 23.

1.2 SUMMARY:

A. Section Includes:

1. Painted Identification Materials.
2. Plastic Pipe Markers.
3. Valve Tags.
4. Valve Schedule Frames.
5. Engraved Plastic-Laminate Signs.
6. Plastic Equipment Markers.
7. Plasticized Tags.
8. Duct Markers.

B. Related Sections: The following Sections contain requirements that relate to this Section:

1. Section 22 05 00 - “Common Work Results for HVAC.”
2. Section 22 05 03 - “Pipes and Tubes for HVAC Piping and Equipment.”
3. Section 23 23 00 - “Refrigerant Piping.”
4. Section 23 30 00 - “HVAC Air Distribution.”
5. Section 23 34 00 - “HVAC Fans.”

1.3 REFERENCES
(Unless otherwise noted, references apply to “latest editions.”)

A. American Society of Mechanical Engineers:

1. ASME A13.1 - Scheme for the Identification of Piping Systems, 2007.

B. National Fire Protection Association:

1. NFPA 99 - Standard for Health Care Facilities, 2005.

1.4 SUBMITTALS

A. General: Submit each item in this Section according to the conditions of the Contract and Division 01 specification sections.

B. Product Data: Submit manufacturer's technical product data and installation instructions for each identification material and device required.

C. Samples: Submit samples of each color, lettering style and other graphic representation

required for each identification material or system.

D. Schedules: Submit valve schedule for each piping system, typewritten and reproduced on 8 1/2" x 11" bond paper. Tabulate valve number, piping system, system abbreviation (as shown on tag), location of valve (room or space), and variations for identification (if any). Mark valves which are intended for emergency shut-off and similar special uses, by special "flags", in margin of schedule. Furnish copies for Maintenance Manuals as specified in the Division 01 Specifications.

E. Maintenance Data: Include product data and schedules in maintenance manuals, in accordance with requirements of Division 01.

1.5 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacturer of identification devices of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Codes and Standards:

1. ANSI Standards: Comply with ANSI A13.1, for lettering size, length of color field, colors, and viewing angles of identification devices.

C. Equipment Lettering and Graphics:

1. General: Coordinate names, abbreviations and other designations used in HVAC identification work, with corresponding designations shown, specified or scheduled. Provide numbers, lettering and wording as indicated or, if not otherwise indicated, as recommended by manufacturers or as required for proper identification and operation/maintenance of HVAC systems and equipment.
   a. Multiple Systems: Where multiple systems of same generic name are shown and specified, provide identification, which indicates individual system number as well as service (for example; Unit Heater No. 3).

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering identification materials which may be incorporated in the work include, but are not limited to, the following:

B. Manufacturer: Subject to compliance with requirements, provide HVAC identification materials of one of the following:

1. Brady (W.H.) Co.; Signmark Div.
2. Industrial Safety Supply Co., Inc.
3. Seton Name Plate Corp.

2.2 MATERIALS:

A. General: Provide manufacturer's standard products of categories and types required for each application as referenced in other Division 23 sections. Where more than single type is specified for application, selection is Installer's option, but provide single selection for each product category.

B. Painted Identification Materials:

1. Stencils: Standard fiberboard stencils, prepared for required applications with letter sizes not less than 1 1/4" high for ductwork and not less than 3/4" high for access door signs and similar operational instructions.
2. Stencil Paint: Standard exterior type stenciling enamel; black, except as otherwise indicated; either brushing grade or pressurized spray-can form and grade.
3. Identification Paint and Background Color; Standard identification enamel of colors indicated or, if not otherwise indicated for piping systems and HVAC equipment comply with ANSI A13.1 for colors. For ductwork, use green paint.

C. Plastic Pipe Markers:

1. Snap-On Type: Provide manufacturer's standard pre-printed, semi-rigid snap-on, UV-resistant color-coded pipe markers, complying with ANSI/ASME A13.1
2. Small Pipes: For external diameters less than 6" (including insulation if any), provide full-band pipe markers, extending 360 degrees around pipe at each location, fastened by one of the following methods:
   a. Snap-on application of pre-tensioned semi-rigid plastic pipe marker.
   b. Adhesive lap joint in pipe marker overlap.
   c. Taped to pipe (or insulation) with color-coded plastic adhesive tape, not less than 3/4" wide; full circle at both ends of pipe marker, tape lapped 1 1/2".
3. Large Pipes: For external diameters of 6" and larger (including insulation if any), provide either full-band or strip-type pipe markers, but not narrower than 3 times letter height (and of required length), fastened by one of the following methods:
   a. Taped to pipe (or insulation) with color-coded plastic adhesive tape, not less than 1 1/2" wide; full circle at both ends of pipe marker, tape lapped 3".
   b. Strapped-to-pipe (or insulation) application of semi-rigid type, with manufacturer's standard stainless steel bands.
4. Lettering: Comply with piping system nomenclature as specified, scheduled or shown, and abbreviate only as necessary for each application length. Operating pressure of steam systems shall be indicated.
   a. Arrows: Print each pipe marker with arrows indicating direction of flow, either integrally with piping system service lettering (to accommodate both directions), or as a separate unit of plastic.
5. Provide pipe markers with the following background colors and designations:

SERVICE	STENCIL DESIGNATION	LETTER COLOR	BACKGROUND COLOR
Refrigerated Suction	Refrigerant Suction (RS)	White	Safety Green
Refrigerated Liquid	Refrigerant Liquid (RL)	White	Safety Green

D. Valve Tags:

1. Plastic Laminate Valve Tags: Provide manufacturer's standard 3/32" thick engraved

plastic laminate valve tags, with piping system abbreviation in 1/4" high letters and sequenced valve numbers 1/2" high, and with 5/32" hole for fastener.
   a. Provide 1 1/2" sq. black tags with white lettering, except as otherwise indicated.
   b. Provide size, shape and color combination as specified or scheduled for each piping system.
2. Plastic Valve Tags: Provide manufacturer's standard solid plastic valve tags with printed enamel lettering, with piping system abbreviation in approximately 3/16" high letters and sequenced valve numbers approximately 3/8" high, and with 5/32" hole for fastener.
   a. Provide 1 1/8" sq. white tags with black lettering.
   b. Provide size, shape and color combination as specified or scheduled for each piping system.
3. Valve Tag Fasteners: Provide manufacturer's standard solid brass chain (wire link or beaded type), or solid brass S-hooks of the sizes required for proper attachment of tags to valves, and manufactured specifically for that purpose.
4. Ceiling Grid and Access Panel Markers: Provide Kroy type clear adhesive printed labels with 3/16" high letters to identify the type of concealed HVAC devices.

E. Engraved Plastic-laminate Signs:

1. General: Provide engraving stock melamine plastic laminate, complying with FS L-P-387, in the sizes and thicknesses indicated, engraved with engraver's standard letter style of the sizes and wording indicated, black with white core (letter color) except as otherwise indicated, punched for mechanical fastening except where adhesive mounting is necessary because of substrate.
2. Thickness: 1/8", except as otherwise indicated.
3. Fasteners: Self-tapping stainless steel screws, except contact-type permanent adhesive where screws cannot or should not penetrate the substrate.
4. Nomenclature: Include the following, matching terminology on schedules as closely as possible:
   a. Name and plan number.
   b. Equipment service.
   c. Design capacity.
   d. Other design parameters such as pressure drop, entering and leaving conditions, rpm, etc.
5. Size: Provide approximate 2 1/2" x 4" markers for control devices, dampers, and valves; and 4 1/2" x 6" for equipment.

F. Plasticized Tags:

1. General: Manufacturer's standard pre-printed or partially pre- printed accident-prevention tags, of plasticized card stock with matt finish suitable for writing, approximately 3 1/4" x 5 5/8", with brass grommets and wire fasteners, and with appropriate pre- printed wording including large-size primary wording (as examples; DANGER, CAUTION, DO NOT OPERATE).

G. Duct Markers:

1. Identify air: supply, return, exhaust, intake and relief ducts with duct markers or provide stenciled signs and arrows showing service and direction of air flow.

a. Locate signs near points where ducts enter into concealed spaces and at maximum intervals of 25 feet.
b. Provide identification labels at access panels to locate concealed duct accessories.

PART 3 - EXECUTION

3.1 PREPARATION

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

3.2 INSTALLATION:

A. General:

1. Coordination: Where identification is to be applied to surfaces, which require insulation, painting or other covering or finish, including valve tags in finished mechanical spaces, install identification after completion of covering and painting. Install identification prior to installation of acoustical ceilings and similar removable concealment.
2. Confined Spaces: Provide labels and signs on all duct and equipment doors, plenums, etc. to indicate service and provide operator warnings as required by OSHA, NFPA, and authority having jurisdiction.

B. Piping System Identification:

1. General: Install pipe markers of one of the following types on each system indicated to receive identification, and include arrows to show normal direction of flow:
   a. Plastic pipe markers, with application system as indicated under "Materials" in this section.
2. Locate pipe markers and color bands as follows on all piping in occupied spaces, above ceilings, machine rooms, accessible maintenance spaces (shafts, tunnels, plenums) and exterior non-concealed locations.
   a. Near each valve and control device.
   b. Near each branch, excluding short take-offs for equipment and terminal units; mark each pipe at branch, where there could be question of flow pattern.
   c. Near locations where pipes pass through walls or floors/ ceilings, or enter non-accessible enclosures.
   d. At access doors, manholes and similar access points, which permit view of concealed piping.
   e. Near major equipment items and other points of origination and termination.
   f. Spaced intermediately at maximum spacing of 25' along each piping run, except reduce spacing to 10' in congested areas.

C. Valve Identification:

1. General: Provide valve tag on every valve, cock and control device in each piping system; exclude check valves, valves within factory-fabricated equipment units, and shut-off valves at HVAC equipment. List each tagged valve in valve schedule for each piping system.

D. Equipment Identification:

1. General: Install engraved plastic laminate sign on or near each major item of HVAC equipment and each operational device, as specified herein if not otherwise specified for each item or device. Provide signs for the following general categories of equipment and operational devices:
   a. Main control and operating valves, including safety devices and hazardous units.
   b. Flow meters.
   c. Water-Source Heat Pump Units.
   d. Indoor Split System Air Handling Units.
   e. Outdoor Split System Air Source Heat Pump Units.
2. Lettering Size: Minimum 1/4" high lettering for name of unit where viewing distance is less than 2'-0", 1/2" high for distances up to 6'-0", and proportionately larger lettering for greater distances. Provide secondary lettering of 2/3 to 3/4 of size of the principal lettering.
3. Text of Signs: In addition to name of identified unit, provide lettering to distinguish between multiple units, inform operator of operational requirements, indicate safety precautions, and warn of hazards and improper operations.

3.3 ADJUSTING:

A. Adjusting: Relocate any identification device, which has become visually blocked by work of this division or other divisions.

3.4 CLEANING:

A. Cleaning: Clean face of identification devices.

3.5 EXTRA STOCK:

A. Furnish minimum of 5% extra stock of each identification material required, including additional numbered valve tags (not less than 3) for each piping system, additional piping system identification markers, and additional plastic laminate engraving blanks of assorted sizes.

1. Where stenciled markers are provided, clean and retain stencils after completion of stenciling and include used stencils in extra stock, along with required stock of stenciling paints and applicators.

END OF SECTION

Division 23 - HVAC

SECTION 230593 - TESTING, ADJUSTING AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawing and general provisions of the Contract, including the General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section and the other Sections of Division 23.

1.2 SUMMARY

A. Coordinate work of this section with all trades.

B. Work covered in this Section shall be performed after completion of work specified in all Divisions as they related to this work.

C. Review of design drawings and specifications, and comment on potential problem areas.

D. Site inspections of ongoing sheet metal installation with written report from each visit.

E. Air leak testing of ductwork system. See Section 23 05 95 - "Leak Testing, Air Distribution and Duct Systems."

F. Measurement and setting of all air, and hydronic (closed loop supply and return) water provided or specified in accordance with these contract documents, recording data, making tests, and preparing reports, all as hereinafter specified.

G. Coordinate with all trades to provide all incidental items not indicated on drawings or in specifications that belong to work described or are required for complete systems balancing, at no additional cost to Owner.

H. Refer to paragraph "Closeout Submittals" in Section 23 05 00 - "Common Work Results for HVAC."

1.3 SUBMITTALS

A. General: Submit each item in this Section according to the conditions of the Contract and Division 01 specification sections.

B. Agency Data:

1. Submit proof that proposed testing, adjusting, and balancing agency meets the qualifications specified within 30 days of award of contract.

C. Engineer and Technicians Data:

1. Submit proof that Test and Balance Engineer assigned to supervise procedures, and technicians proposed to perform procedures meet qualifications specified within 30 days of award of contract.

D. Procedures and Agenda: Submit synopsis of testing, adjusting, and balancing procedures

and agenda proposed to be used for this project within 90 days of award of contract.

E. Document Review:

1. Submit certification in writing that all design drawings and specifications have been reviewed, and comment on potential problems within 90 days of award of contract.

F. Maintenance Data: Submit maintenance and operating data that include how to test, adjust, and balance the building systems. Include this information in maintenance data specified in Division 01 and Section 23 05 00 - "Common Work Results for HVAC."

G. Certified Reports: Submit testing, adjusting, and balancing reports bearing the seal and signature of Test and Balance Engineer. Reports shall be certified proof that systems have been tested, adjusted, and balanced in accordance with referenced standards; are an accurate representation of how systems have been installed; are true representation of how systems are operating at completion of testing, adjusting, and balancing procedures; and are accurate record of final quantities measured, to establish normal operating values of the systems. Follow procedures and format specified below:

1. Report Format: Report forms shall be those standard forms prepared by referenced standard for each respective item and system to be tested, adjusted, and balanced. Bind report forms complete with schematic systems diagrams and other data in reinforced, vinyl, three-ring binders. Provide binding edge labels with project identification and a title descriptive of contents. Divide contents of binder into divisions listed below, separated by divider tabs:
   a. General Information and Summary
   b. Air Systems
   c. Hydronic (Closed Loop Supply and Return) Systems
   d. Automatic Temperature Controls
   e. Special Systems
   f. Sound and Vibration Systems
2. Report Contents: Provide following minimum information, forms and data:
   a. General Information and Summary: Inside cover sheet to identify testing, adjusting, and balancing agency, Contractor, Owner, Architect, Engineer, and Project. Include addresses, and contact names and telephone numbers. Include certification sheet containing seal and name address, telephone number, and signature of Certified Test and Balance Engineer. Include in this division listing of the instrumentations used for the procedures along with proof of calibration.
   b. Remainder of the report shall contain appropriate forms containing as minimum, information indicated on standard report forms prepared by AABC and NEBB, for each respective item and system. Prepare schematic diagram for each item of equipment and system to accompany each respective report form.
3. Reports shall be submitted no later than 30 days after substantial completion.

H. Final submittal shall include but not be limited to following:

1. List of equipment used to perform test and procedures.
2. Equipment performance data and equipment curves with actual points of performance indicated on curves as compiled during balancing.
3. Air Devices including VAV Boxes (supply, return and exhaust) and all air outlets.

4. Duct traverse readings during balancing.
5. Room sound power levels where requested by Owner or Architect.
6. Hydronic system components flow rates, pressures and temperatures.
7. On balance report documents record date and time of reading.

1.4 QUALITY ASSURANCE

A. Agency Qualifications:

1. General Contractor shall employ the services of independent testing, adjusting, and balancing agency meeting qualifications specified below, to be single source of responsibility to test, adjust, and balance the building heating, ventilating and air conditioning systems to produce design objectives. Services shall include checking installations for conformity to design, measurement and establishment of fluid quantities of mechanical systems as required to meet design specifications, and recording and reporting results.
2. Certified by National Environmental Balancing Bureau (NEBB) or by Associated Air Balance Council (AABC) in those testing and balancing disciplines required for this project, and having at least one Professional Engineer registered in State in which services are to be performed, certified by NEBB or AABC as Test and Balance Engineer.

B. Work shall be accomplished in accordance with specifications. Procedures specified shall be followed and, if not specifically described herein, in general, shall be in accordance with Associated Air Balance Council's National Standards or National Environmental Balancing Bureau's Procedural Standards.

C. Design Review

1. Review all design drawings and specifications. Review shall include:
   a. Duct pressure classification
   b. Control device location and balancing devices location in duct systems and piping systems.
   c. Indicate additional balancing devices required for proper balancing.
   d. Specifications on all devices required for balancing.
   e. Note any potential noise problems.
2. Within 90 days of award of contract, meet with the Architect, Mechanical Contractor, and Building Automation System Contractor to review procedures and agenda and comments on design documents as to potential problem areas.

D. Shop Drawing Review

1. Review “Instrumentation and Control for HVAC” shop drawing submittals noting any potential balancing problems. Note comments on submittal, sign, stamp and return to General Contractor. All “Instrumentation and Control for HVAC” submittals must be reviewed by balancing agency prior to review by Architect.

E. Pre-Balancing Conference: Prior to beginning of testing, adjusting, and balancing procedures, schedule and conduct conference with Architect and representatives of installers of mechanical systems. Objective of conference is final coordination and verification of system operation and readiness for testing, adjusting, and balancing.

F. During construction, balancing agency shall inspect the installation of pipe systems, sheet

metal work, temperature controls, and other component parts of heating, ventilating, and air conditioning systems. Inspections shall be performed periodically as work progresses. Minimum of two inspections are required as follows: (1) when 60 percent of ductwork is installed; (2) when 90 percent of equipment is installed. Balancing agency shall submit brief written report of each inspection to Owner and Architect.

G. Standards:

1. Associated Air Balance Council (AABC) Publication:
   a. National Standards for Testing and Balancing Heating, Ventilating and Air Conditioning Systems, Latest Edition.
2. American Society of Heating, Refrigeration and air Conditioning Engineers (ASHRAE) Publications:
   a. "ASHRAE Research Report No. 1162, "Air Flow Measurements at Intake and Discharge Openings and Grilles," ASHVE Transactions, Volume 46.
   b. ASHRAE Handbook of Fundamentals, Latest Edition.
3. American National Standards Institute (ANSI) Publications:
4. National Environmental Balancing Bureau (NEBB)
   a. Procedural Standards for Testing-Balancing- Adjusting of Environmental Systems, Latest Edition.
5. Sheet Metal and Air Conditioning Contractors National Association Inc. (SMACNA) - Air Duct Leakage Test Manual, Latest Edition.

1.5 OWNER'S INSTRUCTIONS

A. Balancing contractor's technician along with his balancing engineer shall provide 16 hours of instruction to Owner's engineers on balancing methods, procedures and equipment. Record instruction sessions. Provide the owner three copies of the recordings in digital versatile disk (DVD) format.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 SYSTEM BALANCE - GENERAL REQUIREMENTS

A. Balance heating, ventilating, and air conditioning to obtain air and water quantities indicated and required for proper operation of system.

B. Field work performed under this Section shall be provided under direct supervision of a Registered Professional Engineer.

C. Furnish services for complete adjustment of water systems and air handling and exhaust systems, water, and air distribution and controls.

D. During all tests, it shall be demonstrated that systems shall be free from leaks and all parts of system will operate correctly. If not, report deficiencies to Contractor and Owner. Balancing Firm shall make final adjustments to equipment as may be required for proper operation, maintaining correct temperatures in all parts of the building. Controls shall be adjusted by "Instrumentation and Control for HVAC" technicians in conjunction with Balancing Firm. Coordinate setpoints and adjustments with "Instrumentation and Control for HVAC."

E. Preliminary Work:

1. Inspect project site prior to starting adjustments to verify completion of trades, including general construction, piping system, ductwork system, building automation systems, and electrical systems, as they relate to balancing work. Verification shall include but not be limited to following:
   a. Ductwork System:
      1) Duct joints sealed.
      2) Witness leakage tests required under sheet metal section.
      3) Dampers and control devices installed.
   b. Piping System (hydronic):
      1) Already cleaned and flushed by mechanical contractor.
      2) Chemical treatment operating, or applicable to system.
      3) System filled and vented of air under Division 15.
      4) Proper isolation valves, temporary bypasses and other means and methods provided to allow the building to be balanced without affecting other buildings.
   c. Proper direction of rotation for motor-driven equipment and for proper speed on multi-speed motors.
   d. Balancing devices are installed and accessible.
   e. Control device connections.
   f. Note problems in general construction of the building that might effect systems performance such as sealing of windows, building joints, exhaust shafts, etc.
   g. Problems discovered during this inspection shall be reported to General Contractor and Owner.
2. Contractor shall certify in writing that each piping system has been prepared as per this Section, indicating dates procedures were done and which contractor did work. Submit in writing to Architect before beginning balancing work.

F. Balancing of hydronic systems and parts installed under this Contract to obtain water quantities and temperature drops in all parts of system shown on plans, in specifications, on approved shop drawings or as required by Architect.

G. Balancing of heating and air conditioning, exhaust and ventilating systems to achieve air quantities specified at each air inlet, outlet, or damper shown on plans at proper conditions of static pressure and temperature differential.

H. Study and report on excessive noise conditions, which may develop during system balancing. Report shall be sent to Architect.

3.2 AIR SYSTEM BALANCE

A. In conjunction with “Instrumentation and Control for HVAC”, equipment shall be started per design sequence. Determine fan airflow at rated speed. If airflow is not within 10% of design capacity at rated speed, review system conditions, procedures, and recorded data. Check and record pressure drops across filters, compensate for clean versus dirty filters, coils, sound traps, airflow sensors, etc., to indicate excessive pressure loss or leakage. Resolve problems with appropriate contractor. If systems are properly operating, and airflow is still unacceptable, adjust fan drive in accordance with manufacturer's recommendations to obtain proper airflow and static pressure. Systems shall be balanced and operated at lowest feasible static pressure with allowance for filter loading. Record fan suction pressure, fan

discharge pressure, amperage and airflow measurement. Correct fan curves to indicated new points of balance. Fan motor shall not be overloaded.

B. With fan systems adjusted and dampers set to handle normal minimum outdoor air, perform following tests and compile following information:

1. Air Handling Equipment
   a. Design Conditions
      1) Supply, Return and Exhaust Airflow
      2) Static and Total Pressure
      3) Outdoor Airflow
      4) Motor rating
      5) Fan speed
      6) Outlet Velocity
   b. Installed Equipment
      1) Manufacturer
      2) Motor serial number
      3) Motor type and efficiency, rating, voltage, phase, full-load amperes.
   c. Field Test
      1) Fan speed
      2) No-load operating amperes
      3) Fan motor operating amperes
      4) Calculated motor output
   d. Test for Total Air
      1) Sum of discharge, exhaust, return air and outside air ducts.
      2) Number and locations of velocity readings taken.
      3) Duct average velocity
      4) Total airflow
   e. After completion of tests, adjustments, and balancing under minimum outdoor air conditions, set system for 100% outdoor air. Repeat the total airflow tests to check field versus design conditions. Results under 100% outdoor air cycle shall agree with conditions found under "minimum fresh air operation" before system is considered to be in balance. Adjustments of proper dampers shall be made to achieve balance.

C. With supply, return, and exhaust systems properly adjusted for airflow and static pressure, conduct following test, adjustments and compilation of data:

1. Duct Mains and Branches:
   a. Adjust, measure and record airflow, static pressure of duct mains and branch ducts to provide required pressure and airflow at terminal devices.
2. Terminal Devices:
   a. Manufacturer, Model No. and Size of airflow control terminal units (supply, return and exhaust).
   b. Inlet velocity, static pressure, minimum and maximum airflow setpoints of valves.
   c. Outlet airflow of valve.
   d. Adjust minimum or maximum setting of valves as required to obtain required airflow of outlets in accordance with manufacturer's procedures and recommendations.
   e. In conjunction with “Instrumentation and Control for HVAC”, operate controls, i.e., thermostats, switches and pressure controls in accordance

with design sequence to verify proper operation.

f. Report control problems in writing to the Contractor. Resolve sequence problems with Section "Instrumentation and Control for HVAC", the Contractor and Architect at no additional cost.

3. Air Outlets (supply, return and exhaust registers diffusers and grilles)
   a. Manufacturer, model number, size of outlet and number of throw directions.
   b. Design and actual airflow.
   c. Adjust outlets to obtain design airflow within ±5%.
   d. Adjust direction of throw as required to match final installation location to prevent drafts.
   e. With supply, return and exhaust balanced to design airflow, report room pressurization, (positive or negative). Report pressure readings relative to adjacent spaces only where requested by Owner or Architect.

D. Sheaves And Belts:

1. Should the air balance not meet acceptable industry standard tolerances as referenced herein, change and replace sheaves and belts to provide a final acceptable air balance. Replacement of sheaves and belts shall be provided at no additional cost.

3.3 HYDRONIC SYSTEM BALANCE

A. Only the work installed under this contract shall be balanced. Provide all necessary isolation valves, temporary bypasses and other means and methods to accommodate. Notify the Architect in writing before entering the central plant in Community Building 1 and adjusting the existing pumps or other equipment.

B. In conjunction with the Instrumentation and Controls Technician, all equipment shall be started per design sequence. With manual valves open, and control valves in normal position, adjust discharge balancing valves to obtain design flow.

C. With pump system adjusted, perform following tests, compile data and submit report:

1. Pipe Mains and Branches:
   a. Adjust branch balancing valves to obtain pressure and flowrates required for terminal devices, i.e., water-source heat pumps, etc.
   b. Provide the following:
      1) Design and actual flow rate and pressure drop.
      2) Record entering and leaving water temperatures.
   c. Terminal Devices (Water-Source Heat Pumps):
      1) Manufacturer's model number, type of terminal device and rated heat output.
      2) Flowrate and differential pressure through component including control device.
      3) Adjust balancing device to obtain required flowrate through device, in accordance with manufacturer's procedures and recommendations.
      4) Record temperatures of fluid at inlet and outlet of device. Record temperatures of air entering and leaving coils. Compare data with design performance, if data is not in conformance with approved shop drawings or design intent, readjust water system to obtain

acceptable performance.

5) With air and water system balanced and in conjunction with "Instrumentation and Control System" operate controls, i.e., thermostats, switches, etc., in accordance with design sequence to verify proper operation.

6) Report control problems in writing to General Contractor. Resolve sequence problems with Instrumentation and Controls Technician, the Contractor and Architect at no additional cost.

d. Heat transfer equipment including closed loop systems and water-source heat pumps, etc.

1) Measured Parameters
   a) Flowrate.
   b) Heat transfer.
   c) Entering and leaving temperatures.
   d) Pressure drops.
   e) Ambient dry and wet bulb (for cooling towers).

2) Equipment data
   a) Manufacturer and model number.
   b) Motor output horsepowers.
   c) Serial numbers.

3) Design Data
   a) Include design data in submittal for comparison.

D. It is not the intent of this contract to re-balance the existing closed loop pumps in the Central Plant of Community Building 1. Should the pumps need to be re-balanced under this contract, they shall be rebalanced as a part of the contract without request for additional payment.

1. Notify the Architect in writing that the contract will require the closed loop pumps in the central plant of Community Building 1 to be rebalanced. Do not commence re-balancing existing equipment in the central plant until approval is given by the Architect.
2. Field verify existing pump manufacturer and model number and other relevant information including motor horsepower. Obtain all relevant information from pump manufacturer including pump curves and operations and maintenance manuals.
3. Verify existing brake horsepower, flow and pressure. Verify existing balancing valve setting.
4. Adjust pump to desired flow and pressure setting via balancing valve and variable frequency drive.
5. With pump system adjusted, perform following tests, compile data and submit report:

a. Pumps

1) Design Data
   a) Flow and total dynamic head.
   b) Pump speed, and motor output.

2) Installed equipment
   a) Manufacturer, size and model number.
   b) Type drive.
   c) Motor rating, voltage, and phase.
   d) Full-load amperes.

3) Field Test
   a) Discharge pressures: Full flow and zero flow.
   b) Suction pressures: Full flow and zero flow.
   c) Operating flow and total dynamic head
   d) No-load amperes (where possible.)
   e) Full-flow amperes, zero-flow amperes.
   f) Calculated motor output.

4) Compare data with pump submittal curve. If test point falls on curve, proceed with balancing. If recorded data does not fall on pump curve, plot new curve parallel with other curves on chart, from zero to maximum flow. Open discharge balancing valve to full and record discharge pressure, suction pressure and total head. Readjust balancing valve to obtain suction and discharge design flow and pressure, and record data. Check and record pump motor voltage and amperage. Pump motor shall not be overloaded.

3.4 ACOUSTICS AND NOISE CRITERIA

A. Verify that mechanical systems comply with noise criteria as specified and indicated in Division 23. Where compliance is questionable or where requested by Owner, Architect or Contractor, take sound power level reading and record. Diagnose equipment causing deviations and report deviations to appropriate trade contractor and Contractor. Resolve noise problems with Contractor and appropriate Installer.

3.5 CALIBRATION

A. During testing and balancing, inspect temperature sensors, pressure sensors, humidity gauges, digital indicators, and thermometers, provided under Division 23. Report discrepancies to the Contractor for replacement or recalibration.

3.6 RE-BALANCE

A. After Architect's review of test and balance report submittal, make adjustment in any balancing point as required by Architect, to correct discrepancies between balance report and design, at no additional cost.

3.7 FINAL BALANCE

A. Visit site within one year after building occupancy if necessary to adjust and rebalance, any system required by Owner, to resolve any and all complaints. After final balance, revise previous submittal and resubmit to architect for record purpose. Rebalance and resubmittals shall be done at no additional cost to Owner.

END OF SECTION

Division 23 - HVAC

SECTION 230700 - HVAC INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and General Provisions of the contract, including General and Supplemental Conditions and Division 01 Specifications, apply to this section and all sections of Division 23.

1.2 SUMMARY

A. Section includes:

1. Insulation Materials:
   a. Cellular glass.
   b. Flexible elastomeric.
   c. Mineral fiber.
   d. Duct lining.
2. Insulating cements.
3. Adhesives.
4. Mastics.
5. Lagging adhesives.
6. Sealants.
7. Factory-applied jackets.
8. Field-applied fabric-reinforcing mesh.
9. Field-applied cloths.
10. Field-applied jackets.
11. Tapes.
12. Securements.
13. Corner angles.

B. Related Sections: The following sections contain requirements that relate to this section.

1. Section 23 05 03 – “Pipes and Tubes for HVAC Piping and Equipment:” Product requirements for piping.
2. Section 23 05 16 – “Expansion Fittings and Loops for HVAC Piping:” Product requirements for expansion loops and fittings.
3. Section 23 05 23 – “General Duty Valves for HVAC Piping:” Product requirements for valves.
4. Section 23 05 29 – “Hangers and Supports for HVAC Piping and Equipment:” Product and Execution requirements for inserts at hanger locations.
5. Section 23 05 53 – “Identification for HVAC Piping and Equipment”: Product requirements for HVAC piping and equipment identification.
6. Section 23 30 00 – “HVAC Air Distribution:” Product requirements for ductwork.

1.3 REFERENCES
(Unless otherwise noted, references apply to “latest editions.”)

A. ASTM International:

1. ASTM A167 - Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
2. ASTM B209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
3. ASTM B209M - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (Metric).
4. ASTM C177 - Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus.
5. ASTM C195 - Standard Specification for Mineral Fiber Thermal Insulating Cement.
6. ASTM C423 – Standard for Reverberation Room Method.
7. ASTM C449/C449M - Standard Specification for Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement.
8. ASTM C518 - Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.
9. ASTM C533 - Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation.
10. ASTM C534 - Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.
11. ASTM C547 - Standard Specification for Mineral Fiber Pipe Insulation.
12. ASTM C552 - Standard Specification for Cellular Glass Thermal Insulation.
13. ASTM C553 - Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications.
14. ASTM C591 - Standard Specification for Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation.
15. ASTM C592 - Standard Specification for Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered) (Industrial Type).
16. ASTM C612 - Standard Specification for Mineral Fiber Block and Board Thermal Insulation.
17. ASTM C795 - Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel.
18. ASTM C921 - Standard Practice for Determining the Properties of Jacketing Materials for Thermal Insulation.
19. ASTM C1071 - Standard Specification for Thermal and Acoustical Insulation (Glass Fiber, Duct Lining Material).
20. ASTM C1126 - Standard Specification for Faced or Unfaced Rigid Cellular Phenolic Thermal Insulation.
21. ASTM C1136 - Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation.
22. ASTM 1622 – 08 Standard Test Method for apparent density, apparent density, apparent overall density.
23. ASTM D1784 - Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.
24. ASTM D3575 – 08 Standard Test Methods for flexible celluar materials made from Olefin Polymers, closed cell materials, flexible cellular, Olefin Polymers, Buoyancy,etc.
25. ASTM C1290 - Standard Specification for Flexible Fibrous Glass Blanket Insulation Used to Externally Insulate HVAC Ducts.

26. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.
27. ASTM E96 - Standard Test Methods for Water Vapor Transmission of Materials.
28. ASTM E162 - Standard Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source.
29. ASTM G21 - Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi.

B. Sheet Metal and Air Conditioning Contractors':

1. SMACNA - HVAC Duct Construction Standard - Metal and Flexible.

1.4 SUBMITTALS

A. General: Submit each item in this Section according to the conditions of the Contract and Division 01 specification sections.
B. Product Data: Submit product description, thermal characteristics and list of materials and thickness for each service, and location.

C. Samples: Submit two samples of representative size illustrating each insulation type.
D. Manufacturer's Installation Instructions: Submit manufacturers published literature indicating proper installation procedures.
E. Manufacturer's Certificate: Certify products meet or exceed specified requirements.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.
B. Perform Work in accordance with all applicable codes, standards and local authorities having jurisdiction requirements.
C. Maintain one copy of each document on site.
D. Fire-Test-Response Characteristics: Insulation and related materials shall have fire-test response characteristics indicated, as determined by testing identical products per ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, and cement material containers, with appropriate markings of applicable testing and inspecting agency.

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

E. Insulation materials shall be tested and rated according to ASTM Test Method C-177 to determine k-factors. ASTM C 335 is for pre-formed pipe insulation. C177 is for flat slab materials such as board products, etc.

1.6 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years experience and service facilities within 50 miles of the project.
B. Applicator: Company specializing in performing Work of this section with minimum three years experience.
C. Convene minimum one week prior to commencing work of this section.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Accept materials on site in original factory packaging, labeled with manufacturer's identification, including product density and thickness.
B. Protect insulation from weather and construction traffic, dirt, water, chemical, and damage, by storing in original wrapping. Remove and replace any wet or damaged unsatisfactory insulation at the Architect’s direction.

1.8 ENVIRONMENTAL REQUIREMENTS

A. Install insulation only when ambient temperature and humidity conditions are within range recommended by manufacturer.
B. Maintain temperature during and after installation for minimum period of 24 hours.

1.9 FIELD MEASUREMENTS

A. Verify field measurements prior to fabrication.

1.10 WARRANTY

A. Furnish five year manufacturer warranty for manmade fiber.

1.11 DEFINITIONS

A. ASJ: Al-service jacket.
B. FSK: Foil, scrim, Kraft paper.
C. FSP: Foil, Scrim, polyethylene.
D. PVDC: Polyvinylidene chloride.
E. SSL: Self-sealing lap.

F. ASJ: All service jacket composed of aluminum foil reinforced with glass scrim bonded to a Kraft paper interweaving with an outer film layer leaving no paper exposed.
G. PSK: Poly Scrim Kraft.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles blow introduce lists, the following requirements apply to product selection.

1. Products: Subject to compliance with requirements, provide one of the products specified.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 INSULATION MATERIALS

A. Refer to Part 3 execution schedule for requirements regarding where insulating materials shall be applied.
B. Products shall not contain asbestos, lead, mercury, mercury compounds, or formaldehyde.
C. Insulation products shall contain no formaldehyde-based binders or will be third-party certified for conformance with Greenguard children and schools or Indoor Advantage Gold.
D. When product to be in contact with austenitic stainless steel is tested according to ASTM C795 (which includes ASTM C692 and ASTM C871), the PH of the leach water from the specific material supplied shall be greater than 7.0 but not greater than 11.7 at 77°F (25°C). An acceptable proportion of sodium plus silicate ions to the chloride ions as found by leaching from the insulation is shown in the “plot point” of figure 6 in ASTM C795.
E. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.
F. Foam insulation materials shall not utilize CFC or HCFC blowing agents in the manufacturing process.
G. Cellular Glass: Inorganic, incombustible, foamed or celluated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in Part 2 “Factory-Applied Jackets” Article.

1. Products:
   a. Pittsburgh Corning Corporation; Foamglass
   b. Specialty Products & Insulation Company (SPI), Lancaster, PA.
2. Block Insulation: ASTM C 552, Type I.
3. Special-Shaped Insulation: ASTM C 552, Type III.

4. Board Insulation: ASTM C 552, Type IV.
5. Preformed Pipe Insulation with Factory-Applied ASJ-SSL: Comply with ASTM C 552, Type II, Class 2.
6. Maximum K-Factor: 0.29 at 75 deg. F. mean temperature.
7. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.

H. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials. Closed-cell polyolefin/polyethylene insulation is not acceptable as a substitution for ASTM C534 closed-cell rubber materials.

1. Products:
   a. Aeroflex USA Inc.: Aerocel.
   b. Armacell LLC; AP Armaflex.
   c. Nomaco; K-Flex Pipe
2. Water Vapor Permeability: 0.02 perm-inch per ASTM E96 Procedure A.
3. Warranty: 25 year warranty against breakdown of the membrane due to
4. ultraviolet radiation.
5. Seal Tape: Thermoplastic rubber membrane backed with pressure sensitive
6. adhesive.

I. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type III with factory-applied FSK jacket. Factory-applied jacket requirements are specified in Part 2 “Factory-Applied Jackets” Article.

1. Products:
   a. CertainTeed Corp.; Duct Wrap.
   b. Johns Manville; Microlite Duct Wrap or Microlite XG.
   c. Knauf Insulation; Friendly Free Duct Wrap with Ecose® Technology.
   d. Owens Corning; All-Service Duct Wrap Type 100.
2. Maximum K-Factor: 0.24 at 75 deg. F. and material thickness compressed 25%.
3. Minimum Density: 1.5 pounds per cubic foot.

J. High-Temperature, Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type V, without factory-applied jacket.

1. Products:
   a. Johns Manville; HTB 23 Spin-Glas.
   b. IIG Industries
2. Maximum K-Factor: 0.23 at 75 deg. F.
3. Minimum Density: 2.0 pounds per cubic foot.

K. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. For duct and plenum applications, provide insulation with factory-applied FSK jacket. Factory-applied jacket requirements are specified in Part 2 “Factory-Applied Jackets” Article.

1. Products:
   a. CertainTeed Corp.; Commercial Board.
   b. Johns Manville; 800 Series Spin-Glas, Type 814.

c. Knauf Insulation; Insulation Board with Ecose® Technology, suitable for operating temperatures up to 450°F.
d. Knauf Insulation: Elevated Temperature Board with Ecose® Technology for operating temperatures to 1000°F.
e. Owens Corning; Fiberglas 700 Series for operating temperatures up to 450°F.
f. Owens Corning: Insul-Quick for operating temperatures up to 850°F.

2. Maximum K-Factor: 0.23 at 75° F.
3. Minimum density: 3.0 pounds per cubic foot.

L. High-Temperature Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type III, without factory-applied jacket.

1. Products:
a. Johns Manville: 1000 Series Spin-Glas.
b. Knauf Insulation: Elevated Temperature Board with Ecose® Technology for operating temperatures to 1000°F.
c. IIG Industries
d. Rock Wool Manufacturing Company; Delta Board.
2. Maximum K-Factor: 0.23 at 75 deg. F mean temperature; 0.33 at 300 deg. F mean temperature.
3. Minimum Density: 3.0 Pounds per cubic foot.

M.

2.3 FIRE RATED INSULATION KITCHEN HOOD/EQUIPMENT FLUE EXHAUST SYSTEMS

A. Fire-Rated Board: Structural-grade, press-molded, xonolite calcium silicate, fireproofing board suitable for operating temperatures up to 1700 deg F. Comply with ASTM C656, Type II, Grade 6. UL tested and certified to provide a 2-hour fire rating.

1. Products:
a. Johns Manville; Super Firetemp M.

B. Fire-RatedBlanket: High-temperature, flexible, blanket insulation with FSK jacket that is UL tested and certified to provide a 2-hour fire rating.

1. Products:
a. CertainTeed Corp.; FlameChek.
b. Johns Manville; Firetemp Wrap.
c. 3M; Fire Master Wrap Products.

2.4 INSULATING CEMENTS

A. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.
B. Expanded or Exfoliated Vermiculite Insulating Cement: Comply with ASTM C 196.
C. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449/C 449M.

2.5 ADHESIVES

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

B. Cellular-Glass and Polyisocyanurate Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 deg F.

1. Products:
   a. Foster Products Corporation, H. B. Fuller Company; 81-84.

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

1. Products:
   a. Armacell LCC; 520 BLV Adhesive.
   b. Foster Products Corporation, H. B. Fuller Company; 85-60.

D. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

1. Products:
   a. Foster Products Corporation, H. B. Fuller Company; 85-70.
   b. Eagle Bridges - Marathon Industries, Inc.; 225.

E. ASJ Adhesive, and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

1. Products:
   a. Foster Products Corporation, H. B. Fuller Company; 85-70.
   b. Eagle Bridges - Marathon Industries, Inc.; 225.

F. PVC Jacket Adhesive: Compatible with PVC jacket.

1. Products:
   a. Dow Chemical Company (The); 739, Dow Silicone.

G. Polyurethane Foam Insulation Board: Manufacturer’s recommended synthetic adhesive compatible with polyurethane insulation.

1. Products:
   a. Sarnafil Sarnacol 2170 or Sarnacol 21425.

2.6 MASTICS

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

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

1. Products:

a. Foster Products Corporation, H. B. Fuller Company; 30-90.
b. Eagle Bridges - Marathon Industries, Inc.; 590.
c. Mon-Eco Industries, Inc.; 55-40.
d. Vimasco Corporation; 749.

2. Water-Vapor Permeance: ASTM E 96, Procedure B, 0.013 perm at 43-mil dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F.
4. Solids Content: ASTM D 1644, 59 percent by volume and 71 percent by weight.
5. Color: White.

C. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.

1. Products:
   a. Foster Products Corporation, H. B. Fuller Company; 35-00.
   b. Eagle Bridges - Marathon Industries, Inc.; 550.
   c. Mon-Eco Industries, Inc.; 55-50.
   d. Vimasco Corporation; WC-1/WC-5.
2. Water-Vapor Permeance: ASTM F 1249, 3 perms at 0.0625-inch dry film thickness.
3. Service Temperature Range: Minus 20 to plus 200 deg F.
4. Solids Content: 63 percent by volume and 73 percent by weight.
5. Color: White.

2.7 LAGGING ADHESIVES

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

1. Products:
   a. Foster Products Corporation, H. B. Fuller Company; 81-42W.
   b. Eagle Bridges - Marathon Industries, Inc.; 130.
   c. Vimasco Corporation; 713/714.
2. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct, equipment, and pipe insulation.
3. Service Temperature Range: Minus 50 to plus 180 deg F.
4. Color: White.

2.8 SEALANTS

A. Joint Sealants:

1. Joint Sealants for Cellular-Glass and Polyisocyanurate Products:
   a. Foster Products Corporation, H. B. Fuller Company; 30-45.
   b. Eagle Bridges - Marathon Industries, Inc.; 405.
   c. Mon-Eco Industries, Inc.; 44-05.
   d. Pittsburgh Corning Corporation; Pittseal 444.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Permanently flexible, elastomeric sealant.
4. Service Temperature Range: Minus 100 to plus 300 deg F.
5. Color: White or gray.

B. FSK and Metal Jacket Flashing Sealants:

1. Products:
   a. Foster Products Corporation, H. B. Fuller Company; 95-44.
   b. Eagle Bridges - Marathon Industries, Inc.; 405.
   c. Mon-Eco Industries, Inc.; 44-05.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: Aluminum.

C. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:

1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.
4. Color: White.

2.9 FACTORY-APPLIED JACKETS

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

1. ASJ: White, Kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
3. ASJ+SSL: ASJ+ - SSL: All Service Jacket composed of aluminum foil reinforced with glass scrim bonded to a kraft paper interleaving with an outer film layer leaving no paper exposed.
4. Redi-Klad Jacket: Factory applied Venture Clad 5-ply weather ad abuse resistant with self-sealing lap. Zero permeability per ASTM E 96-05; puncture resistance 35.4 kg (189.3 N) per ASTM D 1000; tear strength 4.3 lb (19.4 N) per ASTM D 624; thickness 14.5 mils (0.0145”); tensile strength 68 lb/inch width [306 N (32 kg)/25 mm].
5. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with Kraft-paper backing; complying with ASTM C 1136, Type II.
6. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.
7. PVDC Jacket for Outdoor Applications: 6-mil- thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perms when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.
8. PVDC Jacket for Indoor Applications: 4-mil thick, white PVDC bioxially oritented barrier film with a permeance at 0.02 perms when tested according to ASTM E96 and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.
9. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.
   a. Products:

1) Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.

10. Vinyl Jacket: UL-rated white vinyl with a permeance of 1.3 perms when tested according to ASTM E 96, Procedure A, and complying with NFPA 90A and NFPA 90B.
11. ASJ: Owens Corning Evolution™ paper-free ASJ pipe insulation.
12. PSK Jacket, Polypropylene scrim with Kraft.

2.10 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Woven Glass-Fiber Fabric for Duct and Equipment Insulation: Approximately 6 oz./sq. yd. with a thread count of 5 strands by 5 strands/sq. inch for covering equipment.
B. Woven Polyester Fabric: Approximately 1 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. inch, in a Leno weave, for duct, equipment, and pipe.

1. Products:
   a. Foster Products Corporation, H. B. Fuller Company; Mast-A-Fab.
   b. Vimasco Corporation; Elastafab 894.

2.11 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.
B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with Kraft-paper backing.
C. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; 20 mil thickness; roll stock Ready for shop or field cutting and forming.

1. Products:
   a. Johns Manville; Zeston.
   b. P.I.C. Plastics, Inc.; FG Series.
   c. Proto PVC Corporation; LoSmoke.
   d. Speedline Corporation; SmokeSafe.
2. Adhesive: As recommended by jacket material manufacturer.
3. Color: white.
4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
   a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps and mechanical joints minimum 20 mil thickness.
5. Factory-fabricated tank heads and tank side panels.

D. Metal Jacket:

1. Products:
   a. Childers Products, Division of ITW; Metal Jacketing Systems.
   b. PABCO Metals Corporation; Surefit.
   c. RPR Products, Inc.; Insul-Mate.
2. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105 or 5005, Temper H-14.

a. Sheet and roll stock ready for shop or field sizing.
b. Thickness:
   1) Up to 24 inch diameter, width, or height: 0.016 inch minimum.
   2) 25 inch to 59 inch diameter, width, or height: 0.024 inch minimum.
   3) 60 inch and larger diameter, width, or height: 0.032 inch minimum.
c. Finish: Smooth finish.
d. Color: White
e. Moisture Retarder: 3-mil- thick Polysurlyn (co-extrusion of polyethylene and Dupont Surlyn® , heat laminated to the metal jacketing).
f. Factory-Fabricated Fitting Covers:
   1) Same material, finish, and thickness as jacket.
   2) Preformed 2-piece or gore, 45- and 90-degree, short- and longradius elbows.
   3) Tee covers.
   4) Flange and union covers.
   5) End caps.
   6) Beveled collars.
   7) Valve covers.
   8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

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

1. Products:
   a. Polygaurd; Alumaguard 60.
   b. MFM Building Products Corp., Flex Clad 400.
   c. Venture Clad Jacketing.

F. Rubber Membrane: 48-mil thick membrane consisting of a glass fiber carrier coated on both sides with liquid PVC-P Plastisol, and laminated to polyester fleece.

G. Pipe Sound Lagging: Loaded vinyl with fibrous glass scrim reinforced aluminum foil facing over 2-inch thick quilted fiberglass decoupler. Loaded vinyl shall be 2 psf minimum surface weight. Glass fiber pipe wrap shall be semi-rigid, preformed type, 2- inch minimum thickness, 1-1/2 pcf density.

1. Manufacturers:
   a. Kinetics.
   b. Sound Seal.
2. Sound Transmission Class (STC) Rating: 26.

H. Duct Sound Lagging: Reinforced, loaded vinyl noise barrier.

1. Products:
   a. Kinetics; KNM-100 AL
   b. Sound seal; B-10R

c. Unger Technologies, Inc.; Model DL-10-LAG
2. Sound Transmission Class (STC) rating: 26.
3. Density: 1 pound per square foot.

2.12 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136 and UL listed.

1. 1. Products:
   a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0835.
   b. Compac Corp.; 104 and 105.
   c. Ideal Tape Co., Inc., an American Biltrite Company; 428 AWF ASJ.
   d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.
2. Width: 3 inches.
3. Thickness: 11.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136 and UL listed.

1. Products:
   a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
   b. Compac Corp.; 110 and 111.
   c. Ideal Tape Co., Inc., an American Biltrite Company; 491 AWF FSK.
   d. Venture Tape; 1525 CW, 1528 CW, and 1528 CW/SQ.
2. Width: 3 inches.
3. Thickness: 6.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive. Suitable for indoor and outdoor applications.

1. Products:
   a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0555.
   b. Compac Corp.; 130.
   c. Ideal Tape Co., Inc., an American Biltrite Company; 370 White PVC tape.
   d. Venture Tape; 1506 CW NS.
2. Width: 2 inches.
3. Thickness: 6 mils.
4. Adhesion: 64 ounces force/inch in width.
5. Elongation: 500 percent.
6. Tensile Strength: 18 lbf/inch in width.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive and UL listed.

1. Products:
   a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0800.
   b. Compac Corp.; 120.
   c. Ideal Tape Co., Inc., an American Biltrite Company; 488 AWF.
   d. Venture Tape; 3520 CW.
2. Width: 2 inches.
3. Thickness: 3.7 mils.
4. Adhesion: 100 ounces force/inch in width.
5. Elongation: 5 percent.
6. Tensile Strength: 34 lbf/inch in width.

2.13 SECUREMENTS

A. Bands:

1. Products:
   a. Childers Products; Bands.
   b. PABCO Metals Corporation; Bands.
   c. RPR Products, Inc.; Bands.
2. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 316; 0.015 inch thick, 3/4 inch wide with wing or closed seal.
3. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 3/4 inch wide with wing or closed seal.
4. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

B. Insulation Pins and Hangers:

1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch- diameter shank, length to suit depth of insulation indicated.
   a. Products:
      1) AGM Industries, Inc.; CWP-1.
      2) GEMCO; CD.
      3) Midwest Fasteners, Inc.; CD.
      4) Nelson Stud Welding; TPA, TPC, and TPS.
2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch- diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
   a. Products:
      1) AGM Industries, Inc.; CWP-1.
      2) GEMCO; Cupped Head Weld Pin.
      3) Midwest Fasteners, Inc.; Cupped Head.
      4) Nelson Stud Welding; CHP.
3. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

a. Products:
   1) AGM Industries, Inc.; Tactoo Insul-Hangers, Series T.
   2) GEMCO; Perforated Base.
   3) Midwest Fasteners, Inc.; Spindle.
b. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
c. Spindle: Copper- or zinc-coated, low carbon steel, fully annealed, 0.106-inch- diameter shank, length to suit depth of insulation indicated.
d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

4. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
   a. Products:
      1) GEMCO; Nylon Hangers.
      2) Midwest Fasteners, Inc.; Nylon Insulation Hangers.
   b. Baseplate: Perforated, nylon sheet, 0.030 inch thick by 1-1/2 inches in diameter.
   c. Spindle: Nylon, 0.106-inch- diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches.
   d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates
   e. indicated without damaging insulation, hangers, and substrates.
5. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inchthick, galvanized-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
   a. Products:
      1) AGM Industries, Inc.; RC-150.
      2) GEMCO; R-150.
      3) Midwest Fasteners, Inc.; WA-150.
      4) Nelson Stud Welding; Speed Clips.
   b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.
6. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
   a. Manufacturers:
      1) GEMCO.
      2) Midwest Fasteners, Inc.

C. Staples: Outward-clinching insulation staples, nominal 3/4-inch- wide, stainless steel or Monel.
D. Wire: 0.062-inch soft-annealed, stainless steel.

1. Manufacturers:
   a. ACS Industries, Inc.
   b. C & F Wire.
   c. Childers Products.

d. PABCO Metals Corporation.
e. RPR Products, Inc.

2.14 CORNER ANGLES

A. Aluminum Corner Angles: 0.040 inch thick, minimum 1 by 1 inch, aluminum according to ASTM B 209, Alloy 3003, 3005, 3105 or 5005; Temper H-14.
B. Stainless-Steel Corner Angles: 0.024 inch thick, minimum 1 by 1 inch, stainless steel according to ASTM A 167 or ASTM A 240/A 240M, Type 304 or 316.

2.15 DUCT LINING

A. Products:

1. K-Flex Gray Duct Liner with PSA

B. Material shall have a density ranging from 3 to 6 lb/ft^3 (ASTM D1622, ASTM D3575).
C. Material shall have a maximum thermal conductivity (k) of 0.25 Btu-in/hr-ft^2-°F @ 75°F mean temperature (ASTM C518, ASTM C177).
D. Material shall have a minimum R-value of 6 at a nominal 1 ½" thickness.
E. Material shall have a maximum Water Vapor Transmission rate of 0.10 Perm-in. (ASTM E96, Desiccant Method).
F. Material shall have a minimum sound absorption coefficient (NRC) of 0.50 at a nominal 1 ½" thickness (ASTM C423).
G. Material shall have a flame spread rating not greater than 25 and a smoke developed rating not greater than 50 when tested in accordance with ASTM E84 at a thickness required to attain a minimum 6 R-value.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Refer to the Division 01 specifications for coordination and project conditions.
B. Verify piping, equipment and ductwork has been tested before applying insulation materials.
C. Verify surfaces are clean and dry, with foreign material removed.

3.2 PREPARATION

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

B. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.
C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.3 COMMON INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment, ducts and fittings, and piping including fittings, valves, and specialties.
B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment, duct system, and pipe system as specified in insulation system schedules.
C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
E. Install multiple layers of insulation with longitudinal and end seams staggered.
F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
G. Keep insulation materials dry during application and finishing.
H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
I. Install insulation with least number of joints practical.
J. Install insulation continuously through hangers and around anchor attachments.
K. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at anchors and other projections with vapor-barrier mastic.

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

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

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

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive selfsealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.
   a. For below ambient services, apply vapor-barrier mastic over staples.
4. Cover joints and seams with tape as recommended by insulation material manufacturer to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct and pipe flanges and fittings.

N. Cut and install insulation in a manner to avoid compressing insulation more than 25 percent of its original nominal thickness.

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

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

Q. Replace insulation on existing piping, and equipment where indicated on the drawings. Match insulation type and thickness indicated by the insulation schedule at the end of this section.

R. Replace insulation on new and existing piping, and equipment where insulation is damaged during construction or removed for testing and balancing work.

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

1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.
4. Manholes.
5. Handholes.
6. Cleanouts.
7. Unions.
8. Flanges.
9. Expansion joints.

T. Duct and plenum liner application.

1. Adhere insulation with 90% adhesive coverage with mechanical pin fasteners.

2. Secure insulation with mechanical liner fasteners. Comply with SMACNA Standards for spacing.
3. Seal and smooth joints. Seal and coat transverse joints.
4. Seal liner surface penetrations with adhesive.
5. Duct dimensions indicated are net inside dimensions required for airflow. Increase duct size to allow for insulation thickness.

U. For hot equipment containing fluids over 140 degrees F, insulate flanges and unions with removable sections and jackets.

V. Heat Traced Piping: Insulate fittings, joints, and valves with insulation of like material, thickness, and finish as adjoining pipe. Size insulation large enough to enclose pipe and heat trace. Cover with aluminum jacket with seams located at 3 or 9 o'clock position on side of horizontal piping with overlap facing down to shed water.

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

X. Exterior and Garage Applications: Provide vapor retarder jacket. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe, and finish with glass mesh reinforced vapor retarder cement. Cover with aluminum jacket with seams located at 3 or 9 o'clock position on side of horizontal piping with overlap facing down to shed water or on bottom side of horizontal equipment.

3.4 BUILDING PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

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

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

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.

4. Seal jacket to wall flashing with flashing sealant.

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

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

F. Insulation Installation at Floor Penetrations:

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

3.5 DUCT AND PLENUM INSULATION INSTALLATION

A. Provide Blanket Insulation Installation on Ducts and Plenums: Secure with SMACNA recommended anti-sag insulation pins for the bottom of ductwork over 24” wide.

1. Apply adhesives according to manufacturer’s recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Protect exposed corners with secured corner angles.
4. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
   a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
   b. On duct sides with dimensions larger than 18 inches, place pins 16 inches o.c. each way and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.

3.6 GENERAL PIPE INSULATION INSTALLATION

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

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

1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity, unless otherwise indicated.

2. Fittings shall be insulated to same thickness as the adjoining insulation. Apply fittings per fitting manufacturer's instructions. When required by specification, a hard insert of sufficient length shall be utilized to avoid compression of the insulation.
3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe wire. Bond pieces with adhesive.
4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below ambient services, provide a design that maintains vapor barrier.
6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below ambient services and a breather mastic for above ambient services. Reinforce the mastic with fabric reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
9. Stencil or label the outside insulation jacket of each union with the word UNION." Match size and color of pipe labels.

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

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

1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange

cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.

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

3.7 CELLULAR-GLASS INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above ambient services, secure laps with outward clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets on below ambient services, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of cellularglass block insulation of same thickness as pipe insulation.
4. Install jacket material with manufacturer’s recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer’s written instructions.
2. When preformed sections of insulation are not available, install mitered sections of cellular-glass insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of cellular-glass insulation to valve body.

2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.8 FLEXIBLE ELASTOMERIC INSULATION INSTALLATION

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

B. Insulation Installation on Pipe Flanges:

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

C. Insulation Installation on Pipe Fittings and Elbows:

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

D. Insulation Installation on Valves and Pipe Specialties:

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

3.9 MINERAL-FIBER INSULATION INSTALLATION

A. Blanket Insulation Installation on Ducts and Plenums: Secure with insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:

a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
b. On duct sides with dimensions larger than 18 inches, place pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
d. Do not overcompress insulation during installation.
e. Impale insulation over pins and attach speed washers.
f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches (50 mm) from 1 edge and 1 end of insulation segment. Secure laps to adjacent insulation section with 1/2- inch (13-mm) outward-clinching staples, 1 inch (25 mm) o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
   a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
   b. Install vapor stops for ductwork and plenums operating below 50 deg (10 deg C) at 18-foot (5.5-m) intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated width equal to 2 times the insulation thickness but not less than 3 inches (75 mm).
5. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches o.c.
6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

B. Board Insulation Installation on Ducts and Plenums: Secure with insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
   a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.

b. On duct sides with dimensions larger than 18 inches, space pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
d. Do not overcompress insulation during installation.
e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches (50 mm) from 1 edge and 1 end of insulation segment. Secure laps to adjacent insulation section with 1/2- inch (13-mm) outward-clinching staples, 1 inch (25 mm) o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
   a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
   b. Install vapor stops for ductwork and plenums operating below 50 deg F (10 deg C) at 18-foot (5.5-m) intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to 2 times the insulation thickness but not less than 3 inches (75 mm).
5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

3.10 FIELD-APPLIED JACKET INSTALLATION

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.

1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch- thick coats of lagging adhesive.
3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where FSK jackets are indicated, install as follows:

1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer’s recommended adhesive.
4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch- wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

C. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's recommended adhesive.

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

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

1. Where rubber membrane jackets are indicated, install the membrane using the manufacturer's recommended adhesive. Before use thoroughly stir the adhesive. Replace the container lid when work is interrupted. If required thin the adhesive as recommended by the manufacturer.
2. Using a sheepskin or similar roller apply a primer coat of adhesive to the roof surface, priming only the area of roof where the membrane will be laid the same day. Allow adhesive to dry.
3. Unroll the membrane and fold back approximately half its length.
4. Apply adhesive with a sheepskin or similar roller to the underside of the membrane ensuring the weld area is kept free of adhesive and allow to touch dry.
5. Carefully roll out the membrane over the previously primed surface and roll with water filled roller.
6. Fold back other half of the roll of membrane and repeat the procedure.
7. Unroll the next roll of membrane, ensuring the end laps are staggered and the side overlaps the previously installed sheet by 2 inches.
8. Repeat the adhering process.
9. Fully hot air weld the 2-inch side lap, allow to cool completely.
10. Mechanically check the integrity of the cooled weld by running a 3/16-inch wide screwdriver (with rounded edges) along the seam applying pressure into the seam.
11. Install Peel Stop and PVC Welding Cord at all perimeters, penetrations and changes of roof direction.

E. Pipe Sound Lagging:

1. Seal and fasten in accordance with manufacturer's written instructions to maintain specified STC rating.
2. Cover entire pipe with glass fiber wrap. Fill all voids with clean glass fiber scrap. Apply over this wrap an airtight cover of loaded vinyl. Do not connect the cover rigidly to pipe or hangers. Overlap longitudinal seams in loaded vinyl 2-inch minimum and tape with cloth-backed tape. Overlap edge seams 1-inch minimum and tape with cloth-backed tape or with acoustical sealant. Extend ends of cover within 1/2-inch of penetration through wall, ceiling, and/or floor. Seal annular gap between pipe lagging and penetration airtight with acoustic sealant.
3. Duct lagging shall be independently supported gypsum board with batt insulation.

3.11 FINISHES

A. Finish Duct, Equipment, and Pipe Insulation with ASJ, Glass Cloth, or Other Paintable Jacket Material. Clad-Type Jacketing such as Venture RediKlad or Venture Clad may be utilized.
B. Flexible Elastomeric Thermal Insulation: after adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.
C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed work.
D. Do not field paint aluminum or stainless-steel jackets.

3.12 INSULATION APPLICATION SCHEDULE

A. Acceptable insulation materials, thickness and vapor retarder requirements are identified for each application and size range. If more than one material is listed for an application and size range, selection from the materials listed is Contractor's option.
B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:

1. Fire-suppression piping.
2. Below-grade piping.
3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.
4. General exhaust ductwork (Not including kitchen exhaust ductwork and elevator relief ductwork which is required to be insulated).
5. Factory-insulated flexible ducts.
6. Factory-insulated plenums and casings.
7. Flexible connectors.
8. Vibration-control devices.
9. Factory-insulated access panels and doors.

C. All supply and outside air ductwork with internal sound lining shall be externally insulated.
D. Where metal ducts are specified to have internal duct liner, the thickness of the external insulation may be reduced by one inch, except minimum duct external in
E. sulation thickness shall be 1 inch.

3.13 HVAC PIPING INSULATION APPLICATION SCHEDULE:

HVAC SERVICE	TYPES OF INSULATION MATERIAL	INSULATION THICKNESS REQUIRED	VAPOR RETARDER REQUIRED
INDOOR REFRIGERANT SUCTION, HOT GAS PIPING AND ALL REFRIGERANT PIPING CONNECTED TO THE VRF SYSTEM (Refer to Note 1)			

All sizes, Generally	Flexible Elastomeric	½”	Yes
All sizes, Unconditioned Space (Refer to Note 1)	Flexible Elastomeric	1-1/2”	Yes
OUTDOOR REFRIGERANT SUCTION, HOT GAS PIPING AND ALL REFRIGERENT PIPING CONNECTED TO THE VRF SYSTEM			
All sizes	Flexible Elastomeric	1”	Yes

3.14 HVAC DUCTWORK INSULATION APPLICATION SCHEDULE

HVAC SERVICE	TYPES OF INSULATION MATERIAL	INSULATION THICKNESS REQUIRED	VAPOR RETARDER REQUIRED
SUPPLY-AIR DUCTS AND PLENUMS			
Indoor Service: (Refer to Note 1)			
Concealed	Mineral-Fiber Blanket	1-1/2”	Yes
Exposed	Mineral-Fiber Board	1-1/2”	Yes
Attic Spaces and Unconditioned Spaces – Excluding Ducts in the Garage (Refer to Note 1)	Mineral-Fiber Board	2”	Yes
GARAGE ABOVEGROUND SUPPLY-AIR DUCTS AND PLENUMS (REFER TO NOTE 3)			
For All Locations and Supply Air Temperatures	Mineral-Fiber Board	2”	Yes
INDOOR RETURN-AIR DUCTS, RELIEF-AIR DUCTS, AND PLENUMS			
In locations other than attics and unconditioned spaces	None	--	--
Attic Spaces and Unconditioned Spaces – Excluding Elevator Relief Ducts	Mineral-Fiber Board	1”	Yes

(Refer to Note 1)			
Between Relief-Air Damper and Outdoors (Louver, louvered penthouse, etc.)	Mineral-Fiber Board	2”	Yes
Between Elevator and Relief Damper	Fire Rated Blanket or Fire Rated Board	As Required for Specified Fire Rating	No
HVAC SERVICE	TYPES OF INSULATION MATERIAL	INSULATION THICKNESS REQUIRED	VAPOR RETARDER REQUIRED
OUTSIDE-AIR DUCTS AND PLENUMS			
Indoor Service:			
Concealed	Mineral-Fiber Blanket	1-1/2”	Yes
Exposed	Mineral-Fiber Board	2”	Yes
Attic Spaces	Mineral-Fiber Board	2”	Yes

Schedule Notes:

1. Unconditioned spaced include locations where summer temperature and humidity conditions are similar to outdoor conditions (such as mechanical rooms ventilated with unconditioned outdoor air, parking garages, pedestrian tunnels, etc.)
2. Where rigid pipe insulation (cellular glass, etc.) is scheduled, provide mineral fiber through and 6 inches beyond pipe sleeves, to allow for pipe expansion.
3. Top of ductwork located outdoors shall be provided with cellular glass, or polyurethane board insulation. Taper insulation to shed water, minimum ¼” per foot slope, with insulation thickness at low edges equal to scheduled insulation thickness.
4. All diffuser cones, air valves, damper boxes, HVAC equipment, coils, coil headers, casings, plenums, air measuring devices, chilled beams, etc. shall be insulated.

3.15 FIELD APPLIED JACKET APPLICATION SCHEDULE

SERVICE	FIELD APPLIED JACKET TYPE
Indoor, exposed insulated piping within 12 feet of floor, for service temperatures 200 degrees F and below	PVC
Indoor, exposed insulated piping within 12 feet of floor, for service temperatures 200 degrees F and below	Aluminum
Indoor, exposed insulated piping greater than 12 feet above floor, generally	None
Indoor concealed piping	None
Outdoor exposed piping	Aluminum
Indoor, All Locations, Fittings and valves in piping systems at service temperatures 200 degrees F and below	Factory Fabricated PVC covers
Indoor, All Locations, Fittings and valves in piping systems at service temperatures 200 degrees F and below	Aluminum
SERVICE	FIELD APPLIED JACKET TYPE
Indoor, exposed insulated ductwork within 12 feet of floor	Woven Glass Fiber Fabric
Indoor, exposed insulated ductwork greater than 12 feet of floor	None
Indoor, concealed insulated ductwork	None
Indoor, exposed insulated ductwork	Aluminum
Garage exposed insulated ductwork, Alternative jacket material	Aluminum
Ductwork in high noise areas (as indicated on the drawings)	Duct Sound Lagging (Refer to Note 3)
All insulated piping within custom AHU service corridors for service temperatures 200 degrees F and below	PVC
All insulated piping within custom AHU service corridors for service temperatures 200 degrees F and below	Aluminum
Piping in sound sensitive areas (as indicated on the drawings)	Pipe Sound Lagging (Refer to Note 3)
Equipment, generally (Refer to Notes 1 & 2)	Woven Glass Fiber Fabric

Equipment, Cold surface (Refer to Notes 1 & 2)	PVC

Jacket Application Schedule Notes:

1. Refer to Part 3 specification section titled “Mechanical Equipment, Tank, and Vessel Insulation Installation” for requirements for revocable, re-usable metal boxes lined with insulation at pumps.
2. Including factory insulated equipment without factory applied jacket.
3. If ductwork or piping indicated to have sound lagging also requires an additional field jacket, install sound lagging between insulation and additional field jacket.

END OF SECTION

Division 23 - HVAC

SECTION 230800 - VERIFICATION OF HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Related Documents:

1. Drawings and general provisions of the Subcontract apply to this Section.
2. Review these documents for coordination with additional requirements and information that apply to work under this Section.

B. Section Includes:

1. General requirements that apply to implementation of Verification of HVAC systems, assemblies and components.

C. Related Sections:

1. Division 01 Section "General Requirements."
2. Division 01 Section "Special Procedures."
3. Division 23 HVAC Sections.

1.2 REFERENCES

A. General:

1. The following documents form part of the Specifications to the extent stated. Where differences exist between codes and standards, the one affording the greatest protection shall apply.
2. Unless otherwise noted, the referenced standard edition is the current one at the time of commencement of the Work.
3. Refer to Division 01 Section "General Requirements" for the list of applicable regulatory requirements.
4. Refer to Division 23 Section "Common Results for HVAC" for codes and standards, and other general requirements.

1.3 DESCRIPTION

A. The purpose of verification is to ensure the Owner that work has been completed as specified and that systems are functioning in the manner as described in Division 23 Section "Common Results for HVAC" and specified system operating criteria. It will assist operating staff training and familiarization with new systems. It will serve as a tool to reduce post-occupancy critical systems operational difficulty or failure. It will, also, be used to develop test protocol and record the associated test data in an effort to advance the building systems from a state of substantial completion to a full dynamic operation.
B. Verification will commence after preliminary punch list items are completed by Contractors.
C. The steps associated with Verification are outlined below:

1. Step One - Installation Verification
2. Step Two - System Start-Up.
3. Step Three – Performance Testing.

D. Operational staff training is essential to the verification process and will run concurrently with steps one through three.

E. The Verification Team will include representatives of the Owner, Construction and Installing Subcontractors, Test and Balance Subcontractor, and FMCS Subcontractor. Equipment manufacturer's representatives will be present for start-up as specified in the equipment specification sections and for equipment training.

1.4 SYSTEMS TO BE VERIFIED

A. Verification will be performed on the following systems:

1. Facility Monitoring and Control System (FMCS)
2. Supply and Return Air Systems.
3. Air Terminals.
4. VRF Systems
5. Unitary Equipment.
6. Fans
7. Ductwork
8. Ductwork accessories including Fire Dampers

1.5 SUBMITTALS

A. Submit under provisions of Division 23 Section "Common Results for HVAC - Review of Materials" and Division 01 Section "General Requirements."

B. Verification Plan.

C. The Owner or Architect shall provide Performance Tests (PT) procedures for the above listed systems.

PART 2 - PRODUCTS

2.1 VERIFICATION PLAN

A. The Verification plan shall outline the organization, scheduling, team members, and documentation pertaining to the overall Verification process.

2.2 NARRATIVE DESCRIPTIONS

A. A narrative description of the design intents of the systems and their intended modes of sequences of operation.

2.3 PERFORMANCE TESTS (PT) PROCEDURES

A. The FPT procedures at the minimum shall consist of the following sections:

1. Narrative Description:
   a. This section provides a narrative description of the design intents of the systems and their intended modes of sequences of operation.

2. Testing Prerequisites:
   a. This section contains verification that primary mechanical, electrical, and controls systems that support or interact with the system that the PT is prepared against are completed, tested and operational.
3. Installation Verification:
   a. This section contains verification that the system installation is completed and is ready for Verification.
4. Commencement of Performance Testing:
   a. This section records the date and time of the start of system Verification.
5. System Condition Prior to Staring Performance Testing:
   a. This section records the current set points and parameters of the system at the start of Verification.
6. Performance Test:
   a. This section shall provide the following:
      1) Sequential steps required to set parameters and conditions required to test component and functions throughout intended ranges of operation.
      2) Full range of checks and tests carried out to determine if electric and pneumatic connections, components, subsystems, systems and interfaces between systems function in accordance with the contract documents and design intents.
      3) All modes and sequences of control operations, interlocks and conditional control responses and specified responses to abnormal emergency conditions.
7. End of Performance Test:
   a. This section records the date and time of the end of system Verification.
8. Field Notes:
   a. This section records notes or remarks during system Verification.
9. List systems modifications, not required by the Contract Documents, but provided by the Subcontractor. List other questions regarding such system modifications.
10. List problems discovered during Verification that were corrected.
11. List problems discovered during Verification that were not corrected.
12. List recommended party that should take action on these problems.

PART 3 - EXECUTION

3.1 GENERAL

A. The Contractors and Subcontractors shall be responsible for performing procedures presented in specification and contract drawings as detailed in the Performance Tests (PT). Members of the designated Verification Team shall witness various portions of the Verification process. Responsibilities for these activities are listed in the following paragraphs. Verification Team members shall sign-off on appropriate sections after verifying installation, operation, or documentation. Final sign-off shall be by the Owner or Architect.

B. Any test ports, gauges, test equipment, etc., needed to accomplish the performance tests shall be provided by Subcontractors.

C. Subcontractors shall provide to the Verification Team documentation of calibration of controls. Documentation shall include dates, setpoints, calibration coefficients, control loop verification, and other data required to verify system check-out. Documentation shall be dated and initialed by field engineer or technician performing the work.

3.2 OPERATIONAL STAFF TRAINING

A. System narrative descriptions will be prepared by the Contractors and supported by flow diagrams, one-line diagrams, and appropriate specification sections for major systems to be verified. The Contractors will coordinate “system description” meetings with the Owner or Architect. The meetings will provide an overview of major system features, components, and arrangements.

B. The Subcontractor and associated manufacturer’s representatives shall provide required training to operational staff after the system description meetings have occurred. The Subcontractor training sessions shall provide a more detailed analogy of systems operation and maintenance.

3.3 INSTRUMENTATION

A. Instrumentation will be provided by the Subcontractor. Instruments used for measurements shall be accurate. Calibration histories for each instrument shall be available for examination. Calibration and maintenance of instruments shall be in accordance with the requirements of NEBB or AABC Standards.

B. Application of instruments and accuracy of measurements shall be in accordance with NEBB or AABC Standards.

3.4 DOCUMENTATION

A. The installing Subcontractor shall be responsible for collection of pertinent data during system start-up and performance testing. The Subcontractor shall submit to the Owner or Architect documentation of tests performed prior to and after system start-up. Documentation shall also include start-up procedures as approved by Owner or Architect.

B. Documentation is to be typewritten on 8-1/2 by 11 inches (200 by 280 mm) paper and inserted in a 2 inches (50 mm) to 3 inches (75 mm) thick three ring binder. Indicate the project name, number, volume number, and volume title on the end panel of each binder.

C. Provide a title sheet for each volume and list the following:

1. Volume Title and Section Name and Number requiring this submittal.
2. Project name, project number, and address.
3. Subcontractor name, address, and phone number.
4. Name, title, signature, and date of person making the submittal.
5. Name of University, a blank line for signature, and the date of person accepting the submittal.
6. Name, address, and phone number of Verification Agent; a blank line for signature; and date of person accepting the submittal.

D. Provide a Table of Contents for multiple submittals. List each submittal and page number. Number each page, centered on the bottom in sequential numerical order. Provide tabs for multiple submittals in a single binder.

3.5 STEP ONE - INSTALLATION VERIFICATION

A. General Verification responsibilities:

1. Before system start-up begins, the Contractor shall conduct a final installation verification audit. The Subcontractor shall be responsible for completion of work

including change orders and punch list items to the Owner or Architect'ssatisfaction. The audit shall include, but not be limited to, checking of:

a. Piping specialties including balance, control, and isolation valves.
b. Ductwork specialty items including turning devices, balance, fire, smoke, control dampers, and access doors.
c. Control sensor types and location.
d. Identification of piping, valves, equipment, controls, etc.
e. Major equipment, pumps, valves, starters, gauges, thermometers, etc.
f. Documentation of prestart-up tests performed, including manufacturer's factory tests.

2. If work is found to be incomplete, incorrect, or non-functional, the Subcontractor shall correct the deficiency before system start-up work proceeds.

3.6 STEP TWO - SYSTEM START-UP

A. General Verification Responsibilities:

1. A start-up plan shall be developed and submitted by the installing Subcontractor. Start-up plan to include the following:
   a. Flushing and cleaning of pipe.
   b. Filters, strainers, and screens.
   c. Valve/damper positions.
   d. Electrical tests.
   e. Pressure tests.
   f. Safeties.
   g. Chemical treatment.
   h. Manufacturer's tests.
2. The start-up plan will be reviewed and a prestart-up inspection performed by designated members of the Owner or Architect. The installing Subcontractor shall commence with system start-up after approval has been given to start-up plan and the prestart-up inspection is completed. Designated members of the Verification Team shall witness system start-up and list system and equipment deficiencies noted during start-up. The Subcontractor shall take corrective action on system deficiencies noted and demonstrate to the Verification Team members suitable system operation.
3. Designated systems requiring test and balance work shall have this activity commence after systems have successfully completed start-up. System and equipment deficiencies observed during this activity is to be noted and corrected.

3.7 STEP THREE - PERFORMANCE TESTING

A. General Verification Responsibilities:

1. Performance Testing begins after operational testing, adjusting, and balancing of the systems have been completed by the Subcontractors; and the System Description and Hands-on Training sessions have been completed.
2. The objective of the Performance Testing is to advance the building systems from a state of substantial completion to full dynamic operation in accordance with the specified design requirements and design intent.
3. Attaining this object will be accomplished by developing individual systems testing protocols which, when implemented by the Subcontractor, will allow the Owner or Architect to observe, evaluate, identify deficiencies, recommend

modifications, tune, and document the systems and systems equipment performance over a range of load and functional levels.

4. Performance tests for the systems to be verified are defined in the Verification Plan. These tests are intended to be conclusive but may require minor modifications as system operation dictates.

END OF SECTION

Division 23 - HVAC

SECTION 230993 - SEQUENCE OF OPERATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes control sequences for HVAC systems, subsystems, and equipment.
B. DDC systems are recommended for the central heating and cooling systems but are not mandatory as long as the detailed sequences of operation in this section can be accomplished.
C. Related Sections include the following:

1. Section 230900 "HVAC Instrumentation and Controls" for control equipment and devices and for submittal requirements.

1.3 DEFINITIONS

A. DDC: Direct digital control.

1.4 HEATING CONTROL SEQUENCES

A. Make-Up Air Unit

1. System shall deliver 65 ºF to 72 ºF, reset linearly as the outdoor air temperature runs from 90 ºF to 65 ºF. System to run 24/7/365.
2. Provide adjustable current switch to monitor the fan in MUA-1. Upon failure of the fan, turn on a 24 VAC red warning light to be located in the Admin area (exact location to be determined by Owner).
3. Gas furnace burner to have 6:1 turndown or better. DX cooling to have three stages or two stages with hot gas bypass for discharge air control modulation.

B. Fan Coil and Split System with DX cooling

A. All systems shall be enabled 24/7/365
B. Provide thermostats with “FAN-OFF-AUTO” selections for continuous or intermittent fan operation as desired.
C. Unit shall cycle heating and cooling coils as needed to maintain space temperature set points.
D. Interlock compressor with indoor fan.

1.5 TERMINAL UNIT OPERATING SEQUENCE

A. Cabinet Unit Heater, Electric or Hydronic: Room or unit mounted line voltage thermostat cycles fan as needed.

1.6 DOMESTIC HOT WATER HEATERS

A. Three units to fire as needed to maintain a domestic hot water set point of 140 ºF. The return circulator shall run 24 hours per day. Should the pump fail, as sensed by an adjustable current switch, the general alarm light specified in 1.4.A.2 above shall turn on. The lead pump shall automatically rotate weekly or monthly.

1.8 PACKAGED TERMINAL AIR CONDITIONING UNITS

A. All systems shall be enabled 24/7/365
B. Provide remote thermostats with “FAN-OFF-AUTO” and “HEAT-COOL” selections for continuous or intermittent fan operation as desired.
C. Unit shall cycle heating and cooling coils as needed to maintain space temperature set points.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION (Not Applicable)

END OF SECTION

SECTION 232300 - REFRIGERANT PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this and the other Sections of Division 23.

1.2 SUMMARY

A. Section includes:

1. Pipes, tubing, fittings, and specialties.
2. Special duty valves.
3. Refrigerants.
4. Installation of refrigerant piping.

B. Products installed but not furnished under this Section include pre-charged tubing, refrigerant specialties, and refrigerant accessories furnished as an integral part of packaged air conditioning equipment.

C. Design and installation shall be provided in accordance with equipment manufacturer's recommendations.

D. Related Sections: The following sections contain requirements that relate to this section:

1. Section 23 05 00 - "Common Work Results for HVAC": Labeling and identification of refrigerant piping.
2. Section 23 05 29 - "Hangers and Supports for HVAC Piping and Equipment."
3. Section 23 05 53 - "Identification for HVAC Piping and Equipment."
4. Section 23 07 00 - "HVAC Insulation": Pipe insulation.
5. Section 23 05 93 - "Testing, Adjusting and Balancing for HVAC."
6. Section 23 81 43 – "Air Source Unitary Heat Pumps."

1.3 SUBMITTALS

A. General: Submit each item in this Section according to the conditions of the Contract and Division 01 specification sections.

B. Product data for the following products:

1. Each type valve specified.
2. Each type refrigerant piping specialty specified.

C. Submit Shop Drawings showing design and layout of refrigerant piping, valves, expansion valves, drains accumulators, traps, filters, and miscellaneous specialties, etc. Shop Drawings shall also include but not necessarily be limited to, pipe and tube sizes, valve arrangements and locations, slopes of horizontal runs, wall and floor penetrations, and equipment connection details. Show interface and spatial relationship between piping and

proximate to equipment. Provide a letter from the equipment manufacturer certifying the design is being provided in accordance with the equipment manufacturer's criteria.

D. Brazer's Certificates signed by Contractor certifying that brazers comply with requirements specified under "Quality Assurance" below.

E. Maintenance data for refrigerant valves and piping specialties, for inclusion in Operating and Maintenance Manual specified in Division 01 and in Section 23 05 00 - "Common Work Results for HVAC."

1.4 QUALITY ASSURANCE

A. Qualify brazing processes and brazing operators in accordance with ASME "Boiler and Pressure Vessel Code," Section IX, "Welding and Brazing Qualifications".

B. Regulatory Requirements: Comply with provisions of the following codes:

1. ANSI B31.5: ASME Code for Pressure Piping - Refrigerant Piping, latest edition.
2. ANSI/ASHRAE Standard 15: Safety Code for Mechanical Refrigeration, latest edition.
3. International Mechanical and Plumbing Codes, 2009.
4. PHCC: National Standard Plumbing Code, latest edition.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Refrigerant Valves and Specialties:
   a. Alco Controls Div, Emerson Electric.
   b. Danfoss Electronics, Inc.
   c. EATON Corporation, Control Div.
   d. Henry Valve Company.
   e. Parker-Hannifin Corporation, Refrigeration and Air Conditioning Division.
   f. Sporlan Valve Company.

2.2 PIPE AND TUBING MATERIALS

A. General: Refer to Part 3, Article "Pipe Application" for identification of systems where the below specified pipe and fitting materials are used.

B. Copper Tubing: ASTM B 280, Type ACR, hard-drawn straight lengths, and soft-annealed coils, seamless copper tubing. Tubing shall be factory cleaned, ready for installation, and have ends capped to protect cleanliness of pipe interiors prior to shipping.

2.3 FITTING MATERIALS

A. Wrought-Copper Fittings: ANSI B16.22, streamlined pattern.

2.4 JOINING MATERIALS

A. Brazing Filler for Joining Similar Metals: AWS A5.8, Classification BCuP series, with melting range from 1190 to 1480°F.

B. Brazing Filler for Joining Dissimilar Metals: AWS A5.8, Classification BAg series, with melting range from 1125 to 1370°F.

2.5 VALVES

A. General: Complete valve assembly shall be UL-listed and designed to conform to ARI 760.

B. Globe: 450 psig maximum operating pressure, 275°F maximum operating temperature; cast bronze body, with cast bronze or forged brass wing cap and bolted bonnet; replaceable resilient seat disc; plated steel stem. Valve shall be capable of being repacked under pressure. Valve shall be straight through or angle pattern, with solder-end connections.

C. Check Valves - Smaller Than 7/8 inch: 500 psig maximum operating pressure, 300 °F maximum operating temperature; cast brass body, with removable piston, Teflon seat, and stainless steel spring; straight through globe design. Valve shall be straight through pattern, with solder-end connections.

D. Check Valves - 7/8 inch and Larger: 450 psig maximum operating pressure, 300°F maximum operating temperature; cast bronze body, with cast bronze or forged brass bolted bonnet; floating piston with mechanically retained Teflon seat disc. Valve shall be straight through or angle pattern, with solder-end connections.

E. Solenoid Valves: 250°F temperature rating, 400 psig working pressure; forged brass, with Teflon valve seat, two-way straight through pattern, and solder end connections. Provide manual operator to open valve. Furnish complete with NEMA 1 solenoid enclosure with 1/2 inch conduit adapter, and 24 volt, 60 Hz. normally closed holding coil.

F. Evaporator Pressure Regulating Valves: pilot-operated, forged brass or cast bronze; complete with pilot operator, stainless steel bottom spring, pressure gage tappings, 24 volts DC, 50/60 Hz, standard coil; and wrought copper fittings for solder end connections.

G. Thermal Expansion Valves: thermostatic adjustable, modulating type; size as required for specific evaporator requirements, and factory set for proper evaporator superheat requirements. Valves shall have copper fittings for solder end connections; complete with sensing bulb, and an external equalizer line.

2.6 REFRIGERANT PIPING SPECIALTIES

A. General: Complete refrigerant piping specialty assembly shall be UL-listed and designed to conform to ARI 760.

B. Strainers: 500 psig maximum working pressure; forged brass body with monel 80-mesh screen, and screwed cleanout plug; Y-pattern, with solder end connections.

C. Moisture/liquid Indicators: 500 psig maximum operation pressure, 200°F maximum operating temperature; forged brass body, with replaceable polished optical viewing window, and solder end connections.

D. Filter-driers: 500 psig maximum operation pressure; steel shell, flange ring, and spring, ductile iron cover plate with steel capscrews, and wrought copper fittings for solder end connections. Furnish complete with replaceable filter-drier core kit, including gaskets, as follows:

1. Standard capacity desiccant sieves to provide micronic filtration.

E. Suction Line Filter-Drier: 350 psig maximum operation pressure, 225°F maximum operating temperature; steel shell, and wrought copper fittings for solder end connections. Permanent filter element shall be molded felt core surrounded by a desiccant for removal of acids and moisture for refrigerant vapor.

F. Suction Line Filters: 500 psig maximum operation pressure; steel shell, flange ring, and spring, ductile iron cover plate with steel capscrews, and wrought copper fittings for solder end connections. Furnish complete with replaceable filter core kit, including gaskets, as follows:

G. Flanged Unions: 400 psig maximum working pressure, 330°F maximum operating temperature; two brass tailpiece adapters for solder end connections to copper tubing; flanges for 7/8 inch through 1-5/8 inch unions shall be forged steel, and for 2-1/8 inch through 3-1/8 inch shall be ductile iron; four plated steel bolts, with silicon bronze nuts and fiber gasket. Flanges and bolts shall have factory-applied rust-resistant coating.

H. Flexible Connectors: 500 psig maximum operating pressure; seamless tin bronze or stainless steel core, high tensile bronze braid covering, solder connections, and synthetic covering; dehydrated, pressure tested, minimum 7 inch in length.

I. Suction Accumulators: Provide as manufactured by Refrigeration Research, Inc.

2.7 REFRIGERANT: Type shall be provided to suit equipment being served.

2.8 LOCKING ACCESS PORT CAPS

A. Provide locking cap(s) with multi-key(s) for all refrigerant circuit access ports located outdoors.

B. Locking caps shall be as manufactured by Win Air Company or comparable acceptable product.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine rough-in for refrigerant piping systems to verify actual locations of piping connections prior to installation.

3.2 PREPARATION

A. Pre-Cleaning:

1. Before installation of copper tubing other than Type ACR tubing, clean the tubing and fitting using following cleaning procedure:
   a. Remove coarse particles of dirt and dust by drawing a clean, lintless cloth through the tubing by means of a wire or an electrician's tape.
   b. Draw a clean, lintless cloth saturated with trichloroethylene through the tube or pipe. Continue this procedure until cloth is not discolored by dirt.
   c. Draw a clean, lintless cloth, saturated with compressor oil, squeezed dry, through the tube or pipe to remove remaining lint. Inspect tube or pipe visually for remaining dirt and lint.
   d. Finally, draw a clean, dry, lintless cloth through the tube or pipe.

3.3 INSTALLATION OF HANGERS AND SUPPORTS

A. General: Hangers, supports, and anchors are specified in Section 23 05 29 - "Hangers and Supports for HVAC Piping and Equipment."

3.4 INSTALLATION OF VALVING

A. General: Install refrigerant valves where indicated, and in accordance with manufacturer's instructions.

B. Install globe valves on each side of strainers and driers, in liquid and suction lines at evaporators, and elsewhere in accordance with manufacturer's instructions.

C. Install a full sized, 3-valve bypass around each drier.

D. Install solenoid valves ahead of each expansion valve. Install solenoid valves in horizontal lines with coil at the top.

   1. Electrical wiring for solenoid valves is specified in Division 26. Coordinate electrical requirements and connections.

E. Thermostatic expansion valves may be mounted in any position, as close as possible to the evaporator.

   1. Where refrigerant distributors are used, mount the distributor directly on the expansion valve outlet.
   2. Install the valve in such a location so that the diaphragm case is warmer than the bulb.
   3. Secure the bulb to a clean, straight, horizontal section of the suction line using two bulb straps. Do not mount bulb in a trap or at the bottom of the line.
   4. Where external equalizer lines are required, make the connection where it will clearly reflect the pressure existing in the suction line at the bulb location.

F. Install pressure regulating and relieving valves as required by ASHRAE Standard 15.

3.5 PIPING APPLICATION

A. Provide Type ACR drawn copper tubing with wrought copper fittings and brazed joints above ground, within building. Provide Type K, annealed temper copper tubing for 2 inch and smaller without joints, within enclosed areas. Mechanical fittings (crimp or flair) are not

permitted.

1. Install annealed temper tubing in pipe duct. Vent pipe duct to the outside.

3.6 INSTALLATION OF PIPING

A. Size piping and install refrigerant piping, traps, specialties as necessary for a complete and operational system in accordance with equipment manufacturer's recommendations.

B. General: Install refrigerant piping in accordance with ASHRAE Standard 15 "The Safety Code for Mechanical Refrigeration". Unless specified otherwise by the Section, comply with "Installation of Piping - General" as specified in Section 22 05 03 - "Pipes and Tubes for Plumbing Piping and Equipment" and Section 23 05 03 - "Pipes and Tubes for HVAC Piping and Equipment."

C. Install piping in as short and direct arrangement as possible to minimize pressure drop.

D. Install piping for minimum number of joints using as few elbows and other fitting as possible.

E. Arrange piping to allow normal inspection and servicing of compressor and other equipment. Install valves and specialties in accessible locations to allow for servicing and inspection.

F. Provide adequate clearance between pipe and adjacent walls and hanger, or between pipes for insulation installation. Use sleeves through floors, walls, or ceilings, sized to permit installation of full thickness insulation.

G. Insulate suction lines. Insulate liquid lines located outside the building. Liquid lines inside the building are not required to be insulated, except where they are installed adjacent and clamped to suction lines, where both liquid and suction lines shall be insulated as a unit.

1. Do not install insulation until system testing has been completed and all leaks have been eliminated.

H. Install branch tie-in lines to parallel compressors equal length, and pipe identically and symmetrically.

I. Install copper tubing in rigid or flexible conduit in locations where copper tubing will be exposed to mechanical injury.

J. Slope refrigerant piping as follows:

1. Install horizontal hot gas discharge piping with 1/2" per 10 feet downward slope away from the compressor.
2. Install horizontal suction lines with 1/2" per 10 feet downward slope to the compressor, with no long traps or dead ends which may cause oil to separate from the suction gas and return to the compressor in damaging slugs.
3. Install traps and double risers and where required in accordance with equipment manufacturer's recommendations to entrain oil in vertical runs.
4. Liquid lines may be installed level.

K. Use fittings for all changes in direction and all branch connections.

L. Install exposed piping at right angles or parallel to building walls. Diagonal runs are not permitted, unless expressly indicated.

M. Install piping free of sags or bends and with ample space between piping to permit proper insulation applications.

N. Conceal all pipe installations in walls, pipe chases, utility spaces, above ceilings, below grade or floors, unless indicated to be exposed to view.

O. Install piping tight to slabs, beams, joists, columns, walls, and other permanent elements of the building. Provide space to permit insulation applications, with 1" clearance outside the insulation. Allow sufficient space above removable ceiling panels to allow for panel removal.

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

Q. Exterior Wall Penetrations: Seal pipe penetrations through exterior walls using sleeves and mechanical sleeve seals. Pipe sleeves smaller than 6" shall be steel; pipe sleeves 6" and larger shall be sheet metal.

R. Fire Barrier Penetrations: Where pipes pass through fire rated walls, partitions, ceilings, and floors, maintain the fire rated integrity. Refer to Division 07 for special sealers and materials.

S. Make reductions in pipe sizes using eccentric reducer fittings installed with the level side down.

T. Install strainers immediately ahead of each expansion valve, solenoid valve, compressor suction valve, and as required to protect refrigerant piping system components.

U. Install moisture/liquid indicators in liquid lines between filter/driers and thermostatic expansion valves and in liquid line to receiver.

1. Install moisture/liquid indicators in lines larger than 2 1/8" OD, using a bypass line.

V. Install unions to allow removal of solenoid valves, pressure regulating valves, expansion valves, and at connections to compressors and evaporators.

W. Install flexible connectors at the inlet and discharge connection of compressors.

X. Refrigerant circuit access ports located outdoors shall be fitted with locking-type-tamper-resistance caps.

3.7 CONSTRUCTION

A. Pipe Joints:

1. Brazed Joints: Comply with the procedures contained in the AWS "Brazing Manual."
   a. WARNING: Some filler metals contain compounds which produce highly toxic fumes when heated. Avoid breathing fumes. Provide adequate ventilation.

b. CAUTION: When solenoid valves are being installed, remove the coil to prevent damage. When sight glasses are being installed, remove the glass. Remove stems, seats, and packing of valves, and accessible internal parts of refrigerant specialties before brazing. Do no apply heat near the bulb of the expansion valve.

2. Fill the pipe and fittings during brazing, with an inert gas (i.e., nitrogen or carbon dioxide) to prevent formation of scale.
3. Heat joints using oxy-acetylene torch. Heat to proper and uniform brazing temperature.
4. All refrigerant piping shall be phosphor copper brazed and not flux brazed.

B. Equipment Connections:

1. The Drawings indicate the general arrangement of piping and fittings.
2. Install piping adjacent to machine to allow servicing and maintenance.

3.8 REFRIGERANT PIPING SYSTEMS

A. Inspect, test and perform corrective action of refrigerant piping in accordance with ASME Code B31.5, Chapter VI, “Refrigerant Piping and Heat Transfer Components”, 2001, and as follows:

1. All refrigerant tubing shall be tested before tube insulation is applied.
2. Note: The use of compressed air for pressure testing refrigerant tubing will not be permitted.
3. Refrigerant relieve valves, if installed, shall be removed prior to pressure testing and shell openings plugged. After system is tested and found to be completely tight, relief valves shall be reinstalled prior to system evacuation.
4. Each tubing system shall be pressure tested with dry nitrogen. Leaks shall be repaired by removing and remaking the defective joint. No caulking will be permitted. After repair of leaks, system shall be retested and provided tight.
5. Tubing shall be tested as a minimum of 550 psig for a 24 hour period. Suggested procedure is as follows:
   a. Charge system with oil pumped dry nitrogen to a pressure of 100 psig. Make a soap bubble test of all joints and all connections. Mark all leaks, blow down and repair all leaks.
   b. After above test and repair, charge high side with R-507 or R-12, R-22 or R-502 gas (based upon application) to a pressure of 30 psig. Make a rapid leak check at this pressure using an electronic leak detector. If no leaks are found, raise pressure to 550 psig using oil pumped dry nitrogen.
   c. Leave nitrogen and refrigerant mixture overnight to permit mixing by diffusion. Check diffusion and leak tester operation by venting a flange or valve stem. Make a thorough leak test. If leaks are found, blow down, repair and retest. Continue this procedure until entire system is provided to be absolutely tight.
   d. After the refrigerant piping has been pressure tested and proven tight, and before piping insulation s applied, the entire system shall be evacuated with a vacuum pump to remove air and moisture. Evacuation shall be performed with all spaces containing refrigerant piping or equipment at no lower than 50°F.
   e. Manual valves except those open to atmosphere shall be opened and all

controls such as solenoids shall be jacked open. Any gauges or pressure controls which could be damaged by a deep vacuum shall be valved off. Seal caps on valves shall be in place and tight. Any valves open to atmosphere shall be closed and capped.

f. The entire system shall be double evacuated to 1500 microns Hg absolute (1.5 torr) as follows:
   1) When vacuum pump is started, vacuum should pull down fairly rapidly to 25,000 microns Hg absolute (28.94”). If vacuum does not pull below 25,000 microns, there are leaks in the system and leak test procedure must be repeated.
   2) At approximately 10,000 microns, evaporation of free water in the system will be rapidly accelerated and vacuum will tend to remain constant as evaporation rate begins to equal vacuum pump capacity. Depending on amount of water, ambient temperature and vacuum pump capacity, it may take several hours to make any noticeable decrease in vacuum below 10,000 microns. During this period, apply heat to any low points or suspected points of moisture. Feel pipes for cold spots and supply heat.
   3) Continue evacuation until a pressure of 1,500 microns (1.5 torr) minimum is reached, then break the vacuum and pressurize to 10 psig with oil pumped dry nitrogen as a holding charge until ready for charging.
   4) When ready for charging, vent nitrogen holding charge to atmosphere and re-evacuate down to a minimum of 1,500 microns. Break vacuum with refrigerant gas. Do not use liquid.

g. Repair leaking joints using new materials, and retest for leaks.

3.9 ADJUSTING AND CLEANING

A. Verify actual evaporator applications and operating conditions, and adjust thermostatic expansion valve to obtain proper evaporator superheat requirements.

B. Clean and inspect refrigerant piping systems in accordance with industry standards.

C. Adjust controls and safeties. Replace damaged or malfunctioning controls and equipment with new materials and products.

3.10 SYSTEM START-UP

A. Charge system using the following procedure:

1. Install core in filter dryer after leak test but before evacuation.
2. Evacuate refrigerant system with vacuum pump; until temperature of 35°F is indicated on vacuum dehydration indicator.
3. During evacuation, apply heat to pockets, elbows, and low spots in piping.
4. Maintain vacuum on system for minimum of 5 hours after closing valve between vacuum pump and system.
5. Break vacuum with refrigerant gas; allow pressure to build up to 2 psi.
6. Complete charging of system, using new filter dryer core in charging line. Provide full operating charge.

B. Train Owner's maintenance personnel on procedures and schedules related to start-up and shut-down, troubleshooting, servicing, and preventative maintenance of refrigerant piping valves and refrigerant piping specialties. Training shall be a minimum of eight (8) hours performed during a regular business day with a one hour lunch break. Record all training sessions. Provide the owner with three (3) copies in digital versatile disk (DVD) format.

C. Review data in Operating and Maintenance Manuals. Refer to the Division 01 Specifications.

D. Schedule training with Owner through the Architect, with at least seven (7) days advance notice.

END OF SECTION

Division 23 - HVAC

SECTION 233000 - HVAC AIR DISTRIBUTION

PART 1 - GENERAL

1.1 GENERAL

A. All work under this section shall also be subject to the Requirements of Section 23 05 00, “Common Work Results for HVAC.”

B. The fabrication and installation of all ductwork, together with related equipment shall comply with the standards of the National Fire Protection Association, as set forth in NFPA Standard No. 90A, as well as with the requirements of the Sheet Metal and Air Conditioning Installer's Association, Inc. and the latest edition of the ASHRAE Guide.

C. All duct sizes shown are net inside clear dimensions. Where internal duct lining is used, increase duct sizes accordingly to provide the indicated net free area. Unless otherwise indicated, size runouts, drops and connections to grilles, registers, diffusers, fans, water-source heat pump units, split system air handling units, louvers, filters and other equipment to the full size of the equipment connection.

D. Minor changes may be made in duct sizes where required to fit the available space, provided the indicated net free area and approximate aspect ratio are maintained.

E. Smoothly transition all ductwork and prevent excessive or unnecessary turbulence or pressure loss.

F. Submit sheet metal fabrication shop drawings.

G. All ductwork shall be cleaned following fabrication using filtered compressed air and the ends shall be sealed at the shop. Upon delivery to the site, duct ends shall remain sealed until time of actual installation. Following installation, ductwork shall be wiped down and cleaned (swept/vacuumed) in place. Partially installed ductwork shall have unfinished areas resealed in place at the end of each working day.

PART 2 - PRODUCTS

2.1 DUCTWORK

A. Unless otherwise indicated or specified, fabricate ductwork of galvanized sheet steel or aluminum, conforming to Commercial Designation 3003 Temper H14 and Duct Sheet. Duct gauges, jointing and reinforcement shall conform to Tables 4, 5, 6 and 7 as applicable, Chapter 1 of 1975 ASHRAE Guide and Data Book and SMACNA HVAC Duct Construction Standards - Metal and Flexible - 1985. Construction for Ventilation and Air Conditioning Systems as published by Sheet Metal and Air Conditioning Installer's Association, Inc.

B. Erect sheet metal ductwork in a first class, workmanlike manner secured in place rigidly and permanently. Provide suitable hangers, securely attached to building construction with bolts, clips or inserts. Hangers shall be structural shapes, flat bars or formed strap hangers; use of wire will not be permitted. Hangers shall not pass through or be inside duct. Support vertical ducts passing through floors by angles riveted to duct and resting either on floors or on brackets secured to building construction. All space around duct where they pass through

walls, floors, ceilings or roofs shall be sealed tight with incombustible inert material. Do not arrange ducts so as to impair the effectiveness of fireproofing around exposed ducts passing through walls, floors or ceilings in finished areas to provide finished appearance. Provide sheet metal flanged collars around all exposed ducts passing through walls, floors or ceilings in finished areas to provide finished appearance. Seal all duct joints and seams including low pressure supply and return and exhaust ductwork with Hardcast Two Part Sealing System as manufactured by Hardcast, Inc. and no others will be acceptable. Two part sealing system shall consist of DT-TAPE with RTA-50 indoor/outdoor sealing system.

C. Flexible connections of neoprene or other NFPA approved non-inflammable fabric shall be provided in duct system at all fan inlet and outlet connections.

D. Provide duct turning vanes in all cut turns where center line radius is less than 1½ times width of duct and in all square elbows. Turning vanes shall be airfoil type with extended trailing edges.

E. Provide duct collars and angle iron framework for mounting of automatic dampers.

2.2 DUCT SYSTEM

A. Duct system shall be constructed as specified below.

1. Supply and return ductwork: 2" w.c. galvanized sheet metal duct construction. Flexible or galvanized sheet metal ductwork from duct branch to diffusers as indicated on plans.
2. All ductwork serving the corridor ventilation system: galvanized steel 2” W.C. construction.
3. Outdoor Air Ductwork: 2" w.c. duct construction.
4. Supply and return ductwork serving apartments: galvanized steel 2” W.C. construction.

2.3 DUCT CONSTRUCTION

A. Round Ductwork: Ductwork shall be single wall Type SS(75) as manufactured by Semco Manufacturing, Inc. or approved equal, uniseal duct and uniform fittings. Construct ductwork of galvanized sheet steel. Elbows 8" diameter and smaller shall be smooth formed. Larger elbows shall be 5 section type. Tees and crosses and laterals shall be conical. Make joints with sleeve type couplings, short length sheet metal screws and duct sealant. Conform to duct manufacturer's recommendations for jointing and installation. Ductwork and fittings shall be manufactured by a company regularly engaged in the construction of spiral ductwork and fittings. Manufacturers substituted for the above specified manufacturers shall submit for approval, independent published laboratory test data on all proposed ductwork and fittings showing materials of construction, air flow, pressure drop and acoustical performance characteristics.

B. Rectangular Ductwork (2" w.g. construction):

1. Make allowance for internal duct lining where required.
2. Determine duct gauges for the longest duct side and use for all 4 sides. Joints and reinforcing requirements apply to the longest duct side.
3. Reinforce all ducts to prevent buckling, vibration or noise as recommended in the

referenced construction standards and as required to suit the installed conditions.

4. Do not crossbreak duct which will receive rigid insulation covering.
5. Where tap sizes of divided flow fittings are not indicated, make branch and main connection sizes proportional to their respective air flows and maintain uniform transverse velocities in the fittings.
6. Make radius elbows and radius tee connection with throat radius equal to or greater than the width of the duct. Use vaned elbows where shown and where radius elbows will not fit the space in all square bends.
7. Turning vanes shall be the airfoil type with extended trailing edges 36" maximum length. Where longer vanes are required, use 2 or more sets of vanes with intermediate runners securely fastened together.
8. Bolts, screws, rivet or spot weld reinforcing members securely to the duct on not less than 6" centers.
9. Where ducts are open ended without grilles, registers or other means of stiffening, reinforce and stiffen the open end with standing seams or an angle frame.
10. Paint all cut ends on galvanized angles, rods and other uncoated surfaces with aluminum paint.
11. Where ductwork is not painted or otherwise finished, remove all exposed traces of joint sealers, manufacturer's identification and other markings.
12. Aluminum sheet shall be 3003 H14 alloy or duct sheet, 16,000 PSI minimum tensile strength and capable of being formed to a Pittsburgh lock seam.
13. Reinforcing members for aluminum ductwork may be galvanized steel or aluminum, unless otherwise indicated. Where aluminum reinforcing is used, size the member in accordance with ASHRAE recommendations to have rigidity equivalent to listed mild steel angle sizes.
14. Where aluminum ductwork is used, make allowance for increased thermal expansion. Particularly avoid direct contact between aluminum and concrete or masonry walls subject to dampness.

C. 1-1/2” Thick Duct Board (only permitted where shown on plans)

1. Duct board shall be constructed of durable fiber glass fibers bonded with thermosetting resin. The airstream side of the duct board shall have a black fiber glass mat. The exterior surface shall have a fire resistant facing to extend the full width of the male edges to serve as an integral closure flap for section joints.
2. Duct board shall have a maximum flame spread index of 25 and a maximum smoke developed index of 50 and meet standard ASTM E84, UL 723 and NFPA 90A and 90B.
3. Maximum K-Factor: 0.23 at 75° F.
4. Minimum thermal performance: R-value of 6.

2.4 AIR VOLUME CONTROLS

A. Provide air volume control devices where indicated and where required to adjust and balance air flow in the systems.

B. Air extraction for air outlets and branch ducts shall be the gang operated vane type, Tuttle & Bailey - Vectrol, Type VLC or VLK as appropriate or approved equal, with suitable adjusting device and means of access.

C. Manual volume dampers in ductwork shall be factory assembled units with rigid frame, opposed blade action and locking quadrant operator. Mark the extended damper shaft and align the operating handle to indicate the blade position. Dampers shall be as manufactured by American Warming and Ventilating, Inc., Ruskin or approved equal. Rectangular dampers shall be Type DAA-P-50, with steel channel frame, 16 gauge steel blades, 9" maximum blade spacing, nylon bearings, galvanized finish with aluminum paint touch up.

D. Automatic temperature control (ATC) dampers shall be as hereinafter specified under Section 23 09 00, “Instrumentation and Control for HVAC”.

E. Duct turning vanes shall be Tuttle & Bailey Ducturns or approved equal.

F. Furnish and install duct collars and angle iron frames for the installation of ATC dampers.

2.5 DUCT ACCESS DOORS

A. Furnish and install adequately sized duct access doors, at coils, automatic dampers and other locations where indicated and required for duct access. Doors shall be the hinged type with approved latches and neoprene compression type gaskets. Stiffen ductwork at door openings where doors are installed in insulated ductwork, provide equivalent insulation in the door assembly. Where access doors are installed in fire rated partitions, provide fire seal access doors as manufactured by Air Balance, Inc. or approved equal, UL approved, meeting the rating of the enclosure in which the access door is installed.

2.6 FLEXIBLE DUCT

A. Flexible ductwork shall be Atco UPC #080 or approved equal, UL listed for Class 1 Air Ducts, Standard 181. Ducts shall be rated for 10" W.G. per UL 181.

B. Limit flexible duct 6' maximum. Install flexible ducts, using all recommended fittings, couplings and accessories. Support ducts with wide straps spaced so that horizontal runs do not sag more than 3" in 3'. Cover with duct tape and fasten with duct strap clamps. 180^{o}F bends in flexible duct are prohibited.

2.7 AIR TERMINAL DEVICES

A. Furnish and install air supply, return and exhaust devices of sizes and capacities as scheduled on the contract drawings. Unless otherwise indicated, catalog numbers shown are Titus products and for equipment which has been found suitable for the application. Products of Hart & Cooley/Tuttle & Bailey Inc., Carnes or Krueger will be considered only if performance characteristics, including throw, drop, pressure loss, sound pressure level, etc. are equal to or better than the performance characteristics of the specified product. Performance characteristics as indicated above shall be included in shop drawing submittals. Shop drawings will not be reviewed unless performance data is submitted.

B. Refer to the contract drawings for information on air terminal basis of design model number, sizes and capacities and direction of throw.

C. Where air terminal devices are installed in duct collars or branches, furnish and install air extractors. Furnish and install control grids, volume dampers and/or other accessories necessary to ensure uniform air flow across the terminal devices. Accessories shall be of

the same material as the terminal device. Install fixed blade terminals so that blades block the normal line of vision. Furnish 3 of each type of removable key operators.

2.8 DUCT THERMOMETERS

A. Duct thermometers shall be Johnson Service Co., Powers Regulator Co. or approved equal, 4½" dial, 2°F divisions, cast aluminum case, mercury actuated, brass movement, 8' copper averaging bulb with bronze braided armor, stainless steel connecting tube as required.

B. Duct thermometers shall be furnished and installed at air handling units as follows:

LOCATION	RANGE
Outdoor Air Duct	-40°F to 120°F
Return Air Duct	30°F to 180°F
Mixed Air Plenum	30°F to 180°F
Supply Air Duct	30°F to 180°F

2.9 SPIN-IN FITTINGS

A. Furnish and install spin-in fittings where indicated on the contract drawings, Buckley Air-Tite Bellmouth Model BM with balancing damper as manufactured by Buckley Air Products, Inc. or approved equal.

2.10 SMOKE DETECTORS

A. Smoke detectors and associated wiring shall be provided under Division 26 and located and installed under this division.

2.11 FIRE DAMPERS

A. Furnish and install automatic fire dampers where indicated and where required by NFPA Standard No. 90A and by the Fire Marshal of the State of Colorado and the Fire Marshal of Loudon County.

B. Construction of fire dampers shall conform to requirements of NFPA No. 90A and shall bear UL label. Fire dampers shall be set in frames adequately secured to fire partitions, floors, etc. and installed in strict accordance with UL 555 listing and manufacturer's instructions.

C. Fire dampers basis of design shall be Air Balance, Inc. Comparable products as manufactured by United Sheet Metal or Ruskin shall be submitted for approval as a comparable product. Fire dampers shall be multi-leaf accordion type, held open by adequate heavy gauge wires and suitable calibrated fusible links. Vertical dampers (horizontal air flow) shall close by gravity. Horizontal dampers (vertical air flow) shall be closed by suitable and positive spring closing devices.

D. Damper frames shall provide pocket which shall store damper leaves in open position outside of air stream and shall provide 100% free air flow when open, Type B fire dampers.

E. Provide adequately sized hinged access doors with cam locks for access to all fusible links and for resetting fire dampers. Where applicable, access to fire dampers shall be through

registers or grilles.

F. Submit complete information to the Engineer, including installation details.

G. Behind air devices, provide thin line fire dampers where indicated shall be Ruskin (Type A), curtain type with 1-7/8" galvanized steel frame, 18 gauge steel enclosure with UL 555 label, rated for wall in which being provided. Dynamic “Curtain blade” fire dampers shall not be acceptable, Static type shall be utilized.

H. Furnish to the Owner in a suitable storage container not less than 6 fusible links of each type, size and rating used on the project.

2.12 COMBINATION FIRE / SMOKE DAMPERS

A. Furnish and install combination fire/smoke dampers where indicated and where required by NFPA Standard No. 90A, 92A and 92B and by the Fire Marshal of the State of Colorado, and by the Fire Marshal of Loudon County.

B. Construction of combination fire/smoke dampers shall conform to requirements of NFPA No. 90A, 92A and 92B and shall be classified for use for fire resistance ratings of less than 3 hours, in strict accordance with UL 555 listing and manufacturer's instructions. Dampers shall further be classified as Smoke Dampers in accordance with the latest version of UL555S. The leakage rating under UL555S shall be leakage Class 2.

C. Combination fire/smoke dampers basis of design shall be Ruskin. Comparable products as manufactured by United Sheet Metal or Air Balance, Inc. shall be submitted for approval as a comparable product. Submit complete information to the Engineer, including installation details.

D. In addition to the leakage ratings already specified herein, the dampers and their actuators shall be qualified under UL555S to an elevated temperature of 250 F (121 °C) or 350 °F (177 °C) depending upon the actuator. Appropriate electric actuators shall be installed by the damper manufacturer at time of damper fabrication. Electric actuators shall have been energized hold open tested for a period of at least 1 year with no spring return failures. Damper and actuator shall be supplied as a single entity which meets all applicable UL555 and UL555S qualifications for both dampers and actuators. Each damper shall be rated for leakage and airflow in either direction through the damper.

E. Each combination fire/smoke damper shall be equipped with a “controlled closure” quick detect heat-actuated release device to prevent duct and HVAC component damage. Instantaneous damper closure is unacceptable.

F. Damper frame shall be minimum 16 (1.6) gage galvanized steel formed into a structural hat channel reinforced at corners. Damper blades shall be single skin galvanized steel 16 (1.60 gage minimum with three longitudinal grooves for reinforcement. Bearings shall be stainless steel sleeve turning in an extruded hole in the frame. Blade edge seals shall be inflatable silicone coated fiberglass and galvanized steel mechanically locked into blade edge (adhesive or clip on seals not acceptable). Jamb seals shall be stainless seals compression type. Each damper shall be supplied with a factory mounted sleeve of 17” (432) minimum length.

G. Provide damper with required end switch appropriate for monitoring damper position while maintaining UL Listing.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

A. Coordinate ductwork with other work and install ducts at proper elevations and locations to maintain indicated ceiling heights and clearances. Provide all elbows, transitions, offsets, connections and other fittings necessary to fit the work into place or to connect to equipment of diffusers. Method of duct support connection to structure and slabs shall be approved by the Architect; submit shop drawings.

B. Substantially support ductwork with structural shapes, flat bars or formed strap hangers securely attached to the building structure by means of bolts, clamps or inserts. Support vertical ducts by angles attached to the duct and resting on the floor or supported by brackets or hangers attached to the building structure. Strap hangers shall be 16 gauge minimum galvanized steel formed under the bottom edge of duct. Use square ¼" thick washers tight against the bend on upper strap attachments to horizontal surfaces. Place all supports external to the ductwork and out of the air stream. Provide additional supports at coils and other concentrated loads. Arrange supports so that duct weight is not transmitted to ceilings, fans or other equipment.

C. Prevent direct contact between ductwork and building surfaces or other equipment. Where ducts pass through walls, partitions, floors, ceilings or roofs, pack and seal the space around the duct with an approved fire safe inert material.

D. Use galvanized or corrosion resistant hangers, supports, brackets and hardware.

E. Furnish and install NFPA approved flexible duct connections where shown and at all connections to fans. Use glass reinforced neoprene fabric, roll formed to sheet metal strips or flanges. Support adjacent ductwork to provide sufficient slack in the connection.

3.2 LEAKAGE TESTS

A. All sheet metal ductwork shall undergo leakage tests according to duct construction ratings. Tests shall be accomplished under this section and witnessed as specified under Section 23 05 95 “Leak Testing, Air Distribution and Duct Systems.”

B. Leakage from each duct system shall not exceed 5% of the normal air handling capacity of the system. If the system ductwork is tested in sections, repair all leaks which are audible, regardless of the leakage rate of the duct system as a whole, by remaking the entire defective joint or seam. Spot sealing of ducts in place will be unacceptable.

C. Submit a complete report of ductwork leakage test to the Architect.

3.3 DUCTWORK CLEANING

A. All ductwork shall be cleaned following fabrication using filtered compressed air and the ends shall be sealed at the shop. Upon delivery to the site, duct ends shall remain sealed until

time of actual installation. Following installation, ductwork shall be wiped down and cleaned (swept/vacuumed) in place. Partially installed ductwork shall have unfinished areas resealed in place at the end of each working day.

END OF SECTION

Division 23 - HVAC

SECTION 233400 - HVAC FANS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specifications, apply to this section, and all sections of Division 23.

1.2 SUMMARY

A. Section Includes:

1. Centrifugal roof mounted make up air unit.
2. Wall mounted propeller fans.
3. Upblast centrifugal roof fans.
4. Centrifugal wall fans.
5. Ceiling fans.
6. Inline ceiling fans.
7. Centrifugal square inline cabinet fans.

B. Related Sections: The following sections contain requirements that relate to this section:

1. Section 23 05 14 - “Common Motor Requirements”: Product requirements for motors for placement by this section.
2. Section 23 05 48 - “Vibration and Seismic Controls for HVAC Piping and Equipment”: Product requirements for resilient mountings and snubbers for fans for placement by this section.
3. Section 23 07 00 - “HVAC Insulation”: Product requirements for power ventilators for placement by this section.
4. Section 23 30 00 - “HVAC Air Distribution.”
5. Section 23 09 00 - “Instrumentation and Control for HVAC”: Product requirements for control components to interface with fans.
6. Section 26 05 19 - “Low Voltage Electrical Power Conductors and Cables:” Requirements for electrical wiring and cable connections for units specified in this section.
7. Section 26 05 33 - “Raceways and Boxes for Electrical Systems:” Requirements for electrical conduits and boxes housing electrical wiring and connections specified by this section.

1.3 REFERENCES
(Unless otherwise noted, references apply to “latest editions.”)

A. American Bearing Manufacturers Association:

1. ABMA 9 - Load Ratings and Fatigue Life for Ball Bearings.
2. ABMA 11 - Load Ratings and Fatigue Life for Roller Bearings.

B. Air Movement and Control Association International, Inc.:

1. AMCA 99 - Standards Handbook.
2. AMCA 204 - Balance Quality and Vibration Levels for Fans.
3. AMCA 210 - Laboratory Methods of Testing Fans for Aerodynamic Performance Rating.
4. AMCA 300 - Reverberant Room Method for Sound Testing of Fans.
5. AMCA 301 - Methods for Calculating Fan Sound Ratings from Laboratory Test Data.

C. American Refrigeration Institute:

1. ARI 1060 - Air-to-Air Energy Recovery Ventilation Equipment Certification Equipment Program.

D. National Electrical Manufacturers Association:

1. NEMA MG 1 - Motors and Generators.
2. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).

E. Underwriters Laboratories Inc.:

1. UL 705 - Power Ventilators.

1.4 SUBMITTALS

A. General: Submit each item in this Section according to the conditions of the Contract and Division 01 specification sections.
B. Shop Drawings: Indicate size and configuration of fan assembly, mountings, weights, ductwork and accessory connections.
C. Product Data: Submit data on each type of fan and include accessories, fan curves with specified operating point plotted, power, RPM, sound power levels for both fan inlet and outlet at rated capacity, electrical characteristics and connection requirements.
D. Manufacturer's Installation Instructions: Submit fan manufacturer’s instructions.
E. Manufacturer's Certificate: Certify products meet or exceed specified requirements.

1.5 CLOSEOUT SUBMITTALS

A. Provide closeout documentation in accordance with the Division 01 Specification Sections.
B. Operation and Maintenance Data: Submit instructions for lubrication, motor and drive replacement, spare parts list, and wiring diagrams.

1.6 QUALITY ASSURANCE

A. Performance Ratings: Conform to AMCA 210 and bear AMCA Certified Rating Seal.

B. Sound Ratings: AMCA 301, tested to AMCA 300, and bear AMCA Certified Sound Rating Seal.
C. UL Compliance: UL listed and labeled, designed, manufactured, and tested in accordance with UL 705.
D. Balance Quality: Conform to AMCA 204.
E. Perform Work in accordance with all applicable codes, standards and local authorities having jurisdiction requirements.
F. Maintain one copy of each document on site.

1.7 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years experience and service facilities within 50 miles of the project.
B. Installer: Company specializing in performing Work of this section with minimum three years experience.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Accept fans and components on site in factory protective containers, with factory shipping skids and lifting lugs, inspect for damage.
B. Protect motors, shafts, and bearings from weather and construction dust.

1.9 FIELD MEASUREMENTS

A. Verify field measurements prior to fabrication.

1.10 WARRANTY

A. Furnish one year manufacturer’s warranty for fans.

1.11 MAINTENANCE SERVICE

A. This applies to all fans except those located in the apartments.
B. Furnish service and maintenance of fans for five years from Date of Substantial Completion.
C. Examine each fan’s components bi-monthly. Clean, adjust, and lubricate equipment.
D. Include systematic examination, adjustment, and lubrication of fans, and controls checkout and adjustments. Repair or replace parts in accordance with manufacturer's operating and maintenance data. Use parts produced by manufacturer of original equipment.
E. Perform work without removing fans from service during building normal occupied hours.

F. Provide emergency call back service at all hours for this maintenance period.
G. Maintain locally, near Place of the Work, adequate stock of parts for replacement or emergency purposes. Have personnel available to ensure fulfillment of this maintenance service, without unreasonable loss of time.
H. Perform maintenance work using competent and qualified personnel under supervision of manufacturer or original installer.
I. Do not assign or transfer maintenance service to agent or subcontractor without prior written consent of Owner.

1.12 EXTRA MATERIALS

A. Furnish two sets of belts for each belt driven fan.

PART 2 - PRODUCTS

2.1 WALL MOUNTED PROPELLER FANS

A. Belt Drive Sidewall Mounted Propeller Fan:

1. Manufacturer:
   a. Fans shall meet model numbers, types, sizes, capacities and electric characteristics as indicated on the contract drawings. Acceptable manufacturers: Greenheck, Cook, Penn Ventilator or Twin City Blower Company.
   b. Belt Drive Sidewall Mounted Propeller Fan:
      1) Fan arrangement shall be either supply or exhaust, refer to contract drawings for arrangement.
      2) Fans shall be suitable for maximum continuous operating temperature 130 Fahrenheit (54.4 Celsius).
      3) Each fan shall bear a permanently affixed manufacturer's engraved metal nameplate containing the model number and individual serial number.
   c. Wheel:
      1) Material type steel blades and hubs.
      2) Securely attached to fan shaft with standard square key and set screw or tapered bushing.
      3) Wheel shall be statically and dynamically balanced in accordance with AMCA Standard 204-05.
      4) The propeller and fan inlet shall be matched and shall have precise running tolerances for maximum performance and operating efficiency.
   d. Motors:
      1) Motor enclosures shall be open drip proof.
      2) Motors shall be permanently lubricated, heavy duty ball bearing type to match with the fan load and furnished at the specific voltage and phase.
      3) Motors shall be accessible for maintenance.
   e. Shafts and Bearings:

1) Fan Shaft shall be ground and polished solid steel with an anti corrosive coating.
2) Bearing shall be stamped steel or cast pillow block.
3) Bearings shall be selected for a minimum L10 life in excess of 100,000 hours (equivalent to L50 average life of 500,000 hours), at maximum cataloged operating speed.
4) Bearings shall be air handling quality and shall be 100% factory tested by bearing manufacturer.
5) Fan Shaft first critical speed is at least 25 percent over maximum operating speed.

f. Drive Frame:
1) Drive frame assemblies shall be galvanized steel, and bolted construction.
2) Drive frame shall have formed channels and fan panels shall have prepunched mounting holes, formed flanges and a deep formed one piece inlet venturi.

a. Disconnect Switches:
1) Disconnect shall be:
a) NEMA 1: indoor application no water: factory standard

b. Drive Assembly:
1) Belts, pulleys, and keys shall be oversized for a minimum of 150 percent of driven horsepower.
2) Belts shall be Static free and oil resistant.
3) Shall have fully machined cast iron pulleys, keyed and securely attached to the wheel and motor shafts.
4) The motor pulley shall be adjustable for final system balancing.
5) Motor shall be readily accessible for maintenance.

c. Options/Accessories:
1) Closure Angles:
a) Provide extra set of mounting flanges for field installation to close off the interior wall opening for a finished appearance.

2.2 CEILING FANS

A. Direct Drive Premium Ceiling Mounted Centrifugal Exhaust Fans:

1. Manufacturer:
a. Fans shall meet model numbers, types, sizes, capacities, and electrical characteristics as indicated on the contract drawings. Acceptable manufacturers: Greenheck, Cook, Penn Ventilator or Twin City Blower Company.
2. General:
a. Maximum operating temperatures shall be 130 Fahrenheit (54.4 Celsius).
b. Sound levels shall be as low as 0.7 AMCA sones.
c. Shall be UL/cUL listed for above bathtub exhaust.
d. Fans shall be UL/cUL listed 507 - Electric Fans.
e. Each fan shall bear a permanently affixed manufacturer's nameplate containing the model number and individual serial number.
3. Wheel:

a. Shall be forward curved centrifugal wheel.
b. Shall be constructed of galvanized steel or calcium carbonate filled polypropylene.
c. Shall be statically and dynamically balanced in accordance to AMCA Standard 204-05.

4. Motors:
   a. Motor enclosures shall be open driproof (ODP), opening in the frame body and or end brackets.
   b. Motor shall be permanently lubricated sleeve bearing type to match with the fan load and furnished at the specific voltage and phase.
   c. Motor shall be mounted on vibration isolators and be accessible for maintenance.
   d. Shall come with thermal overload protection.
5. Housing:
   a. Shall be constructed of heavy gauge galvanized steel.
   b. Interior shall be lined with 0.5 inches of acoustical insulation.
   c. Profile shall be as low as 10 ½ inches.
6. Provide Spring Loaded Aluminum Backdraft Damper:
7. Outlet:
   a. Shall be field rotatable from horizontal to vertical discharge.
   b. Duct collar shall include an aluminum backdraft damper.
8. Grille:
   a. Types: Aluminum
   b. Shall be constructed of high impact polystyrene for sizes 50 thru 390, plastic shall be factory standard on unit under 390.
   c. Shall be constructed of aluminum non-yellowing for sizes 410 thru 1550, aluminum shall be factory standard on units over 410.
9. Provide External Electrical Access:
   a. Shall eliminate removing the motor pack on installation.
10. Mounting Brackets:
    a. Shall be adjustable for multiple installation conditions.
11. Options/Accessories:
    a. Ceiling Radiation Damper:
       1) UL classified and shall be rated for three to four hours fire resistance.
       2) Shall be mounted directly beneath the fan.
       3) Shall adhere National Fire Protection Association (NFPA), Standard 90A, which requires the opening in fire rated ceiling/floors to be protected by rated CRD's.
    b. Disconnect Switches:
       1) Disconnect shall be: <<select one of the following, consult rep. for exact type applicable to your project.>>:
          a) NEMA 1: indoor application no water: factory standard
    c. Wall Discharge:
       1) Type: Square/Rectangular Connection, hooded wall cap model WC.

2.3 CENTRIFUGAL SQUARE INLINE CABINET FANS

A. Direct Driven Backward Inclined Inline Fans:

1. Manufacturer:
   a. Fans shall meet model numbers, types, sizes, capacities, and electrical characteristics as indicated on the contract drawings. Acceptable manufacturers: Greenheck, Cook, Penn Ventilator or Twin City Blower Company.
2. General:
   a. Shall have a normal operating temperature of up to 130 Fahrenheit (54.4 Celsius).
   b. Each fan shall bear a permanently affixed manufacture's engraved metal nameplate containing the model number and individual serial number.
3. Wheel:
   a. Shall be non-overloading, backward inclined centrifugal wheel.
   b. Shall be constructed of aluminum.
   c. Shall be statically and dynamically balanced in accordance to AMCA Standard 204-05.
   d. The wheel cone and fan inlet shall be matched and shall have precise running tolerances for maximum performance and operating efficiency.
   e. Single thickness blades shall be securely riveted or welded to a heavy gauge back plate and wheel cone.
4. Motors:
   a. Motor enclosures shall be Open driproof
   b. Motors shall be permanently lubricated, sleeve bearing type on sizes 8-12 and ball bearing type on sizes 14-24 to match with the fan load and furnished at the specific voltage and phase.
   c. Motor shall be accessible for maintenance.
5. Housing/Cabinet Construction:
   a. Construction material: Galvanized
   b. Square design constructed shall be of heavy gauge galvanized steel and shall include square duct mounting collars.
   c. Housing and bearing supports shall be constructed of heavy gauge bolted and welded steel construction to prevent vibration and to rigidly support the shaft and bearing assembly.
6. Housing Supports and Drive Frame:
   a. Housing supports shall be constructed of structural steel with formed flanges.
   b. Drive frame shall be welded steel which supports the motor.
7. Disconnect Switches:
   1) NEMA 1: indoor application no water: factory standard
8. Duct Collars:
   a. Shall be of square design to provide a large discharge area.
9. Access Panel:
   a. Provide two sided access panels, to allow access to all internal components.
   b. Locate perpendicular to the motor mounting panel.

B. Belt Drive Duct Inline Centrifugal Fans:

1. Manufacturer:
   a. Fans shall meet model numbers, types, sizes, capacities, and electrical characteristics as indicated on the contract drawings. Acceptable

manufacturers: Greenheck, Cook, Penn Ventilator or Twin City Blower Company.

2. General:
   a. Fans shall have a maximum continuous operating temperature of 130 Fahrenheit (54.4 Celsius).
   b. Each fan shall bear a permanently affixed manufacture's engraved metal nameplate containing the model number and individual serial number.
3. Wheel:
   a. Shall be forward curved centrifugal wheel.
   b. Shall be constructed of galvanized steel.
   c. Shall be statically and dynamically balanced in accordance with AMCA Standard 204-05.
4. Motors:
   a. Motor enclosures: Open driproof
   b. Motors shall be permanently lubricated, heavy duty ball bearing type to match with the fan load and furnished at the specific voltage and phase.
   c. Motor shall be mounted on vibration isolators, out of the airstream.
   d. For motor cooling there shall be fresh air drawn into the motor compartment through an area free of discharge contaminants.
   e. Motor shall be accessible for maintenance.
5. Shafts and Bearings:
   a. Fan shaft shall be ground and polished solid steel with an anti corrosive coating.
   b. Shall be permanently sealed bearings or pillow block ball bearings.
   c. Bearings shall be selected for a minimum L10 life in excess of 100,000 hours (equivalent to L50 average life of 500,000 hours), at maximum cataloged operating speed.
   d. Bearings shall be100 percent factory tested.
   e. Fan Shaft first critical speed shall be at least 25 percent over maximum operating speed.
6. Housing:
   a. Shall be constructed of heavy gauge galvanized steel.
   b. Shall be of rectangular design construction and shall include rectangular duct mounting collars.
   c. Shall include prepunched mounting brackets.
7. Housing Supports and Drive Frame:
   a. Drive frame assemblies shall be constructed of heavy gauge steel and mounted on vibration isolators.
   b. Shall be designed with belt adjustment to eliminate scroll damage.
8. Duct Collars:
   a. Shall be provided for duct connections for outlet and inlet collars.
9. Drive Assembly:
   a. Belts, pulleys, and keys shall be oversized for a minimum of 150 percent of driven horsepower.
   b. Belts shall be static free and oil resistant.
   c. Pulleys shall be: Cast type, keyed, and securely attached to wheel and motor shafts.
   d. Motor pulleys shall be adjustable for final system balancing.
   e. Readily accessible for maintenance.
10. Access Panel:
   a. Provide removable access panel for access to all internal components.

11. Mounting Brackets:
    a. Provide fully adjustable mounting brackets for multiple installation conditions.
12. Options/Accessories:
    a. Disconnect Switches:
        a) NEMA 1: indoor application no water: factory standard

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify roof curbs are installed and dimensions are as shown on the shop drawings and instructed by the fan manufacturer.

3.2 PREPARATION

A. Coordinate roof curb installation with the Division 07 specifications.
B. Ensure that roof openings are square and/or round and accurately aligned, correctly located, and in tolerance.
C. Ensure that ducts are plumb, sized correctly, and to proper elevation above roof decks.

3.3 INSTALLATION

A. Secure roof, and wall fans and gravity ventilators with cadmium plated steel lag screws to roof curb.
B. Suspended Cabinet Fans: Install flexible connections between fan and ductwork. Ensure metal bands of connectors are parallel with minimum one inch (25 mm) flex between ductwork and fan while running.
C. Provide backdraft dampers on outlet from cabinet and ceiling fans and as indicated on Drawings.
D. Install safety screen where inlet or outlet is exposed.
E. Pipe scroll drains to nearest floor drain.
F. Install backdraft dampers on the discharges of exhaust fans when they are not integral with fans and as indicated on the Contract Drawings.
G. Provide adjustable sheaves as required for final air balance.
H. Install Work in accordance with all applicable codes, standards, and local authorities having jurisdiction requirements.
I. Install fans in accordance with the fan manufacturer’s instructions and as indicated on the contract drawings.

3.4 MANUFACTURER'S FIELD SERVICES

A. Furnish services of factory trained representative for minimum of one day to start-up, calibrate controls, and instruct Owner on operation and maintenance.

3.5 CLEANING

A. Vacuum clean coils and inside of fan cabinet.

3.6 DEMONSTRATION

A. Demonstrate fan operation and maintenance procedures.

3.7 PROTECTION OF FINISHED WORK

A. Refer to Division 01 Section 01700 - “Execution Requirements”: Requirements for protecting finished Work.
B. Do not operate fans until ductwork is clean, filters are in place, bearings are lubricated, and each fan has been test run under observation.

3.8 ADJUSTING

A. Adjust fans to function properly.
B. Adjust belt tension on belt driven fans.
C. Lubricate bearing.
D. Adjust drives for final system balancing.
E. Check wheel overlap.

END OF SECTION

Division 23 - HVAC

SECTION 233713 - DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Louver face diffusers.
2. Linear bar diffusers.
3. Linear slot diffusers.

B. Related Sections:

1. Division 08 Section "Louvers and Vents" for fixed and adjustable louvers and wall vents, whether or not they are connected to ducts.
2. Division 23 Section "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers, registers, and grilles.

PART 2 - PRODUCTS

2.1 CEILING DIFFUSERS

A. Louver Face Diffuser:

1. Material: Steel or Aluminum.
2. Finish: Baked enamel, color selected by Architect.
3. Face Size: As per schedule
4. Mounting: See architectural plans for ceiling types.
5. Pattern: One-way, Two-way, Two-way, corner Three-way Four-way, Adjustable core style.
6. Dampers: Radial opposed blade, Butterfly, Combination damper and grid.

2.2 CEILING LINEAR SLOT OUTLETS

A. Linear Bar Diffuser:

1. Material: Steel or Aluminum.
2. Finish: Baked enamel, color selected by Architect.
3. Narrow Core Spacing Arrangement: 1/8-inch- thick blades spaced 1/4 inch apart, zero or 15-degree deflection.
4. Wide Core Spacing Arrangement: 1/8-inch- thick blades spaced 1/2 inch apart, zero or 15-degree deflection.
5. Wide Core Spacing Arrangement: 3/16-inch- thick blades spaced 1/2 inch apart, zero or 15 degree deflection.

6. Pencil-Proof Core Spacing Arrangement: 3/16-inch- thick blades spaced 7/16 inch apart, zero or 15-degree deflection.
7. Two-Way Deflection Vanes: Extruded construction fixed louvers with removable core.
8. Frame: 1-1/4 inches 1 inch 3/4 inch 1/2 inch 3/16 inch wide.
9. Mounting Frame: .
10. Mounting: Concealed bracket.
11. Damper Type: Adjustable opposed-blade assembly.
12. Accessories: Plaster frame Directional vanes Alignment pins Core clips Blank-off strips.

B. Linear Slot Diffuser:

1. Material - Shell: Aluminum,.
2. Material - Pattern Controller and Tees: Aluminum.
3. Finish - Face and Shell: Baked enamel, black.
4. Finish - Pattern Controller: Baked enamel, black.
5. Finish - Tees: Baked enamel, color selected by Architect.
6. Slot Width: 1 inch.
7. Number of Slots: Four.
8. Length: 48 inches.
9. Accessories: Plaster frame T-bar slot Center notch T-bar on inlet side T-bar on both sides T-bar clip on one side T-bar clips on both sides. Verify with Architect.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.
B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

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

3.3 ADJUSTING

A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION

Division 23 - HVAC

SECTION 236200 - PACKAGED COMPRESSOR AND CONDENSER UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes packaged, refrigerant compressor and condenser units.

1.3 ACTION SUBMITTALS

A. Product Data: For each compressor and condenser unit. Include rated capacities, operating characteristics, and furnished specialties and accessories. Include equipment dimensions, weights and structural loads, required clearances, method of field assembly, components, and location and size of each field connection.
B. Shop Drawings: For compressor and condenser units. Include plans, elevations, sections, details, and attachments to other work.

1. Wiring Diagrams: For power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Warranty: Sample of special warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For compressor and condenser units to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
B. Fabricate and label refrigeration system according to ASHRAE 15, "Safety Standard for Refrigeration Systems."

1.7 COORDINATION

A. Coordinate sizes and locations of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Section 033000 "Cast-In-Place Concrete" and Section 033053 "Miscellaneous Cast-In-Place Concrete."
B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Section 077200 "Roof Accessories."

C. Coordinate location of piping and electrical rough-ins.

1.8 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of compressor and condenser units that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:
   a. Compressor failure.
   b. Condenser coil leak.
2. Warranty Period: Five years from date of Substantial Completion.
3. Warranty Period (Compressor Only): [Five] [Seven] [10] <Insert number> years from date of Substantial Completion.
4. Warranty Period (Components Other Than Compressor): [Five] [10] <Insert number> years from date of Substantial Completion.
5. Warranty Period (Condenser Coil Only): [Five] <Insert number> years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 COMPRESSOR AND CONDENSER UNITS, AIR COOLED, 1 TO 5 TONS

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Carrier Corporation; Commercial HVAC Systems.
2. Lennox International Inc.
3. Trane; a business of American Standard Companies.
4. YORK; a Johnson Controls company.

B. Description: Factory assembled and tested; consisting of compressor, condenser coil, fan, motors, refrigerant reservoir, and operating controls.

C. Compressor: Scroll, hermetically sealed, with rubber vibration isolators.

1. Motor: [Single] [Two] speed, and includes thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
2. Two-Speed Compressor: Include manual-reset, high-pressure switch and automatic-reset, low-pressure switch.
3. Accumulator: Suction tube.

D. Refrigerant: R-410A.

E. Condenser Coil: Seamless copper-tube, aluminum-fin coil; circuited for integral liquid subcooler, with removable drain pan and brass service valves with service ports.

F. Condenser Fan: Direct-drive, aluminum propeller fan; with permanently lubricated, totally enclosed fan motor with thermal-overload protection and ball bearings.

G. Accessories:

1. Crankcase heater.
2. Low-voltage thermostat and subbase to control compressor and condenser unit and evaporator fan.
3. PE mounting base.
4. Thermostatic expansion valve.
5. Time-Delay Relay: Continues operation of evaporator fan after compressor shuts off.

H. Unit Casing: Galvanized steel, finished with baked enamel; with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Mount service valves, fittings, and gage ports on exterior of casing.

2.2 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

2.3 SOURCE QUALITY CONTROL

A. Verification of Performance: Rate compressor and condenser units according to ARI 210/240

B. Energy Efficiency: Equal to or greater than prescribed by ASHRAE/IESNA 90.1, "Energy Efficient Design of New Buildings except Low-Rise Residential Buildings," Section 6, "Heating, Ventilating, and Air-Conditioning."

C. Test and inspect shell and tube condensers according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

D. Testing Requirements: Factory test sound-power-level ratings according to ARI 270

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of compressor and condenser units.

B. Examine roughing-in for refrigerant piping systems to verify actual locations of piping connections before equipment installation.

C. Examine walls, floors, and roofs for suitable conditions where compressor and condenser units will be installed.

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

3.2 INSTALLATION

A. Install units level and plumb, firmly anchored in locations indicated; maintain manufacturer's recommended clearances.

B. Install compressor and condenser units on PE mounting base.

C. Vibration Isolation: Mount compressor and condenser units on rubber pads with a minimum deflection of 1/4 inch Vibration isolation devices and installation requirements are specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."

D. Maintain manufacturer's recommended clearances for service and maintenance.

E. Loose Components: Install electrical components, devices, and accessories that are not factory mounted.

3.3 CONNECTIONS

A. Comply with requirements for piping in other Section 232113 "Hydronic Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.

C. Connect precharged refrigerant tubing to unit's quick-connect fittings. Install tubing so it does not interfere with access to unit. Install furnished accessories.

D. Connect refrigerant piping to air-cooled compressor and condenser units; maintain required access to unit. Install furnished field-mounted accessories. Refrigerant piping and specialties are specified in Section 232300 "Refrigerant Piping."

E. Connect refrigerant piping to condenser units. Refrigerant piping and specialties are specified in Section 232300 "Refrigerant Piping".

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test. Certify compliance with test parameters.
2. Leak Test: After installation, charge system with refrigerant and oil and test for leaks. Repair leaks, replace lost refrigerant and oil, and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor operation and unit operation, product capability, and compliance with requirements.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
5. Verify proper airflow over coils.