

DIVISION 23 - HEATING, VENTILATING, AND AIR-CONDITIONING (HVAC)

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SECTION 23 05 00

BASIC HVAC AND HYDRONIC PIPING REQUIREMENTS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Basic Mechanical Requirements specifically applicable to Divisions 22 and 23 Sections, in addition to Division 1 - General Requirements.

1.02 SCOPE OF WORK

- A. The Mechanical Contract Installation shall include a complete HVAC and Hydronic piping installation of both outside and inside utilities for the building. All piping, fixtures and equipment herein specified, mentioned or shown on Drawings, shall be furnished and installed in place, connected up and ready for normal operation except for such items as are specifically mentioned to be furnished by others.
- B. The Mechanical Contract shall also include furnishing and installing a complete system of ventilating and air conditioning for the building remodeling with piping, air handling units, ductwork for air delivery and distribution systems for the building and all other related Work as called for under the Specifications and shown on Drawings.

1.03 WORK INCLUDED

- A. Mechanical Contract shall include all Work under the listed Sections of the Specifications Index and all related Mechanical Work as shown on the Drawings for the Project.
- B. A complete table of Mechanical Reference Symbols is shown on the Drawings.

1.04 WORK NOT INCLUDED

- A. The following Work is not included as part of the Mechanical Contract.
 - 1. Electrical Contractor shall furnish and install all power wiring, magnetic starters, disconnect switches, etc., except as called for to be included with the equipment and shall make all final connections to the equipment provided by the Mechanical Contractors.

1.05 CODES, FEES AND LATERAL COSTS

- A. The HVAC and Hydronic Installation shall meet all applicable local, state and federal codes and standards.
- B. All permits necessary for a complete heating and ventilation installation shall be paid for by this Contractor.
- C. The Hydronic piping work shall be installed in strict accordance with the Minnesota State Plumbing Code. Any change from the Drawings and Specifications required by the State or City Plumbing Inspector shall be made by this Contractor at no additional cost to the Owner.
- D. Except in those municipalities which provide state-approved electrical inspection, all installation of electrical equipment wiring shall be inspected by the State Board of Electricity. Allowance shall be made in the bid and Contract for the cost of such inspection.

- E. Fees for such inspection shall be charged in accordance with the rules and regulations of the State Board of Electricity. Evidence of payment of fees shall be provided by the Contractor with their Application for Payment.

1.06 CONTRACT TYPE

- A. The Mechanical installation to be made under Divisions 22 and 23 is set up for Contract bidding as follows:
 - 1. See Division 1 for Bid Breakdown

1.07 WORK BY OWNER

- A. The Owner has awarded a Contract which commence prior to this contract. Specifically this Work shall include:
 - 1. N/A

1.08 WORK SEQUENCE (SEE DIVISION 1)

- A. Install Work to accommodate Owner's occupancy requirements. During the construction period coordinate mechanical schedule and operations with Architect or Construction Manager.

1.09 ALTERNATES

- A. If required, Bid Alternates quoted on Bid Forms shall be reviewed and accepted or rejected at the Owner's option.

1.10 REFERENCES

- A. All equipment, piping, etc., shall be new and shall be installed to meet the approval of the following additional ordinances: ASME Rules for Pressure Tanks, National Board of Fire Underwriter's Rules, American Water Works and the American Gas Association.

1.11 SUBMITTALS

- A. Submit shop drawings under provisions of Division 1 and/or where noted in specific sections of the Specification.
- B. Proposed Products List: Include information on products specified in the following Sections for Engineer's review, approval and for inclusion in the Owner's Manuals:
 - 1. Section 23 05 13 - Common Motor Requirements for HVAC Equipment
 - 2. Section 23 05 29 - Hangers, Supports and Firestopping for Plumbing, HVAC Piping and Equipment
 - 3. Section 23 05 53 - Identification for HVAC, Plumbing Piping and Equipment
 - 4. Section 23 05 93 - Testing, Adjusting and Balancing for HVAC
 - 5. Section 23 07 00 - HVAC and Piping Insulation
 - 6. Section 23 09 93 - Sequence of Operations for HVAC Controls
 - 7. Section 23 23 00 - Refrigeration Piping
 - 8. Section 23 25 00 - HVAC Water Treatment
 - 9. Section 23 31 00 - HVAC Duct and Casings
 - 10. Section 23 33 00 - Air Duct Accessories
 - 11. Section 23 34 05 - HVAC Fans
 - 12. Section 23 37 00 - Air Inlets and Outlets
 - 13. Section 23 81 27 - Split System Heating and Cooling

- C. Submit shop drawings and product data grouped to include complete submittals of related systems, products, and accessories in a single submittal.
- D. Mark dimensions and values in units to match those specified.
- E. Number of Submittals Required: Minimum of five (5) complete sets of shop drawings submitted for review.
- F. **NOTICE: The Contractor's stamp, initialed or signed, must be provided certifying review of submittal, verification of products, verification of field measurements and field construction criteria, and coordination of the information within the submittal with requirements of the Work and the Contract Documents. If shop drawings are not stamped by the Contractor and marked as "Approved" or "Approved as Noted", they shall not be checked by the Engineer.**

1.12 PROJECT/SITE CONDITIONS

- A. Install Work in locations shown on Drawings, unless prevented by Project conditions.
- B. Prepare drawings showing proposed rearrangement of Work to meet Project conditions, including changes to Work specified in other Sections. Obtain permission of Architect/Engineer before proceeding.

1.13 SEQUENCING AND SCHEDULING

- A. Construct Work in sequence under provisions of Division 01.

1.14 PRE-CONSTRUCTION COORDINATION AND VERIFICATION

- A. This Contractor shall coordinate his Work with other Contractors on this job. Any conflict which cannot be resolved shall be settled by the Architect/Engineer.
- B. Field verification of scale dimensions on Drawings is directed since actual locations, distances and levels shall be governed by actual field conditions.
- C. The Contractors shall check architectural, structural, plumbing, heating, ventilating and electrical conditions and Drawings to avert possible installation conflicts. Shall drastic changes from original Drawings be necessary to resolve such conflicts this Contractor shall notify the Architect/Engineer and secure written approval and agreement on necessary adjustments before the installation is started.
- D. Discrepancies shown on different Drawings or between Drawings and actual field conditions or between Drawings and Specifications shall promptly be brought to the attention of the Architect/Engineer for a decision. Contractor shall not scale drawings for exact locations of equipment. (Verify final location.) All dimensions shall be taken from Architectural Drawings.
- E. The Contractor shall consider and review the complete set of documents, etc., Architectural, Structural, Mechanical, Electrical, etc., (Drawings and Specifications) and the existing site conditions as his complete set. He shall be responsible for any and all mechanical Work shown or stated (to be by him), to include this Work in his bid and install such items even though they are not specifically shown or stated on the Mechanical Sections of the Drawings and Specifications.

1.15 INTERPRETATIONS OF DOCUMENTS

- A. Contractors shall promptly notify the Engineer of inconsistencies, errors and omissions found in the Drawings and Specifications prior to bid date.
- B. Questions regarding the bidding and requests for interpretation of the Drawings and Specifications shall be submitted to the Engineer in writing in duplicate in sufficient time to be received prior to the date for receipt of bids.
- C. Interpretation and correction of the Drawings and Specifications shall be made by addendum. Interpretations and corrections made by any other method shall not be binding on the Owner or the Engineer.
- D. The drawings and Specifications are complementary to one another. This defines a relationship such that any item which is called for in one document is to be considered called for in both sets of documents. Where conflicts exist between the Specifications and/or drawings, the more stringent requirement shall apply.

1.16 TEMPORARY HEAT FOR REMODELING AND NEW CONSTRUCTION WORK

- A. The air handling systems shall not be used for temporary heating, ventilation or cooling during the construction of this project without the written permission of the Engineer.
- B. When deemed acceptable by the Engineer, the air handling systems may be used provided all return air duct and grille openings are protected by a filter with a 20% efficiency rating of MERV 6 or higher.
- C. Air handling system filters in the units shall be in place during all temporary heating, ventilating or cooling operation. When temporary operation is completed, the filters shall be replaced with new, specified units and an additional set of filters shall also be stored for the first filter change per Specification Section 23 40 00.
- D. If air handling systems are operated in deference to the restrictions, the Engineer may request all affected ductwork, equipment and coils be internally cleaned at no additional cost to the owner or Engineer.
- E. Prior to and during spraying of paint and/or sheetrock sanding, the openings into duct systems shall be sealed with taped-on poly, provided and installed by Mechanical Contractor and all air handling systems shall not be operated.

1.17 CUTTING, PATCHING AND FIRESTOPPING

- A. This Mechanical Contractor shall set all sleeves in construction for the mechanical equipment installation. Where cutting is required, it shall be done by this Contractor. All patching shall be done by the Mechanical Contractor. Mechanical Contractor shall provide and install firestopping materials as specified in Division 23 for mechanical penetrations.

1.18 ELECTRICAL

- A. Electrical Contractor shall furnish all motor starters and motor controls and provide all wiring for motor control operation, except if specified otherwise.

1.19 ADDITIONAL ELECTRICAL COSTS

- A. If the Mechanical Contractor substitute's equipment that was approved equal for bidding instead of the specified units, the Mechanical Contractor shall be responsible for any additional electrical costs resulting from this substitution regardless of whether the other

equipment was listed as equal in the Specification or was approved equal after the Project was in the bidding process. Mechanical Contractor to verify substituted equipment matches electrical specifications on schedule page.

1.20 GUARANTEE

- A. The Contractor shall be responsible for the proper installation and working of everything in their portion of the project and shall guarantee to remedy free of charge any defects in workmanship and materials that may appear to give or gives rise to trouble of any kind for a period of one year from the date of Substantial Completion of the work.

1.21 OWNER'S MANUALS AND OPERATING INSTRUCTIONS

- A. Under this Contract the Mechanical Contractor shall furnish the Owner with four (4) 3-ring binders of all pertinent systems information and related documents accordance with Division 1. Submit these manuals to the Engineer for his review. The books shall contain the following items:
 - 1. Shop drawings on all major equipment, complete with Engineer's approval stamp.
 - 2. Operating Instructions for all equipment.
 - 3. VFD start-up report for each unit. Document when training was provided, what information was shared, who provided the training and who was present. – If required.
 - 4. Submit certification to Engineer showing that all required testing for the entire project, including water piping, sewer/vent piping, and storm piping.
 - 5. Maintenance instructions for all major equipment.
 - 6. Wiring diagrams for all equipment.
 - 7. Completed Startup forms with Signature and Date of startup
 - 8. Warranty information.
- B. Using the Owner's manuals, the Mechanical Contractor shall instruct the Owner/Owner's Representative on the proper operation of all equipment installed as part of this Contract. These instructions shall include, but not be limited to preventative maintenance, safety instructions and normal operating procedures.
- C. After the Owner has been instructed, the Contractor shall submit a letter to the Mechanical Engineer documenting that the information was given to the Owner and that he has signed off on this part of the Contract. Final Contract payment will not be issued till this is complete.

1.22 ASBESTOS INSULATION AND/OR LEAD CONTAMINATION

- A. Where insulation on existing piping or equipment being removed under this Contract contains asbestos products or has lead contamination, the Contractor shall stop all Work and notify the Owner/Architect/Engineer and not proceed with any further Work until the asbestos has been removed and/or encapsulated by others under a separate Contract between the Owner and the asbestos removal company. If lead is encountered, the Owner shall have the quantities and hazard identified and shall inform the Contractor of the necessary steps required to eliminate the hazard.

1.23 EQUIPMENT REMOVAL

- A. The Mechanical Contractor shall remove all unused material and equipment from jobsite.

PART 2 PRODUCTS
\\Not Used

PART 3 EXECUTION
\\Not Used

END OF SECTION

SECTION 23 05 13

COMMON MOTOR REQUIREMENTS FOR HVAC AND PLUMBING EQUIPMENT

PART 1 GENERAL

1.1 SUMMARY

- A. Section includes single- and three-phase motors for application on equipment provided under other sections and for motors furnished loose to Project.
- B. Related Sections:
 - 1. Sections 22 and 23 - Inclusive of all motors.
 - 2. Division 26 - Grounding and Bonding for Electrical Systems.

1.2 REFERENCES

- A. American Bearing Manufacturers Association:
 - 1. ABMA 9 - Load Ratings and Fatigue Life for Ball Bearings.
- B. National Electrical Manufacturers Association:
 - 1. NEMA MG 1 - Motors and Generators.
- C. International Electrical Testing Association:
 - 1. NETA ATS - Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.

1.3 SUBMITTALS

- A. See Division 1 - Submittal Procedures: Submittal procedures.
- B. Product Data: Submit catalog data for each motor furnished loose. Indicate nameplate data, standard compliance, electrical ratings and characteristics, and physical dimensions, weights, mechanical performance data, and support points.
- C. Test Reports: Indicate procedures and results for specified factory and field testing and inspection.

1.4 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years of experience.
- B. Testing Agency: Company member of International Electrical Testing Association and specializing in testing products specified in this section with minimum three years documented experience.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. See Division 1 - Product Requirements: Product storage and handling requirements.
- B. Lift only with lugs provided. Handle carefully to avoid damage to components, enclosure, and finish.
- C. Protect products from weather and moisture by covering with plastic or canvas and by maintaining heating within enclosure.

- D. For extended outdoor storage, remove motors from equipment and store separately.

PART 2 PRODUCTS

2.1 PRODUCT REQUIREMENTS FOR MOTORS FURNISHED WITH EQUIPMENT

- A. General Purpose: Allis Chalmers, Century, General Electric, Lincoln, Louis Allis, Marathon, Westinghouse, Gould, Reliance and Baldor
- B. Motors 1/2 hp and Larger: Three-phase motor as specified below.
- C. Motors Smaller Than 1/2 hp: Single-phase motor as specified below, except motors less than 250 watts or 1/4 hp may be equipment manufacturer's standard.
- D. Three-Phase Motors: NEMA MG 1, Design B, energy-efficient squirrel-cage induction motor, with windings to accomplish starting methods and number of speeds as indicated on Drawings.
1. Voltage: As indicated on Drawings.
 2. Service Factor 1.15.
 3. Enclosure: Meet conditions of installation unless specific enclosure is indicated on Drawings.
 4. Design for continuous operation in 40 degrees C environment, with temperature rise in accordance with NEMA MG 1 limits for insulation class, service factor, and motor enclosure type.
 5. Insulation System: NEMA Class F.
 6. Motor Frames: NEMA Standard T-Frames of steel, aluminum, or cast iron with end brackets of cast iron or aluminum with steel inserts.
 7. Thermistor System (Motor Frame Sizes 254T and Larger): Three PTC thermistors embedded in motor windings and epoxy encapsulated solid state control relay with wiring to terminal box.
 8. Bearings: Grease lubricated anti-friction ball bearings with housings equipped with plugged provision for re-lubrication, rated for minimum ABMA 9, L-10 life of 200,000 hours. Calculate bearing load with NEMA minimum V-belt pulley with belt center line at end of NEMA standard shaft extension. Stamp bearing sizes on nameplate.
 9. Sound Power Levels: Conform to NEMA MG 1.
- E. Single Phase Motors:
1. Permanent split-capacitor type where available, otherwise use split-phase start/capacitor run or capacitor start/capacitor run motor.
 2. Voltage: As indicated on Drawings.
- F. Wiring Terminations: Furnish terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated.

2.2 THREE-PHASE MOTORS FURNISHED LOOSE

- A. Manufacturers: Refer to 2.1.
- B. Product Description: NEMA MG 1, Design B, energy-efficient squirrel-cage induction motor, with windings to accomplish starting methods and number of speeds indicated.
- C. Voltage: As indicated on Drawings.
- D. Service Factor: 1.15
- E. Enclosure: Meet conditions of installation unless specific enclosure is specified.

- F. Design for continuous operation in 40 degrees C environment, with temperature rise in accordance with NEMA MG 1 limits for insulation class, service factor, and motor enclosure type.
- G. Insulation System: NEMA Class F.
- H. Motor Frames: NEMA Standard T-Frames of steel, aluminum, or cast iron with end brackets of cast iron or aluminum with steel inserts.
- I. Thermistor System (Motor Frame Sizes 254T and Larger): Three PTC thermistors embedded in motor windings and epoxy encapsulated solid state control relay with wiring to terminal box.
- J. Bearings: Grease lubricated anti-friction ball bearings with housings equipped with plugged provision for re-lubrication, rated for minimum ABMA 9, L-10 life of 200,000 hours. Calculate bearing load with NEMA minimum V-belt pulley with belt center line at end of NEMA standard shaft extension. Stamp bearing sizes on nameplate.
- K. Sound Power Levels: Conform to NEMA MG 1.
- L. Wiring Terminations: Furnish terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated.

2.3 SOURCE QUALITY CONTROL

- A. Test motors in accordance with NEMA MG 1, including winding resistance, no-load speed and current, locked rotor current, insulation high-potential test, and mechanical alignment tests.
- B. All motors shall meet or exceed the minimum efficiencies listed by the local power company.
- C. Motors 3-HP and larger shall meet the minimum efficiencies list by local power company to qualify for rebate(s).

PART 3 EXECUTION

3.1 EXISTING WORK

- A. N/A

3.2 INSTALLATION

- A. Install securely on firm foundation. Mount ball bearing motors with shaft in any position.
- B. Install engraved plastic nameplates. Three-layer laminated plastic, white letters on a black background, 1/4".
- C. Ground and bond motors in accordance with NEC 2011.
- D. Install in accordance with manufacturer's instructions.
- E. Check line voltage and phase and ensure agreement with nameplate.
- F. If a VFD is being used with any motor, verify that the motor is a "premium efficiency" motor with "inverter grade insulation" before installing and making final connection.

3.3 FIELD QUALITY CONTROL

- A. Inspect and test in accordance with NETA ATS, except Section 4.
- B. Perform inspections and tests listed in NETA ATS, Section 7.15.

3.4 POWER FACTOR

- A. Data on minimum acceptable motor power factor and efficiency at five different loads (full load, 3/4 load, 1/2 load, 1/4 load and no load) for all 1/2 horsepower and larger motors.

<u>LISTED MOTOR HORSEPOWER</u>	<u>MINIMUM ACCEPTABLE MOTOR EFFICIENCY (%)</u>
	1800 RPM shown Open or Enclosed
1	82.5
1.5	84.0
2	84.0
3	86.5
5	87.5
7-1/2	88.5

Minimum power factor to be 85% for all motors.

- B. All motors shall meet or exceed the minimum efficiencies listed by the State of Minnesota.
- C. Motors 3 HP and larger shall meet the minimum efficiencies listed by local power company to qualify for any possible rebate(s).

3.5 POWER FACTOR - PREMIUM HIGH EFFICIENCY MOTORS

- A. Data on minimum acceptable motor power factor and efficiency at five different loads (full load, 3/4 load, 1/2 load, 1/4 load and no load) for all 1 horsepower and larger motors.

<u>LISTED MOTOR HORSEPOWER</u>	<u>MINIMUM ACCEPTABLE MOTOR EFFICIENCY (%) for NEMA Premium Eff. Motors</u>
	1800 RPM shown Open or Enclosed
1	85.5
1.5	86.0
2	86.0
3	89.5
5	89.5
7-1/2	91.0

Minimum power factor to be 85% for all motors.

- B. All motors shall meet or exceed the minimum efficiencies listed by the State of Minnesota.
- C. Motors 3 HP and larger shall meet the minimum efficiencies listed above or by local power company to qualify for any possible rebate(s) - whichever is higher.

END OF SECTION

SECTION 23 05 29

HANGERS, SUPPORTS AND FIRESTOPPING FOR PLUMBING, HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Pipe hangers and supports.
2. Hanger rods.
3. Flashing.
4. Sleeves.
5. Formed steel channel.
6. Equipment bases and supports.

B. Related Sections:

1. Section 23 05 48 - Vibration for HVAC Piping and Equipment: Product and execution requirements for vibration isolators.

1.2 REFERENCES

A. American Society of Mechanical Engineers:

1. ASME B31.9 - Building Services Piping.

B. ASTM International:

1. ASTM E84 - Test Method for Surface Burning Characteristics of Building Materials.
2. ASTM E119 - Method for Fire Tests of Building Construction and Materials.
3. ASTM F708 - Standard Practice for Design and Installation of Rigid Pipe Hangers.

C. American Welding Society:

1. AWS D1.1 - Structural Welding Code - Steel.

D. FM Global:

1. FM - Approval Guide, A Guide to Equipment, Materials & Services Approved By Factory Mutual Research For Property Conservation.

E. Manufacturers Standardization Society of the Valve and Fittings Industry:

1. MSS SP 58 - Pipe Hangers and Supports - Materials, Design and Manufacturer.
2. MSS SP 69 - Pipe Hangers and Supports - Selection and Application.
3. MSS SP 89 - Pipe Hangers and Supports - Fabrication and Installation Practices.

F. Underwriters Laboratories Inc.:

1. UL 263 - Fire Tests of Building Construction and Materials.
2. UL 723 - Tests for Surface Burning Characteristics of Building Materials.

3. UL 1479 - Fire Tests of Through-Penetration Firestops.
4. UL 2079 - Tests for Fire Resistance of Building Joint Systems.
5. UL - Fire Resistance Directory.

1.3 SYSTEM DESCRIPTION

- A. Surface Burning: ASTM E84 with maximum flame spread / smoke developed rating of 25/450.
- B. Firestop interruptions to fire rated assemblies, materials, and components.

1.4 SUBMITTALS

- A. Shop Drawings: Indicate system layout with location including critical dimensions, sizes, and pipe hanger and support locations and detail of trapeze hangers.
- B. Product Data:
 1. Hangers and Supports: Submit manufacturers catalog data including load capacity.
 2. Firestopping: Submit data on product characteristics, performance and limitation criteria.
- C. Design Data: Indicate load carrying capacity of trapeze, multiple pipe, and riser support hangers. Indicate calculations used to determine load carrying capacity of trapeze, multiple pipe, and riser support hangers.
- D. Manufacturer's Installation Instructions:
 1. Hangers and Supports: Submit special procedures and assembly of components.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Accept materials on site in original factory packaging, labeled with manufacturer's identification.
- B. Protect from weather and construction traffic, dirt, water, chemical, and damage, by storing in original packaging.

1.6 FIELD MEASUREMENTS

- A. Verify field measurements prior to fabrication.

PART 2 - PRODUCTS

2.1 APPROVED MANUFACTURERS - PIPE HANGERS AND SUPPORTS

- A. Hangers - B-Line.
- B. Riser Clamps - B-Line.
- C. Expansion Anchors – Hilti.

- D. Power Driven Fasteners – Hilti.
- E. Anvil International (Hangers and Clamps).
- F. Tolco/Nibco.
- G. Pipe Hangers and Devices "P.H. & D."

2.2 PIPE HANGERS AND SUPPORTS

- A. Hangers for Pipe Sizes 1/2 to 1-1/2 Inch: Split ring of malleable iron, Malleable iron, adjustable swivel, clevis.
- B. Hangers for Pipe Sizes 2 to 4 Inches and Cold Pipe Sizes 6 Inches and Over: Adjustable, clevis.
- C. Hangers for Hot Pipe Sizes 6 Inches and Over: Adjustable steel yoke, cast iron roll hanger.
- D. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
- E. Wall Support for Pipe Sizes to 3 Inches: Cast iron hook.
- F. Copper Pipe Support: Carbon steel ring, adjustable, copper plated.
- G. Shield for Insulated Piping 2 Inches and Smaller: 18 gauge galvanized steel shield over insulation in 180 degree segments, minimum 12 inches long at pipe support.
- H. Shields for Insulated Piping 2-1/2 Inches and Larger: Hard block non-conducting saddles in 90 degree segments, 12 inch minimum length, block thickness same as insulation thickness.
- I. Shields for Vertical Copper Pipe Risers: Sheet lead.
- J. All plumbing water piping shall have hangers sized to accommodate pipe insulation so the pipe does not come in contact with the hanger.

2.3 HANGER RODS

- A. Steel Hanger Rods: Threaded both ends, threaded one end, or continuous threaded.

2.4 SLEEVES

- A. Sleeves for Pipes through Non-fire Rated Walls, Footings, and Potentially Wet Floors: Form with steel pipe or 20 gauge galvanized steel or Schedule 40 PVC.
- B. Sleeves for Round Ductwork: Form with galvanized steel.
- C. Sleeves for Rectangular Ductwork: Form with galvanized steel or wood. (Remove wood blocking after concrete has set.)
- D. Stuffing Insulation: Glass fiber type, non-combustible.
- E. Caulk: Silicone sealant.

- F. Pre-fabricated wall sleeves by Thunderline or equal.
- G. Wall and floor seals by Pyropal or equal are an acceptable option.

2.5 FABRICATION

- A. Size sleeves large enough to allow for movement due to expansion and contraction. Provide for continuous insulation wrapping through sleeve.
- B. Design hangers without disengagement of supported pipe.
- C. Provide copper plated hangers and supports for copper piping or sheet lead packing between hanger or support and piping.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify existing conditions before starting work.
- B. Verify openings are ready to receive sleeves.
- C. Verify openings are ready to receive firestopping.

3.2 PREPARATION

- A. Obtain permission from Architect/Engineer before using powder-actuated anchors.
- B. Obtain permission from Architect/Engineer before drilling or cutting structural members.

3.3 PIPE HANGERS AND SUPPORTS

- A. Support horizontal piping as follows:

PIPE SIZE	MAX. HANGER SPACING	HANGER DIAMETER
1/2 to 1-1/4 in.	6'-0"	3/8"
1-1/2 to 2 in.	10'-0"	3/8"
2-1/2 to 3 in.	10'-0"	1/2"
4 to 6 inch	10'-0"	5/8"
PVC (All Sizes)	2'-8"	3/8"
8" and Under C.I. Bell and Spigot (or No-Hub) and at Joints	5'-0"	5/8"

- B. Install hangers to provide minimum 1/2 inch space between finished insulation covering and adjacent work.
- C. Place a hanger within 12 inches of each horizontal elbow.
- D. Use hangers with 1-1/2 inch minimum vertical adjustment.

- E. Support horizontal cast iron pipe adjacent to each joint, with 5 feet maximum spacing between hangers.
- F. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
- G. Support riser piping independently of connected horizontal piping.
- H. Do not use side clamps to hang support rods from the side of bar joists. Hang from the center of a bar joist with a threaded rod in the center of the two joist angles (pipe 1-1/2" and smaller).

3.4 FLASHING

- A. Provide flexible flashing and metal counter-flashing where piping and ductwork penetrate weather or waterproofed walls, floors, and roofs.
- B. Flash vent and soil pipes projecting 8 inches minimum above finished roof surface with lead worked one inch minimum into hub, 8 inches minimum clear on sides with 24 x 24 inches sheet size. For pipes through outside walls, turn flanges back into wall and caulk, metal counter-flash and seal.

3.5 SLEEVES

- A. Set sleeves in position in form work. Provide re-enforcing around sleeves.
- B. Where piping or ductwork penetrates ceiling, or wall, close off space between pipe or duct and adjacent work with stuffing insulation and caulk seal air tight. Provide close fitting metal collar or escutcheon covers at both sides of penetration.
- C. Install chrome plated steel escutcheons at finished surfaces. Use plastic escutcheons in damp areas of toilet/showers.

3.8 HANGER AND SUPPORT PAINTING

- A. None.

3.9 SCHEDULES

- A. Copper and Steel Pipe Hanger Spacing:

PIPE SIZE Inches	COPPER TUBING MAXIMUM HANGER SPACING Feet	STEEL PIPE MAXIMUM HANGER SPACING Feet	COPPER TUBING HANGER ROD DIAMETER Inches	STEEL PIPE HANGER ROD DIAMETER Inches
1/2	5	7	3/8	3/8
3/4	5	7	3/8	3/8
1	6	7	3/8	3/8
1-1/4	7	7	3/8	3/8
1-1/2	8	9	3/8	3/8
2	8	10	3/8	3/8
2-1/2 (Note 2)	9	11	1/2	1/2
3	10	12	1/2	1/2
4	12	14	1/2	5/8

B. Plastic and Ductile Iron Pipe Hanger Spacing:

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

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

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

END OF SECTION

SECTION 23 05 48

VIBRATION AND SOUND CONTROLS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Vibration isolators.

1.2 REFERENCES

- A. Air Movement and Control Association International, Inc.
 - 1. AMCA 300 - Reverberant Room Method for Sound Testing of Fans.
 - 2. Noise Sources.
- B. Air-Conditioning and Refrigeration Institute:
 - 1. ARI 575 - Method of Measuring Machinery Sound within Equipment Space.
- C. American Society of Heating, Refrigerating and Air Conditioning Engineers:
 - 1. ASHRAE Handbook - HVAC Applications.

1.3 SUBMITTALS

- A. Shop Drawings: Indicate location of vibration isolators, with static and dynamic load on each. Indicate assembly, materials, thickness, dimensional data, pressure losses, acoustical performance, layout, and connection details for sound attenuation products fabricated for this project.
- B. Product Data: Submit schedule of vibration isolator type with location and load on each. Submit catalog information indicating, materials, dimensional data, pressure losses, and acoustical performance for standard sound attenuation products.
- C. Design Data: Submit calculations indicating maximum room sound levels are not exceeded.
- D. Manufacturer's Installation Instructions: Submit special procedures and setting dimensions. Indicate installation requirements maintaining integrity of sound isolation.
- E. Manufacturer's Certificate: Certify isolators meet or exceed specified requirements.

1.4 FIELD MEASUREMENTS

- A. Verify field measurements prior to fabrication.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Korfund

- B. Vibration Mountings and Controls
- C. Ameber/Booth
- D. Vibration Eliminator
- E. Peabody Engineering
- F. Mason Industries

2.2 VIBRATION ISOLATORS

- A. Open Spring Isolators:
 - 1. Spring Isolators:
 - a. For Exterior and Humid Areas: Furnish hot dipped galvanized housings and neoprene coated springs.
 - b. Code: Color code springs for load carrying capacity.
 - 2. Springs: Minimum horizontal stiffness equal to 75 percent vertical stiffness, with working deflection between 0.3 and 0.6 of maximum deflection.
 - 3. Spring Mounts: Furnish with leveling devices, minimum 0.25 inch thick neoprene sound pads, and zinc chromate plated hardware.
 - 4. Sound Pads: Size for minimum deflection of 0.05 inch; meet requirements for neoprene pad isolators.
- B. Spring Hanger:
 - 1. Spring Isolators:
 - a. For Exterior and Humid Areas: Furnish hot dipped galvanized housings and neoprene coated springs.
 - b. Code: Color code springs for load carrying capacity.
 - 2. Springs: Minimum horizontal stiffness equal to 75 percent vertical stiffness, with working deflection between 0.3 and 0.6 of maximum deflection.
 - 3. Housings: Incorporate neoprene isolation pad meeting requirements for neoprene pad isolators.
 - 4. Misalignment: Capable of 20 degree hanger rod misalignment.
- C. Neoprene Pad Isolators: (Not Used)
 - 1. Rubber or neoprene-waffle pads.
 - a. 30 durometer.
 - b. Minimum 1/2 inch thick.
 - c. Maximum loading 40 psi.
 - d. Height of ribs: not to exceed 0.7 times width.
 - 2. Configuration: 1/2 inch thick waffle pads bonded each side of 1/4 inch thick steel plate.
- D. Rubber Mount or Hanger: Molded rubber designed for 0.5 inches deflection with threaded insert.

- E. Glass Fiber Pads: Neoprene jacketed pre-compressed molded glass fiber.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify equipment, ductwork and piping is installed before work in this section is started.

3.2 INSTALLATION

- A. Install isolation for motor driven equipment.
- B. Adjust equipment level.
- C. Install spring hangers without binding.
- D. On closed spring isolators, adjust so side stabilizers are clear under normal operating conditions.

END OF SECTION

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SECTION 23 05 53

IDENTIFICATION FOR HVAC, PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Pipe markers.
2. Labels.

1.2 REFERENCES

A. American Society of Mechanical Engineers:

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

1.3 SUBMITTALS

- A. Product Data: Submit manufacturers catalog literature for each product required.
- B. Shop Drawings: Submit list of wording, symbols, letter size, and color coding for mechanical identification and valve chart and schedule, including valve tag number, location, function, and valve manufacturer's name and model number.
- C. Manufacturer's Installation Instructions: Indicate installation instructions, special procedures, and installation.
- D. Manufacturer's Certificate: Certify products meet or exceed specified requirements.

1.4 CLOSEOUT SUBMITTALS

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

1.5 QUALITY ASSURANCE

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

PART 2 - PRODUCTS

2.1 NAMEPLATES

A. Manufacturers:

1. Craftmark Identification Systems.
2. Safety Sign Co.
3. Seton Identification Products.
4. Brady Markers.
5. Marking Services, Inc. (MSI).
6. EMED, Inc.
7. Brimar Industries.

2.2 PIPE MARKERS

- A. Color and Lettering: Conform to ASME A13.1.
- B. Plastic Tape Pipe Markers:
 - 1. Flexible, vinyl film tape with pressure sensitive adhesive backing and printed markings. Wrap arrows on-a-roll pressure sensitive tape completely around the pipe label overlapping itself and the end of the pipe marker by 1/2 inch.

PART 3 - EXECUTION

3.1 PREPARATION

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

3.2 INSTALLATION

- A. Pipe Markers: Install in accordance with manufacturer's instructions.
- B. Piping: Identify piping, concealed or exposed, with pipe markers.

3.3 PIPE MARKING

- A. Identify piping, concealed above accessible ceilings, with pipe markers and color coded banding. Identify service and flow direction. Install in clear view and align with axis of piping. Locate identification not to exceed 20 feet on straight runs including risers and drops, adjacent to each valve and "T", at each side of penetration of structure or enclosure and at each obstruction.
- B. All exposed piping both covered and uncovered shall be designated by color code in accordance with the following:
 - 1. Coding shall be accomplished by self-adhesive pipe markers running parallel to pipe axis. Similar to Seton "Opti-Code" pipe markers 8" long with 3/4" high letters up to 2-3/8" OD and 12" long with 1-1/4" high letters up to 7-7/8" OD. (8" long color field)
 - 2. At each end of the marker, directional flow arrows shall completely encircle the pipe/or pipe covering. Banding shall be similar to Seaton arrows on-a-roll tape, two inch wide band. Overlap marker and arrow tape.
- C. The standard piping color code is as follows:

Color	Opti-Code No.	Legend Function
Green/White	M4208	Domestic Cold Water
Yellow/Black	M4267	Domestic Hot Water
Yellow/Black	M8146	Dom. Hot Wtr Return (Recirc.)
Green/White	M8143	Heating Supply and Return Piping
Yellow/Black	M4159	Natural Gas Piping
Yellow/Black	98923	Non-Potable Water- Tag on all RO water piping
Red/White	M4289	Sprinkler-Fire (in Mech Rm Only)

3.4 DUCTWORK

- A. Labels to be installed on all ductwork either in mechanical rooms or above ceiling. Labeling needs to identify type of ductwork and airflow direction. Labeling needs to be at no more than 20 ft. increments.

<u>Duct</u>	<u>Color code</u>
Supply air	Black letters on White background
Return air	White letters on Blue background
Exhaust air	White letters on Green background

3.5 EQUIPMENT TAGS

- A. All equipment needs to have identifying tags. Interior equipment such as boiler and vav boxes can have adhesive labels install. All equipment located outside of building shall have engraved plastic tag.
- B. Equipment tags shall correspond to prints and be referenced on startup sheets and balancing reports.
- C. All equipment tags with have Black Lettering on White background.
- D. Identify locations of equipment, valves, dampers located above ceilings with adhesive label. Label should identify equipment, valve, or damper referencing plan or valve schedule.

3.6 VALVE IDENTIFICATION

All valves and regulators shall be tagged with brass tags with stamped numbers and or letters. Tags shall indicate system and number of valve if more than one in system. Contractor to provide Schedule detailing valve use and location that shall be incorporated into O&M manual.

3.7 FIRE/ FIRE SMOKE DAMPERS

Furnish and install $\frac{3}{4}$ " white labels with black lettering on ceiling grid directly below fire/fire smoke dampers. Where damper access is located above sheetrock ceiling install tag on access door.

END OF SECTION

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SECTION 23 05 93

TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Testing, Adjusting, and Balancing of air systems.
2. Testing, Adjusting, and Balancing of hot water heating systems (boilers, pumps, and in-floor heating system).
3. Measurement of final operating condition of HVAC systems.
3. Sound measurement of equipment operating conditions.
5. Vibration measurement of equipment operating conditions.

1.2 REFERENCES

A. Associated Air Balance Council:

1. AABC MN-1 - National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems.

B. American Society of Heating, Refrigerating and Air-Conditioning Engineers:

1. ASHRAE 111 - Practices for Measurement, Testing, Adjusting and Balancing of Building Heating, Ventilation, Air-Conditioning and Refrigeration Systems.

C. Natural Environmental Balancing Bureau:

1. NEBB - Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems.

1.3 SUBMITTALS

- A. Prior to commencing Work, submit proof of latest calibration date of each instrument.
- B. Test Reports: Indicate data on AABC MN-1 National Standards for Total System Balance forms or NEBB Report forms. Submit data in S.I. units.
- C. Field Reports: Indicate deficiencies preventing proper testing, adjusting, and balancing of systems and equipment to achieve specified performance.
- D. Prior to commencing Work, submit report forms or outlines indicating adjusting, balancing, and equipment data required. Include detailed procedures, agenda, sample report forms and copy of AABC National Project Performance Guaranty or Copy of NEBB Certificate of Conformance Certification.
- E. Submit draft copies of report for review prior to final acceptance of Project.
- F. Furnish reports in soft cover, letter size, 3-ring binder manuals, complete with table of contents page and indexing tabs, with cover identification at front and side. Include set of reduced drawings with air outlets and equipment identified to correspond with data sheets, and indicating thermostat locations.

1.4 CLOSEOUT SUBMITTALS

- A. Project Record Documents: Record actual locations of flow measuring stations and balancing valves.

1.5 QUALITY ASSURANCE

- A. Perform Work in accordance with AABC MN-1 National Standards for Field Measurement and Instrumentation, Total System Balance or NEBB Procedural Standards for Testing, Balancing and Adjusting of Environmental Systems.

1.6 QUALIFICATIONS

- A. Approved Agencies:
 - 1. Certified "AABC" Balancing Contractors.
 - 2. Certified "NEEB" Balancing Contractors.
- B. Perform Work under supervision of AABC Certified Test and Balance or NEBB Certified Testing, Balancing and Adjusting registered professional engineer experienced in performance of this Work.

1.7 SEQUENCING

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

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify systems are complete and operable before commencing work. Verify the following:
 - 1. Systems are started and operating in safe and normal condition.
 - 2. Temperature control systems are installed complete and operable.
 - 3. Proper thermal overload protection is in place for electrical equipment.
 - 4. Final filters are clean and in place. If required, install temporary media in addition to final filters.
 - 5. Duct systems are clean of debris.
 - 6. Fans are rotating correctly.
 - 7. Volume dampers are in place and open.
 - 8. Air coil fins are cleaned and combed.
 - 9. Access doors are closed and duct end caps are in place.
 - 10. Air outlets are installed and connected.
 - 11. Duct system leakage is minimized.
 - 12. Hydronic piping has no leakage.
 - 13. Valves and sensors and installed.

3.2 PREPARATION

- A. Furnish instruments required for testing, adjusting, and balancing operations.
- B. Make instruments available to Architect/Engineer to facilitate spot checks during testing.

3.3 INSTALLATION TOLERANCES

- A. Air Handling Systems: Adjust to within plus or minus 10 percent of design.
- B. Air Outlets and Inlets: Adjust total to within plus or minus 10 percent of design to space.

3.4 ADJUSTING

- A. Verify recorded data represents actual measured or observed conditions.
- B. Permanently mark settings of valves, dampers, and other adjustment devices allowing settings to be restored. Set and lock memory stops.
- C. After adjustment, take measurements to verify balance has not been disrupted. If disrupted, verify correcting adjustments have been made.
- D. Report defects and deficiencies noted during performance of services, preventing system balance.
- E. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.
- F. At final inspection, recheck random selections of data recorded in report. Recheck points or areas as selected and witnessed by Owner.
- G. Check and adjust systems approximately six months after final acceptance and submit report.

3.5 AIR SYSTEM PROCEDURE

- A. Adjust air handling and distribution systems to obtain required or design supply, return, and exhaust air quantities at site altitude.
- B. Make air quantity measurements in main ducts by Pitot tube traverse of entire cross sectional area of duct.
- C. Measure air quantities at air inlets and outlets.
- D. Adjust distribution system to obtain uniform space temperatures free from objectionable drafts.
- E. Use volume control devices to regulate air quantities only to extent adjustments do not create objectionable air motion or sound levels. Effect volume control by using volume dampers located in ducts.
- F. Vary total system air quantities by adjustment of fan speeds. Provide sheave drive changes to vary fan speed. Vary branch air quantities by damper regulation.

- G. Provide system schematic with required and actual air quantities recorded at each outlet or inlet.
- H. Measure static air pressure conditions on air supply units, including filter and coil pressure drops, and total pressure across fan. Make allowances for 50 percent loading of filters.
- I. Adjust outside air automatic dampers, outside air, return air, and exhaust dampers for design conditions.
- J. Measure temperature conditions across outside air, return air, and exhaust dampers to check leakage.
- K. At modulating damper locations, take measurements and balance at extreme conditions.
- L. Measure building static pressure and adjust supply, return, and exhaust air systems to obtain required relationship between each to maintain approximately 0.05 inches positive static pressure.

3.6 HYDRONIC HEATING SYSTEM

- A. Adjust boilers and hydronic in-floor heating system in order to achieve desired space heating.
- B. Balance hydronic heating system to achieve desired hot water temperature and flow rate (gpm).

3.7 SCHEDULES

- A. Equipment Requiring Testing, Adjusting, and Balancing:
 - 1. Air Handling Unit.
 - 2. Air Filters.
 - 3. Powered Ventilators.
 - 4. Air Inlets and Outlets.
- B. Report Forms:
 - 1. Title Page:
 - a. Name of Testing, Adjusting, and Balancing Agency.
 - b. Address of Testing, Adjusting, and Balancing Agency.
 - c. Telephone and facsimile numbers of Testing, Adjusting, and Balancing Agency.
 - d. Project name.
 - e. Project location.
 - f. Project Architect.
 - g. Project Engineer.
 - h. Project Contractor
 - i. Project altitude.
 - j. Report date
 - 2. Summary Comments:
 - a. Design versus final performance
 - b. Notable characteristics of system

- c. Description of systems operation sequence
- d. Summary of outdoor and exhaust flows to indicate building pressurization
- e. Nomenclature used throughout report
- f. Test conditions

3. Instrument List:

- a. Instrument
- b. Manufacturer
- c. Model number
- d. Serial number
- e. Range
- f. Calibration date

4. Electric Motors:

- a. Manufacturer
- b. Model/Frame
- c. HP/BHP and kW
- d. Phase, voltage, amperage; nameplate, actual, no load
- e. RPM
- f. Service factor
- g. Starter size, rating, heater elements
- h. Sheave Make/Size/Bore

5. V-Belt Drive:

- a. Identification/location
- b. Required driven RPM
- c. Driven sheave, diameter and RPM
- d. Belt, size and quantity
- e. Motor sheave diameter and RPM

6. Cooling Coil Data:

- a. Identification/number
- b. Location
- c. Service
- d. Manufacturer
- e. Air flow, design and actual
- f. Entering air DB temperature, design and actual
- g. Entering air WB temperature, design and actual
- h. Leaving air DB temperature, design and actual
- i. Leaving air WB temperature, design and actual
- j. Entering water temperature, design and actual
- k. Leaving water temperature, design and actual
- l. Saturated suction temperature, design and actual
- m. Air pressure drop, design and actual

7. Air Moving Equipment:

- a. Location
- b. Manufacturer

- c. Model number
- d. Serial number
- e. Arrangement/Class/Discharge
- f. Air flow, specified and actual
- g. Return air flow, specified and actual
- h. Outside air flow, specified and actual
- i. Total static pressure (total external), specified and actual
- j. Inlet pressure
- k. Discharge pressure
- l. Sheave Make/Size/Bore
- m. Number of Belts/Make/Size
- n. Fan RPM

8. Return Air/Outside Air Data:

- a. Identification/location
- b. Design air flow
- c. Actual air flow
- d. Design return air flow
- e. Actual return air flow
- f. Design outside air flow
- g. Actual outside air flow
- h. Return air temperature
- i. Outside air temperature
- j. Required mixed air temperature
- k. Actual mixed air temperature
- l. Design outside/return air ratio
- m. Actual outside/return air ratio

9. Exhaust Fan Data:

- a. Location
- b. Manufacturer
- c. Model number
- d. Serial number
- e. Air flow, specified and actual
- f. Total static pressure (total external), specified and actual
- g. Inlet pressure
- h. Discharge pressure
- i. Sheave Make/Size/Bore
- j. Number of Belts/Make/Size
- k. Fan RPM

10. Duct Traverse:

- a. System zone/branch
- b. Duct size
- c. Area
- d. Design velocity
- e. Design air flow
- f. Test velocity
- g. Test air flow
- h. Duct static pressure
- i. Air temperature
- j. Air correction factor

11. Air Distribution Test Sheet:

- a. Air terminal number
- b. Room number/location
- c. Terminal type
- d. Terminal size
- e. Area factor
- f. Design velocity
- g. Design air flow
- h. Test (final) velocity
- i. Test (final) air flow
- j. Percent of design air flow

12. Pump Data:

- a. Identification/number
- b. Manufacturer
- c. Size/model
- d. Service
- e. Design flow rate, pressure drop, BHP
- f. Actual flow rate, pressure drop, BHP
- g. Discharge pressure
- h. Suction pressure
- i. Total operating head pressure

END OF SECTION

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SECTION 23 07 00

HVAC AND PIPING INSULATION

1.1 SUMMARY

A. Section Includes:

1. Piping system insulation.
2. Pipe insulation jackets.
3. Insulation accessories including vapor retardants and accessories.
4. Ductwork insulation.
5. Ductwork insulation jackets.
6. Breeching insulation.
7. Insulation accessories including vapor retardants and accessories.

B. Related Sections:

1. Section 22 07 19 – Plumbing Piping Insulation
2. Section 23 05 29 - Hangers and Supports and Firestopping for Piping and Equipment: Product and Execution requirements for inserts at hanger locations.
3. Section 23 05 53 - Identification for Piping and Equipment: Product requirements for piping and equipment identification.
4. Section 23 21 13 – Hydronic Piping
5. Section 23 23 00 – Refrigeration Piping

1.2 REFERENCES

A. ASTM International:

1. ASTM B209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
2. ASTM C177 - Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus.
3. ASTM C534 - Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.
4. ASTM C518 - Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.
5. ASTM C921 - Standard Practice for Determining the Properties of Jacketing Materials for Thermal Insulation.
6. ASTM C1136 - Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation.
7. ASTM C1290 - Standard Specification for Flexible Fibrous Glass Blanket Insulation Used to Externally Insulate HVAC Ducts.
8. ASTM D1784 - Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.
9. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.
10. ASTM E96 - Standard Test Methods for Water Vapor Transmission of Materials.
11. ASTM E162 - Standard Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source.
12. ASTM G21 - Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi.

- B. Sheet Metal and Air Conditioning Contractors' National Association:
 - 1. SMACNA - HVAC Duct Construction Standard - Metal and Flexible.

1.3 SUBMITTALS

- A. See Division 1 – Administrative requirements for Submittal procedures.
- B. Product Data: Submit product description, thermal characteristics and list of materials and thickness for each service, and location.
- C. Manufacturer's Installation Instructions: Indicate installation procedures to ensure acceptable workmanship and installation standards will be achieved.

1.4 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with not less than three years of documented experience.
- B. Applicator Qualifications: Company specializing in performing the type of work specified in this section with minimum 3 years' experience.
- C. Test Pipe Insulation for maximum flame spread in accordance to ASTM E84.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. See Division 1 - Product Requirements: Requirements for transporting, handling, storing, and protecting products.
- B. Accept materials on site in original factory packaging, labeled with manufacturer's identification, including product density and thickness.
- C. Protect insulation from weather and construction traffic, dirt, water, chemical, and damage, by storing in original wrapping.

1.6 ENVIRONMENTAL REQUIREMENTS

- A. See Division 1 - Product Requirements: Environmental conditions affecting products on site.
- B. Install insulation only when ambient temperature and humidity conditions are within range recommended by manufacturer.
- C. Maintain temperature during and after installation for minimum period of 24 hours.

1.7 WARRANTY

- A. See Division 1 - Execution and Closeout Requirements: Product warranties and product bonds.
- B. One year warranty on product and workmanship.

PART 2 PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS (PIPE INSULATION)

- A. Owens Corning Fiberglass
- B. Certainteed
- C. Johns-Manville
- D. Knauf, Inc.
- E. Rubatex
- F. Armoflex
- G. Imcoshield/Imcolock

2.2 INSULATION (PIPE INSULATION)

- A. Type A: Glass fiber insulation; ANSI/ASTM C547; 'k' value of 0.24 at 75°F noncombustible. ASTM C-335.
- B. Type C: Phenolic foam, chemically neutral; 'k' value of 0.24 at 75° F.
- C. Type D: Cellular foam or elastomer; flexible, plastic; 'k' value of 0.28 at 75°F.

2.3 JACKETS (PIPE INSULATION)

- A. Vapor Barrier Jacket "ASJ"
 - 1. ASTM C921, ASJ white kraft paper reinforced with glass fiber yarn and bonded to aluminized film.
 - 2. Vapor barrier for polyisocyanurate foam is 4 mil saran vapor barrier film with saran tape at the joints and fittings.
 - 3. Moisture Vapor Transmission: ASTM E96; 0.02 perm inches.
- B. Indoor, Exposed or Concealed Applications: Insulated pipes conveying fluids above ambient temperature shall have standard ASJ type jacket stapled on six inch centers. Cover fittings, joints and valves.
- C. Indoor, Exposed or Concealed Applications: Insulated cold pipes conveying fluids below ambient temperature shall have vapor barrier jackets, ASJ or saran type with positive sealing system. Cover fittings, joints, and valves.
- D. Tie Wire: 18 gauge stainless steel with twisted ends on maximum 12 inch centers.
- E. PVC Plastic
 - 1. Jacket: ASTM C921, one piece molded type fitting covers and sheet material, off white color.
 - a. Minimum Service Temperature: -40°F.
 - b. Maximum Service Temperature: 150°F.
 - c. Moisture Vapor Transmission: ASTM E96; 0.002 perm inches.
 - d. Maximum Flame Spread: ASTM E84; 25.
 - e. Maximum Smoke Developed: ASTM E84; 50.
 - f. Thickness: 20 mil.

- g. Connections: Brush on welding adhesive or pressure sensitive color matching vinyl tape.

2.4 ACCESSORIES (PIPE INSULATION)

- A. Adhesives: Compatible with insulation.
- B. Insulation Bands: 3/4 inch wide; 0.015 inch thick galvanized steel or 0.007 inch thick aluminum.
- C. PVC Covers: Zestone, Foster, Speedline or equal 0.020 inch thick pre-formed covers for fittings, valves and joints.

2.5 ACCEPTABLE MANUFACTURERS - (DUCT INSULATION)

- A. Owens Corning
- B. Certainteed
- C. Johns Manville
- D. Knauf
- E. CSG

2.6 MATERIALS (DUCT INSULATION)

- A. Type A: Flexible glass fiber duct liner; ANSI/ASTM C553; 'k' value of 0.28 per inch at 75°F; 1.5 lb/cu ft minimum density; coated air side for maximum 4,000 ft/min air velocity.
- B. Type B: Rigid glass fiber; ANSI/ASTM C612, Class 1; 'k' value of 0.24 per inch at 75°F; 3.0 lb/cu ft maximum density, 0.002 inch foil scrim or FSK facing for air conditioning, heating and venting ducts.
- C. Type C: Flexible glass fiber; ANSI/ASTM C612; commercial grade; 'k' value of 0.29 per inch at 75°F, 1.50 lb/cu ft minimum density, 0.002 inch foil scrim or FSK facing for air conditioning, heating and venting ducts.
- D. Type D: Flexible glass fiber; ANSI/ASTM C612, Class 1; 'k' value of 0.29 per inch at 75°F, 0.75 lb/cu.ft. minimum density, 0.002 metalized fiberglass scrim provided in five foot slide-over sleeve length.
- E. Adhesives: Waterproof fire-retardant type.
- F. Outdoor Jacket: Coated glass fiber sheet, 3.0 lb/sq.yd.
- G. Joint Tape: Glass fiber cloth, open mesh.
- H. Tie Wire: Annealed steel, 16 gauge.
- I. Mechanical Fasteners: Pin-type with welded connection to duct side wall. Do not use nail-type fasteners or glue type connections.
- J. Vapor Barrier Jacket

1. Kraft paper reinforced with glass fiber yarn and bonded to aluminized film, 0.0032 inch ASJ jacket.
2. Moisture vapor transmission: ASTM #96; 0.04 perm.
3. Secure with pressure sensitive tape.

2.7 ADHESIVE FOR DUCT INSULATION

A. Water Base Type

1. Cain – Hydrotak
2. Duro Dyne – WSA
3. Hardcast - IA-901
4. Kingco - 10-568
5. Miracle - PF-101
6. Mon-Eco - 22-67
7. Techno Adhesive – 133
8. United McGill - Unitack

2.8 FASTENERS FOR DUCT INSULATION

A. Adhesively secured fasteners not allowed.

B. Approved Manufacturers.

1. AGM Industries, Inc - "DynaPoint" Series DD-9 pin.
2. Cain.
3. Duro Dyne.
4. Omark dished head "Insul-Pins".

C. Grip nails may be used if each nail is installed by "Grip Nail Air Hammer" or by Automatic Fastener Equipment" in accordance with manufacturer's recommendations.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. See Division 1 - Administration Requirements: Coordination and project conditions.
- B. Verify that piping has been tested before applying insulation materials.
- C. Verify that surfaces are clean, foreign material removed and dry.

3.2 INSTALLATION (PIPE INSULATION)

- A. Install materials in accordance with manufacturer's instructions.
- B. Insulated pipe supported on trapeze type supports shall have a sheet metal saddle installed between the insulation jacket and support (see Specification Section 23 05 29). Notching of pipe insulation around the support member is not acceptable.
- C. Continue insulation with vapor barrier through penetrations, i.e.
- D. In exposed piping, locate insulation and cover seams in least visible locations.
- E. On insulated piping with vapor barrier, insulate fittings, valves, unions, flanges, strainers, flexible connections, and expansion joints. For insulation with self-sealing adhesive tab,

install insulation such that the vapor barrier seal tab folds down towards the bottom of the pipe.

- F. For insulated pipes conveying fluids above ambient temperature:
 - 1. Provide standard jackets, with or without vapor barrier.
 - 2. For hot piping conveying fluids 140°F or less, do not insulate flanges and unions at equipment, but bevel and seal ends of insulation. (Domestic water).
 - 3. Piping: Insulate fittings, joints and valves with insulation of like material and thickness as adjoining pipe and finish with ASJ or PVC jacket.
- G. Insulated cold pipes conveying fluids below ambient temperature.
 - 1. Provide vapor barrier jackets with the factory applied positive sealing system at seams. (Also seal all joints.)
 - 2. Continue insulation through walls, sleeves, pipe hangers and other pipe penetrations.
 - 3. Insulate entire system including fittings, valves, unions, flanges, strainers, flexible connections, pump bodies and expansion joints.
 - 4. Piping: Insulate fittings, joints and valves with insulation of like material and thickness as adjacent pipe finish with ASJ or PVC jacket.
- H. Provide an insert, not less than 6 inches long, of same thickness and contour as adjoining insulation, between support shield and piping, but under the finish jacket, on piping 2 inches diameter or larger, to prevent insulation from sagging at support points. Inserts shall be cork or other heavy density insulating material suitable for the planned temperature range. Factory fabricated inserts may be used.
- I. Neatly finish insulation at supports, protrusions, and interruptions.
- J. Pipe covering shall be started at the piece of equipment. All piping and valves serving each item of equipment including all branch arms shall be insulated.
- K. For pipe exposed in finished spaces finish with PVC jacket and fitting covers.
- L. For pipe exposed in mechanical equipment rooms finish with PVC jacket and fitting covers.

3.3 TOLERANCE

- A. Substituted insulation materials shall provide thermal resistance within 10 percent at normal conditions, as materials indicated. Substituted materials must be submitted for Engineer's approval prior to installation.

3.4 SCHEDULE FOR PIPE INSULATION (NOT USED)

Low Pressure Steam Mains	A	Up to 2"	1-1/2"
Low Pressure Steam Mains	A	2-1/2" and Up	2"
Low Pressure Steam Runouts	A	Up to 2"	1"
Low Pressure Condensate Runouts	A	Up to 2"	1"
(From steam main to the heating unit)			
High Pressure Steam (Over 15 psi)	A	Up to 1-1/4"	2-1/2"
High Pressure Steam (Over 15 psi)	A	1-1/2" to 4"	3"
High Pressure Steam (Over 15 psi)	A	4" and up	4"
Heating Water Supply and Return	A	3/4"	1"

Heating Water Supply and Return	A	1" to 12"	1-1/2"
Heating Water Runouts	A	Up to 2"	1/2"
Chilled Water Supply and Return	A	Up to 1"	1/2"
Chilled Water Supply and Return	A	1-1/4" to 2"	3/4"
Chilled Water Supply and Return	A	2-1/2" to 4"	1"
Chilled Water Supply and Return	A	5" to 6"	1"
Chilled Water Supply and Return	A	8" and Up	1"
Chilled Water Runouts	A	Up to 2"	1/2"
Refrigeration Piping	D	1/5" to 3"	1/2"

3.5 PAINTING (PIPE INSULATION)

- A. None.

3.6 PREPARATION (DUCT INSULATION)

- A. All HVAC ductwork shall be externally insulated except transfer air plenums.
- B. Install external materials after ductwork has been tested and approved.
- C. Insulated ductwork conveying air conditioning, room air or air below ambient temperature:
1. Provide insulation with vapor barrier jackets.
 2. Finish with tape and vapor barrier jacket.
 3. Continue insulation through walls, sleeves, hangers, and other duct penetrations.
 4. Insulate entire system including fittings, joints, flanges, fire dampers, flexible connections, and expansion joints.
- D. Liner (Type A) Application (return air transfer air duct for noise attenuation only):
1. Adhere insulation with adhesive for 100% coverage. Secure insulation with mechanical fasteners on 15" centers maximum on top and side of ductwork with dimension exceeding 20". Seal and smooth joints. Seal vapor barrier penetrations by mechanical fasteners with vapor barrier adhesive.
- D. External Insulation (Type B or Type C) Application:
1. Secure insulation with vapor barrier with wires and seal jacket joints with vapor barrier adhesive or tape to match jacket.
 2. Secure insulation without vapor barrier with staples, tape, or wires.
 3. Install without sag on underside of ductwork. Use adhesive or mechanical fasteners where necessary to prevent sagging. Lift ductwork off trapeze hangers and insert spacers. Seal vapor barrier penetrations by mechanical fasteners with vapor barrier adhesive. Stop and point insulation around access doors and damper operators to allow operation without disturbing wrapping.
 4. Seal all insulation butt joints and insulation terminations at diffusers, registers, branch ducts and main duct connections with tape such that no insulation is left exposed to ambient air.
- E. External Insulation (Type D) Application:
1. Secure insulation with vapor barrier sleeve using vapor barrier adhesive tape.
 2. Stop and point insulation around access doors and damper operators to allow operation without disturbing wrapping or vapor barrier.
 3. Slide sleeve over round branch ducts in five foot lengths.

4. Seal all insulation butt joints and insulation terminations at diffusers, registers, branch ducts and main duct connections with tape such that no insulation is left exposed to ambient air.

- F. Ductwork dimensions indicated on Drawings are internal metal dimensions. Increasing duct dimensions for duct liner insulation thickness is necessary. Round dimensions are the clear inside diameter after insulation.

3.8 TOLERANCE (DUCT INSULATION)

- A. Substituted insulation materials shall provide thermal resistance within 10 percent at normal conditions, as materials indicated.

3.9 FLEXIBLE CONNECTORS (DUCT INSULATION)

- A. Provide 1" fiberglass insulation and vapor barrier jacket over entire connector to a point 12" downstream of connector.

3.10 DUCT INSULATION SCHEDULE

INSULATION DUCTWORK TYPE	Type	THICKNESS
Exh/Relief within 10' of Exterior Opening C	C	1-1/2"
Round Metal Supply Ducts C	C	1-1/2"
Rectangular Supply Ducts	C	1-1/2"
All ductwork located within curbing of unit	C	2"
Outside Air Intake	C	2"
Transfer Air Duct	A	1"
Exposed Ductwork	NONE	

END OF SECTION

SECTION 23 09 93

SEQUENCE OF OPERATIONS FOR HVAC CONTROLS

PART 1 GENERAL

1.1 SUMMARY

- A. Section includes sequence of operation for:
 - 1. Packaged rooftop units.
 - 2. Exhaust fans and Louvers
 - 3. Unit Heaters.
 - 4. Split System Heating and Cooling.
 - 5. Domestic hot water circulating pump.
- B. Related Sections:
 - 1. Section 23 09 00 - Instrumentation and Control for HVAC: For equipment, devices, and system components to implement sequences of operation.

1.2 SUBMITTALS

- A. Shop Drawings: Indicate mechanical system controlled and control system components.
 - 1. Label with settings, adjustable range of control and limits. Submit written description of control sequence.
 - 2. Submit flow diagrams for each control system, graphically depicting control logic.

1.3 CLOSEOUT SUBMITTALS

- A. Project Record Documents: Record actual locations of components and set points of controls, including changes to sequences made after submission of shop drawings.

PART 2 PRODUCTS

- A. Mechanical contractor shall furnish and install necessary control panels, their components and wiring to satisfy the sequence of control for the In-Floor Heating System/
- B. Mechanical contractor shall furnish and install necessary control components and wiring for each HVAC equipment described below.
- C. No building wide automation shall be installed.

PART 3 EXECUTION

3.1 EXHAUST FANS AND LOUVERS

- A.

3.2 UNIT HEATERS

- A. Unit heaters shall be controlled by its own space thermostat shown on the plan.

3.3 HI EFFICIENCY BOILERS AND PUMPS – NOT USED

3.6 Split System

- A. Furnace and condensing unit shall be controlled by a 7-day programmable thermostat at the location shown on the plan.

3.7 DOMESTIC WATER CIRCULATING PUMP

A single domestic circulating hot water pump shall cycle on and off as required to maintain temperature in the circulating hot water line. When the temperature falls below 110°F (adj.) the pump shall start and shall run until the indicated water temperature reaches 115°F (ad.), at which time, the pump will be off.

END OF SECTION

SECTION 23 23 00
REFRIGERANT PIPING

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Piping.
- B. Refrigerant.
- C. Moisture and liquid indicators.
- D. Valves.
- E. Strainers.

1.2 RELATED SECTIONS

- A. Section 23 07 00 – HVAC and Piping Insulation

1.3 REFERENCES

- A. ASHRAE Std 15 – Safety Standard for Refrigeration Systems; American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.; 2007.
- B. ASHRAE Std 34 – Designation and Safety Classification of Refrigerants; American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.; 2004.
- C. ASME B16.22 - Wrought Copper and Copper Alloy Solder Joint Pressure Fittings; The American Society of Mechanical Engineers; 2001 (R2005)
- D. ASME B16.26 – Cast Copper Alloy Fittings for Flared Copper Tubes; The American Society of Mechanical Engineers; 2006.
- E. ASTM B31.5 – Refrigeration Piping and Heat Transfer Components; The American Society of Mechanical Engineers; 2006.
- F. ASTM B 88 – Standard Specification for Seamless Copper Water Tube; 2003.
- G. ASTM B 88M – Standard Specification for Seamless Copper Water Tube (Metric); 2005.
- H. ASTM B 280 – Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service; 2003.
- I. ASW A5.8/A5.8M – Specification for Filler Metals for Brazing and Braze Welding; American Welding Society; 2004

1.4 SYSTEM DESCRIPTION

- A. Where more than one piping system material is specified, ensure system components are compatible and joined to ensure the integrity of the system is not jeopardized.

Provide necessary joining fittings. Ensure flanges, union, and couplings for servicing are consistently provided.

B. Filter-Driers:

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

PART 2 – PRODUCTS

2.1 PIPING

A. Copper Tube: ASTM B 280, H58 hard drawn or O60 soft annealed.

1. Fittings: ASME B16.22 wrought copper.
2. Joints: Braze, AWS A5.8 BCuP silver/phosphorus/copper alloy.

B. Copper Tube to 7/8 inch OD: ASTM B 88 (ASTM B 88M), Type K (A), annealed.

1. Fittings: ASME B16.26 cast copper.
2. Joints: Flared.

C. Pipe Supports and Anchors:

1. Conform to ASME B31.5.
2. Hangers for Pipe Sizes 1/2 to 1-1/2 Inch: Malleable iron adjustable swivel, split ring.
3. Hangers for Pipe Sizes 2 Inches and Over: Carbon steel, adjustable, clevis.
4. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
5. Wall Support for Pipe Sizes to 3 Inches: Cast iron hook.
6. Wall Support for Pipe Sizes 4 Inches and Over: Welded steel bracket and wrought steel clamp.
7. Vertical Support: Steel riser clamp.
8. Floor Support: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
9. Copper Pipe Support: Carbon steel ring, adjustable, copper plated.
10. Hanger Rods: Mild steel threaded both ends, threaded on end, or continuous threaded.
11. Inserts: Malleable iron case of galvanized steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit threaded hanger rods.

2.2 REFRIGERANT

A. Refrigerant: 410a as defined in ASHRAE Std 34.

2.3 MOISTURE AND LIQUID INDICATORS

A. Indicators: Single port type, UL listed, with copper or brass body, flared or solder ends, sight glass, color coded paper moisture indicator with removable element cartridge and plastic cap; for maximum temperature of 200 degrees F and maximum working pressure of 500 psi.

2.4 VALVES

A. Diaphragm Packless Valves:

1. UL listed, globe or angle pattern, forged brass body and bonnet, phosphor bronze and stainless steel diaphragms, rising stems and handwheel, stainless steel spring, nylon seat disc, solder or flared ends, with positive backseating; for

maximum working pressure of 500 psi and maximum temperature of 275 degrees F.

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

2.5 STRAINERS

- A. Straight Line or Angle Line Type:
 - 1. Brass or steel shell, steel cap and flange, and replaceable cartridge, with screen of stainless steel wire or monel reinforced with brass; for maximum working pressure of 430 psi.

2.6 CHECK VALVES

- A. Globe Type:
 - 1. Cast bronze or forged brass body, forged brass cap with neoprene seal, brass guide and disc holder, phosphor-bronze or stainless steel spring, Teflon seat disc; for maximum temperature of 300 degrees F and maximum working pressure of 425 psi.
- B. Straight Through Type:
 - 1. Brass body and disc, phosphor-bronze or stainless steel spring, neoprene seat; for maximum working pressure of 500 psi and maximum temperature of 200 degrees F.

2.7 PRESSURE REGULATORS

- A. Brass body, stainless steel diaphragm, direct acting, adjustable over 0 to 80 psi range, for maximum working pressure of 450 psi.

2.8 PRESSURE RELIEF VALVES

- A. Straight Through or Angle Type: Brass body and disc, neoprene seat, factory sealed and stamped with ASME UV and National board Certification NB, selected to ASHRAE Std 15, with standard setting of 235 psi.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.

- B. Remove scale and dirt on inside and outside before assembly.
- C. Prepare piping connections to equipment with flanges or unions.

3.2 INSTALLATION

- A. Install refrigeration specialties in accordance with manufacturer's instructions.
- B. Route piping in orderly manner, parallel to building structure, and maintain gradient.
- C. Install piping to conserve building space and to avoid interference with use of space.
- D. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment. Refer to Section 23 05 16.
- E. Inserts:
 - 1. Provide inserts for placement in concrete formwork.
 - 2. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
 - 3. Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4 inches.
 - 4. Where concrete slabs from finished ceiling, locate inserts flush with slab surface.
 - 5. Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut above slab.
- F. Pipe Hangers and Supports:
 - 1. Install in accordance with ASME B31.5.
 - 2. Support horizontal piping as scheduled.
 - 3. Install hangers to provide minimum 1/2 inch space between finished covering and adjacent work.
 - 4. Place hangers within 12 inches of each horizontal elbow.
- G. Arrange piping to return oil to compressor. Provide traps and loops in piping, and provide double risers as required. Slope horizontal piping 0.40 percent in direction of flow.
- H. Flood piping system with nitrogen when brazing.
- K. Use eccentric reducers to maintain top of pipe level.
- I. Where pipe support members are welded to structural building framing, scrape, brush clean and supply one coat of zinc rich primer to welds.
- J. Insulate piping and equipment; refer to Section 23 07 00.
- K. Provide external equalizer piping on expansion valves with refrigerant distributor connected to evaporator.
- L. Insulate Refrigeration lines to meet equipment manufacturer's specifications.
- M. Fully charge completed system with refrigerant after testing.

3.3 FIELD QUALITY CONTROL

- A. Test refrigeration system in accordance with ASME B31.5.
- B. Pressure test system with dry nitrogen to 200 psi. Perform final tests as 27 inches vacuum and 200 psi using halide torch. Test to no leakage.

3.4 SCHEDULES

- A. Hanger Spacing for Copper Tubing:
 - 1. 1/2 inch, 5/8 inch, and 7/8 inch OD: Maximum span, 5 feet; minimum rod size, 1/4 inch.
 - 2. 1-1/8 inch OD: Maximum span, 6 feet; minimum rod size, 1/4 inch.
 - 3. 1-3/8 inch OD: Maximum span, 7 feet; minimum rod size, 3/8 inch.
 - 4. 1-5/8 inch OD: Maximum span, 8 feet; minimum rod size, 3/8 inch.
 - 5. 2-1/8 inch OD: Maximum span, 8 feet; minimum rod size, 3/8 inch.
 - 6. 2-5/8 inch OD: Maximum span, 9 feet; minimum rod size, 3/8 inch.
 - 7. 3-1/8 inch OD: Maximum span, 10 feet; minimum rod size, 3/8 inch.
 - 8. 3-5/8 inch OD: Maximum span, 11 feet; minimum rod size, 1/2 inch.
 - 9. 4-1/8 inch OD: Maximum span, 12 feet; minimum rod size, 1/2 inch.

END OF SECTION

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SECTION 23 31 00
HVAC DUCTS AND CASINGS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
1. Duct Materials.
 4. Transverse duct connection system.
 5. Ductwork fabrication.
- B. Related Sections:
1. See Division 1 – Painting and Coating: Execution requirements for Weld priming, weather resistant, paint specified by this section.
 2. Section 23 05 29 - Hangers and Supports for HVAC Piping and Equipment: Product requirements for hangers, supports and sleeves for placement by this section.
 3. Section 23 33 00 - Air Duct Accessories: Product requirements for duct accessories for placement by this section.

1.2 REFERENCES

- A. ASTM International:
1. ASTM A36 - Standard Specification for Carbon Structural Steel.
 2. ASTM A90 - Standard Test Method for Weight Mass of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings.
 3. ASTM A167 - Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
 4. ASTM A568 - Standard Specification for Steel, Sheet, Carbon, and High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, General Requirements for.
 5. ASTM A653 - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
 6. ASTM A1008 - Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability.
 7. ASTM A1011 - Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability.
 8. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.
- B. National Fire Protection Association:
1. NFPA 90A - Standard for the Installation of Air Conditioning and Ventilating Systems.
- C. Sheet Metal and Air Conditioning Contractors National Association:
1. SMACNA - HVAC Duct Construction standard - Metal and Flexible.
 2. SMACNA - HVAC Air Duct Leakage Test Manual.

D. Underwriters Laboratories Inc.:

1. UL 181 - Factory-Made Air Ducts and Connectors.

1.3 PERFORMANCE REQUIREMENTS

A. Variation of duct configuration or sizes other than those of equivalent or lower loss coefficient is not permitted except by written permission. Size round ducts installed in place of rectangular ducts in accordance with ASHRAE table of equivalent rectangular and round ducts.

1.4 SUBMITTALS

A. Product Data: Submit data for duct materials, duct connectors.

B. Test Reports: Indicate pressure tests performed. Include date, section tested, test pressure, and leakage rate, following SMACNA HVAC Air Duct Leakage Test Manual.

1.5 CLOSEOUT SUBMITTALS

A. Project Record Documents: Record actual locations of ducts and duct fittings. Record changes in fitting location and type. Show additional fittings used.

1.6 QUALITY ASSURANCE

A. Perform Work in accordance with SMACNA - HVAC Duct Construction Standards – Metal and flexible.

B. Construct ductwork to NFPA 90A and NFPA 96 standards.

1.7 ENVIRONMENTAL REQUIREMENTS

A. Do not install duct sealant when temperatures are less than those recommended by sealant manufacturers.

B. Maintain temperatures during and after installation of duct sealant.

1.8 FIELD MEASUREMENTS

A. Verify field measurements prior to fabrication.

1.9 DEFINITIONS

A. Rectangular Duct Sizes: Metal duct dimensions are indicated on plans and the sizes on the plans have been increased to take any duct liner into account, where the ducts are specified to be lined.

B. Low Pressure: Three pressure classifications: 1 inch WG positive or negative static pressure and velocities less than 2,000 fpm; 2 inch WG positive or negative static pressure and velocities less than 2,500 fpm.

1.10 PAYMENTS

A. During the construction period ductwork shall not be considered billable on a payment request until it has been fabricated and delivered to the job site.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Galvanized Steel Ducts: ASTM A525 and ASTM A527 galvanized steel sheet, lock-forming quality, having G90 zinc coating of in conformance with ASTM A90.
- B. Steel Ducts: ASTM A569.
- C. Aluminum Ducts: ASTM B209; aluminum sheet, alloy 3003-H14. Aluminum Connectors and Bar Stock: Alloy 6061- T6 or of equivalent strength.
- D. Sealant: Non-hardening, water resistant, fire resistive, compatible with mating materials; liquid used alone or with tape, or heavy mastic tested in accordance with ASTM E-84-80 and to not exceed 25 flame spread and 50 smoke developed.
- E. Joint Sealer: Acceptable Manufacturer - Minnesota Mining and Manufacturing Duct Sealer 900, Foster 30-02 Ductmate Industries 795 Duct Sealer or 5511M if applied at the time of forming.
- F. Fasteners: Rivets, bolts, or sheet metal screws.
- G. Hanger Rod: ASTM A36; steel, galvanized; threaded both ends, threaded one end, or continuously threaded.

2.2 DUCTWORK FABRICATION

- A. Fabricate and support in accordance with SMACNA HVAC Duct Construction Standards – Metal and Flexible, and as indicated. Provide duct material, gages, reinforcing, and sealing for operating pressures indicated.
- B. Construct T's, bends, and elbows with radius of not less than 1-1/2 times width of duct on centerline. Where not possible and where rectangular elbows are used, provide air foil turning vanes.
- C. Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible; maximum 30 degrees divergence upstream of equipment and 45 degrees convergence downstream..
- D. Provide standard 45 degree lateral wye takeoffs unless otherwise indicated where 90 degree conical tee connections may be used.

2.3 MANUFACTURED DUCTWORK AND FITTINGS

- A. Manufacture in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible, and as indicated. Provide duct material, gauges, reinforcing and sealing for operating pressures indicated.
- B. Transverse Duct Connection System:
 - 1. Manufacturers:

- a. Ductmate
 - b. Nexus
 - c. SMC (R-Angle)
 - d. Ward Industries
 - e. Transverse Duct Connections (TDC)
 - f. Approved equal prior to bidding.
- 2. SMACNA "E" rated class rigidly connection, interlocking angle and duct edge connection system with sealant, gasket, cleats, and corner clips.
 - 3. All components including sealants and gaskets shall be provided to meet manufacturer's requirements. No substitutions shall be allowed.
 - 4. Round ductwork can be "snap seam" and elbows can be adjustable gore. Comply with required gauges and sealants for ductwork pressure class as per SMACNA guidelines.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Coordinate with project conditions and other Contractors.
- B. Verify sizes of equipment connections before fabrication of transitions.

3.2 INSTALLATION

- A. Spiral Duct to have barrel clamp style joint. Coupling joint with caulk will not be permitted. Install in accordance with manufacturer's instructions.
- B. Install and seal ducts in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible.
- C. Provide openings in ductwork where required to accommodate thermometers and controllers. Provide pilot tube openings where required for testing of systems, complete with metal can with spring device or screw to ensure against air leakage. Where openings are provided in insulated ductwork, install insulation material inside a metal ring.
- D. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.
- E. Use double nuts and lock washers on threaded rod supports.
- G. Joint Sealing - All low pressure ductwork to be sealed in accordance with SMACNA.
 - 1. Seal Class 'B': Seal transverse joints and longitudinal seams 3" WG and less.
- H. All outside air intake ductwork to be sealed at inside and outside of all joints before insulation wrap. Seal to be watertight.
- I. Cross Breaking - Cross break all sheet metal surfaces of rectangular ducts 18 inches through 60 inches. Beaded ductwork may be used in lieu of cross breaking. Cross breaking may be omitted on internally lined ducts and on ducts 24 inches and larger where rigid insulation is applied to the exterior of the ducts.

- J. Connect flexible ducts to metal ducts with liquid adhesive plus tape or draw bands and/or sheet metal screws.
- K. During construction provide temporary closures of metal or taped polyethylene on open ductwork to prevent construction dust from entering ductwork system.
- L. All in-line duct transitions shall be gradual (20°) taper to minimize pressure loss and noise increase due to turbulent flow.
- M. All branch duct take-off to be installed with high efficiency rectangular to round transition as shown on plan. If a round duct is shown directly connected to the rectangular duct, a spin-in conical take-off is required. On single line drawings a spin-in conical take-off shall be used unless noted otherwise on plans.
- N. Seal all insulation terminations at diffusers, registers, branch ducts and main duct connections with tape such that no insulation is left exposed to ambient air.
- O. When aluminum ductwork is specified, the Contractor shall use all aluminum duct material for the entire system. If dissimilar metals are used in the system, a flexible connection shall be used between the metals to eliminate any galvanic action.

3.3 SCHEDULES

A. DUCTWORK MATERIAL SCHEDULE

AIR SYSTEM	MATERIAL
Low Pressure Supply	Galvanized Steel
Outside Air Intake	Galvanized Steel
Return Air Duct	Galvanized Steel
Exhaust Air Duct	Galvanized Steel

B. DUCTWORK PRESSURE CLASS SCHEDULE

AIR SYSTEM PRESSURE CLASS	
Supply	1 inch
Return and Relief	1 inch
General Exhaust	1 inch
Outside Air Intake	1 inch

END OF SECTION

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SECTION 23 33 00

AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Volume controls dampers.
2. Damper Regulators.
3. Backdraft Dampers
4. Flexible duct connections.
5. Duct Access Doors.
6. Duct test holes.
7. Combination Smoke Fire Dampers
8. Motorized Dampers

B. Related Sections:

1. Section 23 31 00 - HVAC Ducts and Casings: Requirements for duct construction and pressure classifications.

1.2 REFERENCES

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

1. AMCA 500 - Test Methods for Louvers, Dampers, and Shutters.

B. ASTM International:

1. ASTM E1 - Standard Specification for ASTM Thermometers.

C. National Fire Protection Association:

1. NFPA 90A - Standard for the Installation of Air Conditioning and Ventilating Systems.
2. NFPA 92A - Recommended Practice for Smoke-Control Systems.

D. Sheet Metal and Air Conditioning Contractors National Association:

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

E. Underwriters Laboratories Inc.:

1. UL 555 - Standard for Safety for Fire Dampers.
2. UL 555C - Standard for Safety for Ceiling Dampers.
3. UL 555S - Standard for Safety for Smoke Dampers.

1.3 SUBMITTALS

A. See Division 1 - Submittal Procedures

B. Shop Drawings: Indicate for shop fabricated assemblies including volume control dampers, duct access doors and duct test holes.

- C. Product Data: Submit data for shop fabricated assemblies and hardware used.

1.4 CLOSEOUT SUBMITTALS

- A. See Division 1 - Execution and Closeout Requirements: Closeout procedures.
- B. Project Record Documents: Record actual locations of access doors and test holes.

1.5 QUALITY ASSURANCE

- A. Dampers tested, rated and labeled in accordance with the latest UL requirements.
- B. Damper pressure drop ratings based on tests and procedures performed in accordance with AMCA 500.

1.6 FIELD MEASUREMENTS

- A. Verify field measurements prior to fabrication.

1.7 COORDINATION

- A. See Division 1 - Administrative Requirements: Coordination and project conditions.
- B. Coordinate Work where appropriate with building control Work.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS - VOLUME CONTROL PRODUCTS

- A. Duro Dyne
- B. Farr
- C. Dowco
- D. Cesco
- E. Parker
- F. Nailor
- G. Greenheck
- H. Ruskin
- I. Air Balance

2.2 VOLUME CONTROL DAMPERS

- A. Fabricate in accordance with SMACNA Duct Construction Standards, and as indicated.
- B. Fabricate dampers of material same gauge as duct to 24 inches size in either direction, and two gauges heavier for sizes over 24 inches.

- C. Secure blade with continuous hinge or rod. Operate with minimum 1/4 inch diameter rod in self aligning, universal joint action flanged bushing with set screw.
- D. Fabricate single blade dampers for duct sizes through 9-1/2 x 30 inches.
- E. Fabricate multi-blade damper of opposed blade pattern with maximum blade from sizes 12 x 30 inch and larger. Assemble center and edge crimped blades in prime coated or galvanized channel frame with suitable hardware.
- F. Except in round ductwork 12 inches and smaller, provide end bearings. On multiple blade dampers, provide oil-impregnated nylon or sintered bronze bearings.
- G. Provide locking, indicating quadrant regulators on single and multi-blade dampers.
- H. On insulated ducts mount quadrant regulators on stand-off mounting brackets, bases, or adapters.

2.3 ACCEPTABLE MANUFACTURERS - CONCEALED DAMPER REGULATORS

- A. Duro-Dyne
- B. Young Regulator
- C. Roto-Twist
- D. United Enertech

2.4 CONCEALED DAMPER REGULATORS

- A. In inaccessible areas, i.e. plaster ceilings, use gear operated concealed damper regulators, set with hex nuts, similar to Duro Dyne Item #8008 Model SRC-380 (3/8" rod), with cast alloy corrosion resistive plated cover.
- B. At duct provide a 90° angle drive die cast miter-gear assembly similar to Duro Dyne Item #8135/Model #AD-38 (3/8" rod).
- C. If the concealed regulator cannot be mounted directly below the damper or if the 3/8" rod length exceeds 36" in length, a flexible cable drive may be utilized between the regulator and the damper.

2.5 ACCEPTABLE MANUFACTURERS - BACKDRAFT DAMPERS

- A. Louvers and Dampers.
- B. Safe-Air.
- C. Farr.
- D. Cesco, Inc.
- E. Ruskin
- F. Arrow United
- G. Creative Metals

- H. American Warming Co.
- I. Air Balance
- J. Nailor
- K. Greenheck, Inc.

2.6 BACKDRAFT DAMPERS.

- A. Gravity backdraft dampers, size 18x18 inches or smaller, furnished with air moving equipment, may be air moving equipment manufacturer's standard construction.
- B. Fabricate multi-blade, parallel action gravity balanced backdraft dampers of 18 gauge galvanized steel or aluminum with blades of maximum 6 inch width, with felt or flexible vinyl sealed edges, linked together steel ball bearings, and plated steel pivot pin; adjustment device to permit setting for varying differential static pressure similar to Model No. ABD-200 (Aluminum) or HDD-150 (Steel) manufactured by Louvers and Dampers.

2.7 ACCEPTABLE MANUFACTURERS - AIR AND EXTRACTING TURNING DEVICES

- A. J & J Register Co.
- B. Cesco, Inc.
- C. Hart & Cooley
- D. Duro-Dyne

2.8 AIR EXTRACTING DEVICES

- A. Multi-blade device with blades aligned in short dimension; steel or aluminum construction; with individually adjustable blades, mounting straps; Model AG-225 manufactured by Titus, Inc. or equal.

2.9 AIR TURNING DEVICES

- A. Provide and install turning vanes in square elbows whether shown or not on drawings. Install pre manufactured vanes and rails only, no shop fabricated turning vanes allowed.

2.10 ACCEPTABLE MANUFACTURERS - FLEXIBLE DUCT CONNECTIONS

- A. Ventfabrics
- B. Ventglas
- C. Duro-Dyne

2.11 INSULATED FLEXIBLE DUCT CONNECTIONS

- A. Fabricate in accordance with SMACNA Low Pressure Duct Construction Standards, and as indicated.
- B. UL listed fire-retardant neoprene coated woven glass fiber fabric to NFPA 90A, minimum density 20 oz per sq yd, approximately 6 inches wide, crimped into metal edging strip.

Insulate with one inch thick flexible fiberglass insulation and a flame safe jacket. Similar to Duro-Dyne's Insulflex connections.

2.12 ACCEPTABLE MANUFACTURERS - DUCT ACCESS DOORS

- A. Ventfabrics.
- B. Cesco.
- C. Ruskin.
- D. Advanced Air.
- E. National.
- F. Controlled Air.
- G. Creative Metals
- H. Nailor
- I. Kees

2.13 DUCT ACCESS DOORS

- A. Fabricate in accordance with SMACNA Low Pressure Duct Construction Standards and as indicated.
- B. Review locations prior to fabrication. Install the largest access door that will fit onto ductwork. Install door in a location that allows inspection and resetting of dampers.
- C. Fabricate rigid and close-fitting doors of galvanized steel with sealing gaskets and quick fastening locking devices. For insulated ductwork, install minimum one inch thick insulation with sheet metal cover.
- D. Access doors smaller than 12 inches square may be secured with sash locks.
- E. Provide two hinges and two sash locks for sizes up to 18 inches square, three hinges and two compression latches with outside and inside handles for sizes up to 24 x 48 inches. Provide an additional hinge for larger sizes.
- F. Access doors with sheet metal screw fasteners are not acceptable.

2.14 DUCT TEST HOLES

- A. Cut or drill temporary test holes in ducts as required. Cap with neat patches, neoprene plugs, threaded plugs, or threaded or twist-on metal caps.
- B. Permanent test holes shall be factory fabricated, air tight flanged fittings with screw cap. Provide extended neck fittings to clear insulation.

2.16 COMBINATION SMOKE/ FIRE DAMPERS

Acceptable Manufacturers

- A. Safe-Air, Inc.
- B. Air Balance.
- C. Prefco, Inc.
- D. National Controlled Air
- E. Advanced Air Corp.
- F. Cesco
- G. Ruskin
- H. Creative Metals
- I. Greenheck Fan Corp.
- J. Nailor
- K. Arrow Industries
- L. Pottorff
- M. Shoemaker

2.2 STATIC FIRE DAMPERS

- A. Fire Rating: UL 555 classified and labeled as a 1-1/2 hour static fire damper.
- B. Air Flow Rating: UL approved for dual directional air flow.
- C. Integral Sleeve Frame: Minimum 20 gauge by 12 inches roll formed, galvanized steel.

1. Factory Sealant: Apply to dampers in HVAC systems with pressures to maximum 4 inches wg.
- D. Blades:
1. Style: Curtain type, in airstream.
 2. Action: Spring or gravity closure upon fusible link release.
 3. Orientation: Horizontal.
 4. Material: Minimum 24 gage roll formed, galvanized steel.
- E. Closure Springs: Type 301 stainless steel, constant force type, if required.
- F. Temperature Release Device:
1. Fusible link, 165 degrees F, Electro-thermal link, 24 VAC or VDC, 165°F.
 2. Mounting: Vertical and/or Horizontal.
- G. Duct Transition Connection, Damper Style:
1. B style - rectangular connection, blades out of air stream, high free area.
 2. A style - rectangular connection, frame and blades in air stream.
- H. Finish: Mill galvanized.
- I. Picture Frame Mounting Angles:
1. One-piece, roll formed retaining angles 1-1/2 x 1-1/2 inches.
 2. Factory matched and shipped attached to damper.

2.3 COMBINATION SMOKE AND FIRE DAMPERS (AUTO- SMOKE OPERATION)

- A. Greenheck Model #FSD-212 or equal in accordance with NFPA 90A and UL 555S and as indicated.
- B. Damper to be Class II rated for 350° F, 2000 FPM, and 4" S.P. differential.
- C. Provide factory sleeve for each damper. Install smoke damper operator and electric temperature sensor on exterior of sleeve and connect to damper operating shaft.
- D. Seals to be extruded silicone rubber.

- E. Fabricate damper with multiple blades having 16 gauge galvanized steel frame and blades, oil-impregnated bronze or stainless steel sleeve bearings and plated steel axles, stainless steel jamb seals, stainless steel closure spring, blade stops, and lock, and 1/2 inch actuator shaft.
- F. Electric thermostat link to be rated at 165° F and UL listed.
- G. Operators shall be electric type suitable to operate on 120 V AC, 60 cycle. Combination operator and damper shall be UL listed and labeled as a unit, internally mounted damper motor.
- H. Mechanical contractor shall coordinate with Electrical Contractor on wiring the smoke detector system and shall provide all necessary wiring diagrams and information. Smoke detection tie-in wiring and connections provided by Electrical Contractor.
- I. Damper shall be opened and held open by the motor operator. On a loss of power or interruption of power by smoke or heat sensors, the damper operator will permit the damper to close. Motor to be located in area accessible by either an access panel or outside of rated wall.
- J. Provide 5 extra fire damper links for each style installed. Turn over to owner's representative.

2.17 MOTORIZED DAMPERS

- A. Furnish and install Low Leak Motorized Dampers where shown on plans. Wiring by Division 26.
- B. Dampers to be multi-blade style.
- C. Damper motors to be 120 volt 2 position with end switch.
- D. Approved Manufacturers.
 - 1. Greenheck
 - 2. Ruskin
 - 3. Nailor
 - 4. Cesco
 - 5. Arrow

PART 3 - EXECUTION

3.1 EXAMINATION

- A. See Division 1 - Administrative Requirements: Coordination and project conditions.
- B. Verify rated walls are ready for fire damper installation.

- C. Verify ducts and equipment installations are ready for accessories.
- D. Check location of air outlets and inlets and make necessary adjustments in position to conform to architectural features, symmetry, and lighting arrangement.

3.2 INSTALLATION.

- A. Install in accordance with NFPA 90A, and follow SMACNA HVAC Duct Construction Standards - Metal and Flexible. Refer to Section 23 31 00 for duct construction and pressure class.
- B. Access Doors: Install access doors at water coils, dampers (either fire or smoke fire) in the largest size that will fit onto ductwork in a location that offers unobstructed access to coils or dampers.
- C. Access Door Sizes: Install minimum 8 x 8 inch size for hand access, 18 x 18 inch size for shoulder access, and as indicated on Drawings. Review locations prior to installation.
- D. Provide balancing dampers at points on low pressure supply return and exhaust systems where branches are taken from larger ducts add additional dampers as required during air balancing. Provide these whether shown or not drawn on print and located in accessible location.
- E. Provide backdraft dampers in relief ducts, for exhaust fans or exhaust ducts nearest to outside wall/roof or where indicated.
- F. Provide flexible connections immediately adjacent to equipment in ducts associated with fans and motorized equipment and supported by vibration isolators.
- G. Provide balancing dampers at points on supply, return, and exhaust systems where branches are taken from larger ducts as required for air balancing. Install minimum 2 duct widths from duct take-off.
- H. Provide duct test holes where indicated and required for testing and balancing purposes.
- I. Motorized Low Leak Dampers with end switches to prove dampers are open prior to energizing Exhaust fans.

END OF SECTION

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SECTION 23 34 00

HVAC FANS

PART 1 GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Cabinet Exhausters.
 - 2. Roof Mounted Fan
 - 3. Ceiling Mounted Bathroom Exhaust fans
- B. Related Sections:
 - 1. Section 23 05 13 - Common Motor Requirements for HVAC Equipment: Product requirements for motors for placement by this section.
 - 2. Section 23 05 48 - Vibration 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 09 00 - Instrumentation and Control for HVAC: Product requirements for control components to interface with fans.
 - 5. Section 23 09 23 - Direct-Digital Control System for HVAC: Controls remote from unit.
 - 6. Section 23 31 00 - HVAC Ducts and Casings: Product requirements for hangers for placement by this section.
 - 7. Section 23 33 00 - Air Duct Accessories: Product requirements for duct accessories for placement by this section.
 - 8. Section 26 05 03 - Equipment Wiring Connections: Execution and product requirements for connecting equipment specified by this section.

1.2 REFERENCES

- 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. National Electrical Manufacturers Association:
 - 1. NEMA MG - Motors and Generators.
 - 2. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).
- D. Underwriters Laboratories Inc.:
 - 1. UL 705 - Power Ventilators.

1.3 SUBMITTALS

- A. See Division 1 - Submittal Procedures
- B. Shop Drawings: Indicate size and configuration of fan assembly, mountings, weights, ductwork and accessory connections.
- C. Product Data: Submit data on each type of fan and include accessories, fan curves with specified operating point plotted, power, RPM, sound power levels for both fan inlet and outlet at rated capacity, electrical characteristics and connection requirements.
- D. Manufacturer's Installation Instructions: Submit fan manufacturer's instructions.
- E. Manufacturer's Certificate: Certify products meet or exceed specified requirements.

1.4 CLOSEOUT SUBMITTALS

- A. See Division 1 - Execution and Closeout Requirements
- B. Operation and Maintenance Data: Submit instructions for lubrication, motor and drive replacement, spare parts list, and wiring diagrams.

1.5 QUALITY ASSURANCE

- A. Performance Ratings: Conform to AMCA 210 and bear AMCA Certified Rating Seal.
- B. Sound Ratings: AMCA 301, tested to AMCA 300 and bear AMCA Certified Sound Rating Seal.
- C. UL Compliance: UL listed and labeled, designed, manufactured, and tested in accordance with UL 705.
- D. Balance Quality: Conform to AMCA 204.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. See Division 1 - Product Requirements: Product storage and handling requirements.
- B. Protect motors, shafts, and bearings from weather and construction dust.

1.7 FIELD MEASUREMENTS

- A. Verify field measurements prior to fabrication.

PART 2 PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Greenheck Fan Co.
- B. Carnes, Inc.
- C. Acme Fan Co.
- D. Loren Cook

E. Penn Berry

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Secure roof exhausters with stainless steel lag screws to roof curb, if applicable.
- C. Coordinate installation with other affected Contractors.

3.2 SCHEDULE

- A. See schedule on Drawings.
- B. If using Approved Equal equipment, verify that all requirements on the basis of design are met. If electrical sizing is different from plans the Mechanical Contractor will be responsible for added costs.

END OF SECTION

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SECTION 23 37 00
AIR INLETS AND OUTLETS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Diffusers.
2. Registers
3. Grilles.
4. Louvers

B. Related Sections:

1. See Division 1 - Painting and Coating: Execution and product requirements for Painting of ductwork visible behind outlets and inlets specified by this section.
2. Section 23 33 00 - Air Duct Accessories: Volume dampers for inlets and outlets.

1.2 REFERENCES

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

1. AMCA 500 - Test Methods for Louvers, Dampers, and Shutters.

B. American Society of Heating, Refrigerating and Air-Conditioning Engineers:

1. ASHRAE 70 - Method of Testing for Rating the Performance of Air Outlets and Inlets.

C. Sheet Metal and Air Conditioning Contractors National Association:

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

1.3 SUBMITTALS

A. See Division 1 - Submittal Procedures

B. Product Data: Submit sizes, finish, and type of mounting. Submit schedule of outlets and inlets showing type, size, location, application, and noise level.

1.4 CLOSEOUT SUBMITTALS

A. See Division 1 - Execution and Closeout Requirements: Closeout procedures.

B. Project Record Documents: Record actual locations of air outlets and inlets.

1.5 QUALITY ASSURANCE

A. Test and rate diffuser, register, and grille performance in accordance with ASHRAE 70.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS - CEILING DIFFUSERS/GRILLES/REGISTERS AND LOUVERS

- A. Titus Manufacturing Co.
- B. Hart & Cooley
- C. Shoemaker
- D. E. H. Price Company
- E. Metal-Aire.
- F. Tuttle & Bailey.
- G. Kees.
- H. Nailor
- I. Greenheck
- J. Ruskin

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install items in accordance with manufacturer's instructions.
- B. Where the grille relates visually to another component of the building construction, the grille must be properly centered or spaced to conform with that element of the building. Where grilles occur in the ceiling which is modular such as tile, etc., the grille must be installed to line up with the normal ceiling lines.
- C. Check location of outlets and inlets and make necessary adjustments in position to conform with architectural features, symmetry and lighting arrangement. Control joints in walls and ceilings shall not be intersected by grille, register or diffuser.
- D. The sheet metal installer shall verify the placement of the grille so that the final location will line up with the rest of the building elements.
- E. All fixed grilles and registers shall be installed with the blades in the position which will be most effective in obscuring the duct beyond from view, and where the duct surface remains visible from any normal viewing angle, the internal surfaces of the duct shall be painted dull black with suitable material.
- F. Install diffusers to ductwork with air tight connection.
- G. Verify ceiling systems are ready for installation

- H. Install balancing dampers on duct take-off to diffusers, grilles, and registers, whether or not dampers are furnished as part of diffuser, grille, and register assembly.
- I. Paint visible portion of ductwork behind air outlets and inlets matte black.

3.2 AIR OUTLET AND INLET SCHEDULE

- A. See Schedule on Plans.

END OF SECTION

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**SECTION 23 55 33
FUEL-FIRED UNIT HEATERS**

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This Section includes gas-fired unit heaters.

1.2 RELATED WORK

- A. General mechanical requirements and items, which are common to more than one section of Division 23.

1.3 QUALITY ASSURANCE

- A. Refer to specification Section 23 05 00, BASIC PLUMBING AND HVAC REQUIREMENTS

1.4 SUBMITTALS

- A. Submit in accordance with specification's for SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES
- B. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for each type of product indicated.

1.5 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. National Fire Protection Association (NFPA):
54-2002 National Fuel Gas Code

PART 2 - PRODUCTS

2.1 GAS-FIRED UNIT HEATERS

- A. Description: Factory assembled, piped, and wired, and complying with ANSI Z83.8/CSA 2.6.
- B. Fuel Type: Design burner for natural gas having characteristics same as those of gas available at Project site.
- C. Type of Venting: Power vented.
- D. Housing: Steel, with integral draft hood and inserts for suspension mounting rods.
1. External Casings and Cabinets: Baked enamel over corrosion-resistant-treated surface.
 2. Suspension Attachments: Reinforce suspension attachments at connection to fuel-fired unit heaters.
- E. Heat Exchanger: Aluminized steel.
- F. Burner Material: Stainless or Aluminized steel.
- G. Unit Fan: Aluminum propeller blades riveted to heavy-gage steel spider bolted to cast-iron hub, dynamically balanced, and resiliently mounted.
1. Fan-Blade Guard: Galvanized steel, complying with OSHA specifications, removable for maintenance.

2. General requirements for motors are specified in Section 23 05 13 Common Motor Requirements for HVAC and Plumbing Equipment.
 - a. Motors: Totally enclosed with internal thermal-overload protection.
- H. Controls: Regulated redundant gas valve containing pilot solenoid valve, electric gas valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff all in one body.
 1. Gas Control Valve: Modulating.
 2. Ignition: Electronically controlled electric spark with flame sensor.
 3. Fan Thermal Switch: Operates fan on heat-exchanger temperature.
 4. Vent Flow Verification: Flame rollout switch.
 5. Control transformer.
 6. High Limit: Thermal switch or fuse to stop burner.
 7. Thermostat: wall-mounting type with fan on switch.
- I. Discharge Louvers: Independently adjustable horizontal blades.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install and connect gas-fired unit heaters and associated fuel and vent features and systems according to NFPA 54, applicable local codes and regulations, and manufacturer's written installation instructions.
- B. Suspended Units: Suspend from substrate using threaded rods, spring hangers, and building attachments. Secure rods to unit hanger attachments. Adjust hangers so unit is level and plumb.

3.2 CONNECTIONS

- A. Install piping adjacent to fuel-fired unit heater to allow service and maintenance.
- B. Gas Piping: Comply with Section 22 11 23 Facility Natural-Gas Piping. Connect gas piping to gas train inlet; provide union with enough clearance for burner removal and service.
- C. Ground electric convection heating units according to Section 26 05 26 Grounding and Bonding for Electrical Systems.
- D. Connect wiring according to Section 26 05 21 Low-Voltage Electrical Power Conductors and Cables.

3.3 FIELD QUALITY CONTROL

- A. Tests and Inspections:
 1. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 2. Verify bearing lubrication.
 3. Verify proper motor rotation.
- B. Remove and replace malfunctioning units and retest as specified above.

3.4 ADJUSTING

- A. Adjust initial temperature set points.
- B. Adjust burner and other unit components for optimum heating performance and efficiency.

END OF SECTION

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SECTION 23 81 27

SPLIT-SYSTEM HEATING AND COOLING

PART 1 - GENERAL

1.1 SECTION INCLUDES:

- A. Forced air furnaces.
- B. Air cooled condensing units
- D. Indoor ductless fan/coil units.
- E. Controls.

1.2 RELATED SECTIONS

- A. Section 22 11 23 – Plumbing Piping: Natural gas piping.
- B. Section 22 13 00 – Plumbing Piping: Equipment drains.
- C. Section 23 31 00 – HVAC Ducts and Casings
- D. Section 26 27 17 – Equipment Wiring: Electrical characteristics and wiring connections and installation and wiring of thermostats and other controls components.

1.3 REFERENCE STANDARDS

- A. ARI 210/240 – Standard for Performance Rating of Unitary Air Conditioning and Air-Source Heat Pump Equipment; Air-Conditioning, Heating, and Refrigeration Institute; 2006.
- B. ARI 520 – Positive Displacement Condensing Units; Air-Conditioning, Heating, and Refrigeration Institute; 2004.
- C. ASHRAE Std 23 – Methods of Testing for Rating Positive Displacement Refrigerant Compressors and Condensing Units; American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.; 2004.
- D. ASHRAE Std 90.1 – Energy Efficient Design of New buildings Except Low-Rise Residential Buildings; American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.; 2004.
- E. ASHRAE Std 103 –Methods of Testing for Annual Fuel Utilization Efficiency of Residential Central Furnaces and Boilers; American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.; 1993 with 1996 Errata.
- F. NFPA 90A – Standard for the Installation of Air-Conditioning and Ventilating Systems; National Fire Protection Association; 2002.
- G. NFPA 90B - Standard for the Installation of Warm Air Heating and Air Conditioning Systems; National Fire Protection Association; 2006.
- H. NFPA 211 - Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances; National Fire Protection Association; 2006.

1.4 SUBMITTALS

- A. See Division 1 – Administrative Requirements, for submittal procedures.
- B. Product Data: Provide rated capacities, weights, accessories, electrical nameplate data, and wiring diagrams.
- C. Shop Drawings: Indicate assembly, required clearances, and location of size of field connections.
- D. Design Data: Indicate refrigerant pipe sizing.
- E. Manufacturer's Instructions: Indicate rigging, assembly, and installation instructions.
- F. Project Record Documents: Record actual locations of components and connections.
- G. Operation and Maintenance Data: Include manufacture's descriptive literature, operating instructions, cleaning procedures, replacement parts list, and maintenance and repair data.
- H. Warranty: Submit manufacturer warranty and ensure forms have been completed in Owners name and registered with manufacturer.

1.5 QUALITY ASSURANCE

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

1.6 WARRANTY

- A. See Division 1 – Closeout Submittals, for additional warranty requirements.

PART 2 - PRODUCTS

2.1 MANUFACTURES

- A. Approved
 - 1. Lennox
 - 2. Bryant
 - 3. Carrier
 - 4. Tempstar
- B. Substitutions: See Division 1 – Product Requirements.

2.2 SYSTEM DESIGN

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

1. Efficiency: Energy Efficiency Rating (EER)/Coefficient of Performance (COP) not less than requirements of ASHRAE Std 90.1; seasonal efficiency to ASHRAE Std 103.

2.3 INDOOR UNITS FOR DUCTED SYSTEM

- A. Indoor Units: Self-contained, packaged, factory assembled, pre-wired unit consisting of cabinet, supply fan, heating and cooling element(s), controls, and accessories; wired for single power connection with control transformer.
 1. Air Flow Configuration: Multipositional
 2. Cabinet: Steel with baked enamel finish, easily removed and secured access doors with safety interlock switches, glass fiber insulation with reflective liner.
- B. Supply Fan: Centrifugal type rubber mounted with direct or belt drive with adjustable variable pitch motor pulley.
 1. Motor: NEMA MG 1; 1750 rpm single speed, permanently lubricated, hinge mounted.
- C. Air Filters: 1 inch thick glass fiber, disposable type arranged for easy replacement.
- D. Evaporator Coils: Copper tube aluminum fin assembly, galvanized or polymer drain pan sloped in all directions to drain, drain connection, refrigerant piping connections, restricted distributor or thermostatic expansion valve.
 1. Construction and Ratings: In accordance with ARI 210/240 and UL listed.
 2. Manufacturers: System manufacturer.
 3. Refer to schedule plan.

2.4 INDOOR UNITS FOR DUCTLESS SYSTEMS – Not Applicable

- A. Indoor Units: Self-contained, packaged, factory assembled, pre-wired consisting of cabinet, supply fan, evaporator coil, and controls; wired for single power connection with control transformer.
- B. Evaporator Coils: Copper tube aluminum fin assembly, galvanized or polymer drain pan sloped in all directions to drain, drain connection, refrigerant piping connections, restricted distributor or thermostatic expansion valve.
 1. Construction and Ratings: In accordance with ARI 210/240 and UL listed.

2.5 OUTDOOR UNITS

- A. Outdoor Units: Self-contained, packaged, factory assembled, pre-wired consisting of cabinet, with compressor and condenser.
 1. Cabinet: Steel with baked enamel finish, easily removed and secured access doors with safety interlock switches, glass fiber insulation with reflective liner.
 2. Construction and Ratings: In accordance with ARI 210/240 with testing in accordance with ASHRAE Std 23 and UL listed.
- B. Compressor: ARI 520; hermetic, two speed 1800 and 3600 rpm, resiliently mounted integral with condenser, with positive lubrication, crankcase heater, high pressure control, motor overload protection, service valves and drier. Provide time delay control to prevent short cycling and rapid speed changes.
- C. Air Cooled Condenser: ARI 520; Aluminum fin and copper tube coil, with direct drive axial propeller fan resiliently mounted, galvanized fan guard.

- D. Accessories: Filter drier, high pressure switch (manual reset), low pressure switch (automatic reset), service valves and gage ports, thermometer well (in liquid line).
- E. Operating Controls:
 - 1. Control by room thermostat to maintain room temperature setting.
 - 2. Low Ambient Kit: Provide refrigerant pressure switch to cycle condenser fan on when condenser refrigerant pressure is above 285 psig and off when pressure drops below 140 psig for operation to 0 degrees F.
- F. Mounting Pad: Manufactured Condensing pad or poured concrete pad per plans

2.6 GAS FURNACE COMPONENTS

- A. Heat Exchanger: Aluminized steel ceramic coated clamshell type welded construction.
- B. Burner: Sealed Combustion type with direct venting connections
 - 1. Gas valve, two stage provides 100 percent safety gas shut-off; 24 volt combining pressure regulation, safety pilot, manual set (ON-OFF), pilot filtration, automatic electric valve.
 - 2. Electronic pilot ignition, with electric spark igniter.
 - 3. Combustion air damper with synchronous spring return damper motor.
 - 4. Non-corrosive combustion air blower with permanently lubricated motor.
- C. Burner Safety Controls:
 - 1. Thermocouple Sensor: Prevents opening of gas valve until pilot flame is proven and stops gas flow on ignition failure.
 - 2. Flame Rollout Switch: Installed on burner box and prevents operation.
 - 3. Vent Safety Shutoff Sensor: Temperature sensor installed on draft hood and prevents operation, manual reset.
 - 4. Limit Control: Fixed stop at maximum permissible setting, de-energizes burner on excessive bonnet temperature, automatic resets.
- D. Operating Controls:
 - 1. Cycle burner by room thermostat to maintain room temperature setting.
 - 2. Supply fan energized room bonnet temperature independent of burner controls, with adjustable timed off delay and fixed timed on delay, with manual switch for continuous fan operation.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify that substrates are ready for installation of units and openings are as indicated on shop drawings.
- B. Verify that proper power supply and fuel supply is available and in correct location.

3.2 INSTALLATION

- A. Install in accordance with NFPA 90A, NFPA 90B and NFPA 211.
- B. Provide Condensate piping and from equipment to locations shown on plans. Conform with Section 22 13 00. Provide approved condensate pump if required.

3.3 SCHEDULES: See Schedule on plans.

END OF SECTION

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