

SECTION 230529
HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section describes hangers and supports for piping, ductwork and equipment in HVAC systems.

1.2 PERFORMANCE REQUIREMENTS

- A. Structural Performance: Hangers and supports for HVAC piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.
1. Design supports for multiple pipes capable of supporting combined weight of supported systems, system contents, and test water.
 2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

1.3 SUBMITTALS

- A. Submit for review:
1. Product data, including installation instructions for each type of support and anchor, materials of construction, finish and rated load capacities.
 2. Shop drawings for each type of support and anchor, indicating dimensions, weights, required clearances and assembly methods of components.
 3. Maintenance data on items requiring maintenance.

1.4 QUALITY ASSURANCE

- A. Materials, design and manufacturer of pipe hangers and supports shall conform to MSS SP-58.
1. Selection and application of pipe hangers and supports shall conform to MSS SP-69, except where more stringent requirements are specified in this section.
 2. Fabrication and installation practices of pipe hangers and supports shall conform to MSS SP-89, except where more stringent requirements are specified in this section.
 3. All work shall conform to the ANSI/ASME Codes for Pressure Piping specified above.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Acceptable Manufacturers, subject to compliance with requirements:
 - 1. Pipe Hangers, Pipe Clamps and Wall Brackets: Anvil Intl. Inc., Carpenter & Patterson, National Pipe Hanger, B-Line, Pipe Shields, Inc.
 - 2. Pipe Insulation Protection Shields: Anvil Intl. Inc., Carpenter and Patterson, National Pipe Hanger, B-Line, Value Engineered Products.
 - 3. Hanger Inserts: Anvil Intl. Inc., National Pipe Hanger, B-Line.
 - 4. Spring Hangers: Anvil Intl. Inc., Power Piping Company, Carpenter & Patterson, National Pipe Hanger, B-Line.
 - 5. Trapeze Hangers: Unistrut, Anvil Intl. Inc., (Power-Struct), National Pipe Hanger, B-Line.
 - 6. U Bolts: Anvil Intl. Inc., B-Line, Carpenter & Patterson, National Pipe Hanger.

2.2 GENERAL

- A. Pre-galvanize strut channels in accordance with ASTM A653 G90.
- B. Paint hangers and clamps for support of bare copper piping with copper colored epoxy.
- C. Zinc-plate hangers not in direct contact with copper pipe in accordance with ASTM B633.SC3.

2.3 HANGER RODS

- A. Hanger rods shall be threaded at both ends or continuously threaded rods of circular cross-section. Provide adjusting locknuts at upper attachments and hangers.
- B. Provide hanger rods for the following pipe sizes as tabulated as a minimum for single rigid rod hangers, subject to the load ratings of MSS-SP-58. Hanger rods may be reduced one (1) size for double rod hangers with 3/8-inch minimum diameter.

| Pipe Size - Inches | Minimum Rod Diameter - Inches |
|--------------------|-------------------------------|
| 1/2 to 2 | 3/8 |
| 2-1/2 to 3 | 1/2 |

2.4 UNINSULATED COPPER TUBING SUPPORTS

- A. Size hangers to fit copper tubing outside diameters.
 - 1. Adjustable steel swivel ring, band type hanger, B-Line B3170 CT.
 - 2. Malleable iron ring hanger, B-Line B3198RCT or hinged ring hanger B3198HCT.
 - 3. Malleable iron split-ring hanger with eye socket, B-Line B3173CT with B3222.
 - 4. Adjustable steel clevis hanger, B-Line B3104CT.
- B. For supporting vertical runs provide epoxy painted or plastic coated riser clamps, B-Line B3373CT or B3373CTC.

2.5 INSULATED HORIZONTAL PIPING HANGERS

- A. Heating Hot Water
 - 1. 2-inch and smaller pipe: Provide adjustable steel clevis, B-Line B3100 with pipe insulation protection shield as indicated.

2.6 PIPE INSULATION PROTECTION SHIELDS

- A. Acceptable Manufacturers, subject to compliance with requirements:
 - 1. B-Line B-3151
 - 2. Carpenter & Paterson
 - 3. Anvil Intl., Inc.
 - 4. National Pipe Hanger 300
- B. Provide pipe insulation protection shields on all insulated piping and tubing.
 - 1. Shields shall be of galvanized steel construction, 16 gauge minimum thickness, and with a saddle arc of 120 degrees minimum.
 - 2. Shield length shall increase with increase in support spacing, and shall be based on the insulation manufacturer's recommendations.
- C. Pipe support spacing shall be as stated in ASHRAE. See pipe support spacing tables, this specification section.

2.7 VERTICAL SUPPORTS

- A. Riser clamp sized to fit outside diameter of pipe, B-Line B3373.
- B. Riser clamp sized to fit outside diameter of copper tubing, B-Line B3373CT.

2.8 BEAM CLAMPS

- A. For Piping 1-inch in diameter and smaller: C-Clamps shall have lock nuts and cup point set screws, B-Line B351L, or B3036L. Provide top flange C-clamps when attaching a hanger rod to the top flange of structural shapes, B-Line B3034 or B3033. Refer to manufacturers' recommendation for set screw torque. Provide retaining straps to maintain the position on the beam where required.
- B. For Piping Larger than 1-inch in diameter: Steel clamps shall be B-Line B3050, or B3055. Malleable iron or forged steel beam clamps with cross bolt shall be B-Line B3054 or B3291-B3297 Series as required to fit beams.

2.9 BRACKETS

- A. Welded strut bracket and pipe straps, B-Line B3064 and B2000 series.
- B. Welded steel brackets, B-Line B3066 or B3067, with roller chair or adjustable steel yoke pipe roll. B-Line B3120 or B3110.

2.10 SPRING HANGERS

- A. Light loads, movement less than 1/4-inch, B-Line B3262 or B3264.
- B. Medium loads, movement 1/4-inch through 3/4-inch, Anvil Intl. Inc., Figure No. B-268.
- C. Heavy loads, movement exceeding 3/4-inch, Anvil Intl. Inc., Figure No. 98.
- D. Sway bracing, Anvil Intl. Inc., Figure No. 301.

2.11 DUCT HANGERS AND SUPPORTS

- A. Provide trapeze, strap or angle iron hangers meeting SMACNA, HVAC Duct Construction Standards - Metal and Flexible, and BOCA Mechanical Code.
- B. Materials of hangers, supports and fasteners shall conform to the manufacturer's load ratings.
- C. Hangers, supports, upper attachments and inserts shall be hot-dip galvanized steel, aluminum, or stainless steel to match the ductwork being supported.

2.12 SUPPLEMENTAL STEEL

- A. Attach hangers to the building structural beams. Where hangers do not correspond with the building structural beams, provide supplemental steel members fastened to the building structural steel beams. Provide two (2) coats of primer on the supplemental steel. Submit details of hanger attachments to the building structure to the Architect for approval before drilling or burning holes in the structure.
- B. Design and fabricate supports using structural quality steel bolted framing materials.

Channels shall be roll formed, 12 gauge ASTM A 570 Grade 33 steel, 1-5/8" x 1-5/8" or greater as required by loading conditions. Provide clamps and fittings designed for use with the strut system.

2.13 U-BOLTS

- A. Heavy-Duty Carbon Steel: B-Line Numbers B3188 and B3188N5.

2.14 SHOP PAINTING

- A. Shop-paint all carbon steel hangers and supports in exposed areas.

2.15 DIELECTRIC CONTROL

- A. For copper tubing in contact with metallic pipe clamps, brackets or supports, provide an insulating pipe clamp assembly with plastic cushion. Pipe clamp assembly shall eliminate metal-to-metal contact and form an insulating liner to prevent galvanic action between copper tubing and metallic clamps, brackets and supports.

2.16 PREFABRICATED ROOF CURBS AND EQUIPMENT SUPPORTS

- A. Acceptable Manufacturers, subject to compliance with requirements: Custom Curb, Pate, ThyCurb, Vent Products, Curbs Plus, RPS.
- B. General: Size curbs and equipment supports as required to suit roof opening and equipment base. Curbs shall be a minimum of 24-inches high, unless indicated otherwise. Refer to Architectural and Structural drawings for roof slope at curb/support location and for installation details. Construct to fit single or double roof pitches as required. Construct and certify load carrying capacity to suit equipment weight and wind loads with not less than 100% safety factor.
- C. Equipment and Duct Mounting Supports: Where indicated on drawings, provide supports tested and certified for load carrying capacities; minimum 14 gauge galvanized steel; mitered and welded corners; internal reinforcing supports welded; self-flashing and mounting flange; 2 x 2 chemically treated wood nailer and counterflashing cap.

PART 3 - EXECUTION

3.1 INSTALLATION - PIPE HANGERS AND SUPPORTS

- A. Support horizontal pipe runs using hangers and supports. Space the hangers so that the supported load does not exceed the load recommended by the hanger manufacturer. Space the hangers so they do not exceed the support spacing requirements listed in this Section. The supported load shall not overstress the building structural members.
- B. Support vertical pipe at each floor using riser clamps. When run in a shaft, support riser clamps on both sides of the clamp. Support piping less than 1-1/4-inch every 8 feet with pipe clamps.
- C. For pipe supported on rod hangers, provide roller hangers where thermal movement will

cause the hanger rod to deviate more than 4 degrees from the vertical, or where longitudinal expansion will cause a movement of more than 1/2-inch in the piping.

- D. Wall brackets are acceptable where pipes are adjacent to walls or other vertical surfaces which may be used for support.
- E. For the support of two or more pipes of similar temperatures running adjacent to each other at the same elevation and at the same slope, structural steel trapeze hangers are acceptable. Limit the longitudinal hanger spacing to suit the smaller diameter pipe.
- F. Support riser piping independently from the connected horizontal piping.
- G. Provide isolation hangers and supports as specified under Section 230548.
- H. Do not provide pipe hooks, chains or perforated steel strap for pipe supports.
- I. Do not support piping from ceiling supports, ductwork, equipment, cable trays, electrical conduit or other piping.
- J. Do not hang piping from metal floor deck, metal roof deck or steel joists.
- K. Cut off excess hanger rod lengths. Secure rods by use of locknuts or elastic stop nuts.
- L. Support the base of vertical pipe stacks, except copper water pipe risers, with a base leg. Cut the top of the base leg to shape and completely weld to the heel of the base elbow. Weld leg support to a bearing plate and bolt to the floor. Locate base leg on the vertical pipe centerline.
- M. Provide maximum support spacing as listed below. Locate one support within one foot on both sides of concentrated pipe-mounted loads, including valves, meters, and pumps. Reduce the span, if required, to comply with the load ratings of the supports/hangers, and so as to not overstress the supporting structural members.

1. Support standard-weight steel piping for water services as follows:

| Nominal Pipe Size (Inches) | Maximum Support Spacing (Feet) |
|-------------------------------|-----------------------------------|
| 1/2 | 7 |
| 3/4 | 7 |
| 1 | 7 |
| 1-1/2 | 9 |
| 2 | 10 |
| 2-1/2 | 11 |
| 3 | 12 |

2. Support copper tubing as follows:

| Nominal Pipe Size (Inches) | Maximum Horiz. & Vert. Support Spacing (Feet) |
|-------------------------------|--|
| 1/4 to 1/2 | 5 |
| 5/8 to 3/4 | 5 |
| 1 | 6 |
| 1-1/4 | 7 |
| 1-1/2 | 8 |
| 2 | 8 |
| 2-1/2 | 9 |
| 3 | 10 |

3.2 INSTALLATION - DUCT HANGERS AND SUPPORTS

- A. Support ductwork using trapeze, strap or angle iron hangers conforming to SMACNA HVAC Duct Construction Standards - Metal and Flexible, and International Mechanical Code. Provide supplemental structural steel to span joists where required. Deflection of supplemental structural steel shall be limited to 1/180 of the span.
- B. Do not support ductwork from furring, hung ceilings, metal floor deck, metal roof deck or from another duct or pipe.
- C. Do not hang lighting fixtures or piping from ductwork.
- D. Where vertical ducts penetrate floor openings, follow the detail identified in the SMACNA HVAC Duct Construction Standards - Metal and Flexible.
- E. Where duct connects to or terminates at masonry openings or at floors where concrete curbs are not present, follow the detail identified in the SMACNA HVAC Duct Construction Standards - Metal and Flexible.
- F. For insulated ductwork, install hangers on the outside of the insulation. To maintain the insulation value, inset a piece of 1-inch thick, 6 pcf fiberglass board with a foil/scrim/kraft (FSK) jacket at these supports.

3.3 SUPPORTS FROM EXISTING CONCRETE

- A. Attach with drilled in mechanical anchors, Hilti or equal, or other approved means, lead shield anchors and powder or power fasteners are not acceptable.

++ END OF SECTION ++

230593
TESTING, ADJUSTING, AND BALANCING (TAB) FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section describes testing, adjusting and balancing of air, **[steam]** and water systems.

1.2 SUBMITTALS

- A. Submit for review:
1. Inspection reports.
 2. Associated Air Balance Council (AABC) or National Environmental Balancing Bureau (NEBB) Certification.
 3. Written step-by-step procedures to be used for the testing and balancing of each system before starting work, including specific reference to components and sequence of testing, adjusting, and balancing (TAB).
 4. List of instruments to be used for each test. Include instrument calibration dates.
 5. Testing and balancing reports, including preliminary and final balance data sheets.

1.3 QUALITY ASSURANCE

- A. The Testing, Adjusting and Balancing Agency shall be certified by the Associated Air Balance Council (AABC) or the National Environmental Balancing Bureau (NEBB).

PART 2 - PRODUCTS

2.1 SYSTEM BALANCE - GENERAL

- A. Provide all instruments, materials and equipment required for testing.
- B. Test and calibrate all instruments permanently installed and those portable instruments used by the balancer.
- C. Perform the work, using methods and test forms published by AABC National Standards for Total System Balance, or using equivalent NEBB methods and forms.
- D. Using controls and devices installed, test and balance air conditioning systems with maximum attainable internal load, including lights and equipment, or simulated maximum load using automatic temperature controls, whichever is closest to design operating conditions.
- E. Perform the final testing and balancing of air handling systems and sound testing, with finished ceilings and partitions in place, and doors closed.

- F. Owner may witness final system testing, adjustments and balancing.
- G. Perform complete balancing services for standby equipment. Verify and report that final terminal device flows and transfer air flows are also achieved when operation is switched to standby equipment.
- H. Submit certification of the accuracy of instruments used by the Testing and Balancing Agency. Show date and method of calibration.
 - 1. Furnish instruments that have been calibrated within six (6) months prior to the estimated commencement date of testing and balancing work.
- I. Verify the accuracy of permanently-installed flow-measuring primary elements and their associated readout instruments, thermometers, sensors, and pressure gauges provided as part of the Work.
 - 1. Verification may be by calculation and calibration of the primary element and read-out instrument, or by independent measurement of flow rate, temperature or pressure of flow, of same flowing medium using calibrated instruments.
 - 2. Submit report of calibration accuracy.

2.2 AIR BALANCING

- A. Altered System(s)
 - 1. Balance to achieve revised flow at existing fans, and in altered or new spaces served by existing systems, and to maintain existing flow in spaces that are not altered.
 - a. Make recommendations, where appropriate, for additional motor, motor drive, or balancing damper changes to improve results.
- B. Verify that all ductwork, dampers, grilles, registers, and diffusers have been installed in accordance with Contract Documents, and set in the full open position. Perform the following TAB procedures:
 - 1. For Supply Fans:
 - a. Fan Speeds: Test and adjust fan speed (RPM) to achieve design CFM.
 - b. Current and Voltage: Test and record motor voltage and amperage, and compare data with the nameplate limits to ensure fan motor is not in or above the service factor.
 - c. Pitot-Tube Transverse: Perform a pitot-tube traverse of main supply and return ducts, as applicable, to obtain total airflow CFM.
 - d. Outside Air: Test and adjust the outside airflow on applicable equipment using a pitot-tube traverse. If a traverse is not practical use the mixed-air temperature method if the inside and outside temperature difference is at least 20°F (-6.7°C), or use the difference between pitot-tube traverses of the supply and return air ducts.
 - e. Static Pressure: Test and record system static profile of each supply fan.

2. For Return, Relief and Exhaust Fans:
 - a. Test and adjust fan speed (RPM) to achieve design CFM.
 - b. Test and record motor voltage and amperage, and compare data with the nameplate limits to ensure fan motor is not in the service factor.
 - c. Perform a pitot-tube traverse of the main return ducts to obtain total airflow CFM.
 - d. Test and record system static pressure profile of each return fan.

3. For Zone, Branch and Main Ducts :
 - a. Adjust ducts to within design CFM requirements.
 - 1) At least one zone balancing damper shall be completely open.
 - 2) Multi-diffuser branch ducts shall have at least one outlet or inlet volume damper completely open.
 - b. Minimum number of points for each duct traverse = 16.
 - c. The balancing report must show all points of the traverse taken and not just a summary of the data.
 - d. The maximum distance between test points is 6", unless the total number of readings equals over 64 points, in which case the distances can be increased over 6", but the total number of readings in this case should average around the 64 readings.

4. Room Air Outlets & Inlets: Test and adjust individual room air outlets and inlets under procedures recommended by the manufacturer.
 - a. Set outlets for air pattern required, and adjust all supply, return and exhaust air dampers for design CFM.
 - b. Change air patterns or settings, as necessary to achieve correct air balance.

- C. Balance air systems for correct operation, at both design maximum and design minimum outside air, and design maximum and design minimum return air.
- D. Balance air systems in all modes of operation, including warm-up mode.
- E. Create test holes in ducts for pitot-tube traverses. Seal test holes in ducts with snap-in plugs, not tape.
 1. Repair insulation where damaged.
 2. Mark insulation on exterior of duct where readings were taken.

2.3 HYDRONIC BALANCING

- A. System Mains and Branches
 1. Adjust water flow to achieve maximum or design GPM.
- B. Coils and Terminal Heat Transfer Equipment

1. Test, adjust, and balance all hydronic coils to design requirements, within the tolerance specified below.
 2. Verify the type, location, final pressure drop and GPM of each coil. Record this information on coil data sheets.
- C. Automatic Control Equipment: In addition to the above work, check the operation of automatic control equipment, and verify equipment set points.

2.4 PERFORMANCE TOLERANCE

- A. At conclusion of testing, adjusting and balancing work, actual air and water flow rates shall be within a plus-or-minus (+/-) ten (10) percent tolerance of the design flow rates.

PART 3 - EXECUTION

3.1 REPORTS

- A. Submit a separate test report for each air and hydronic system containing actual temperatures, pressure drops and flow rates at all terminal devices (i.e. air volume control units, grilles/registers/diffusers, coils, terminal heat transfer equipment, etc.), and compare to the design parameters.
1. Furnish a written detailed summary for each balanced system, which must include the following:
 - a. A complete detailed description on the procedures followed when the system was balanced.
 - b. A complete description of any deficiencies that still remain after the TAB work has been completed.
 2. TAB report identification numbering:
 - a. Furnish a system-by-system single line drawing showing all of the outlets & inlets with their corresponding TAB report numbers. This drawing must include the room numbers and a reasonable architectural layout.
 - b. Or, furnish a copy of the mechanical drawings, or a copy of the sheet metal shop drawings with the TAB Contractor's numbering sequence written on them.
- B. In addition to data required on AABC or NEBB forms, the following additional information is required for all scheduled equipment:
1. Motors: Type, amps per phase, frame number, serial number, motor horsepower, and calculated brake horsepower and efficiency at final conditions.
 - a. Every motor reported on, must include a calculated BHP.
 2. Fans: Blade design type such as air foil, backwardly inclined (BI), single inlet single width (SISW) or double width double inlet (DWDI), class and number of blades.

3. Hydronic Systems: Record GPM in each significant branch, and position of each balancing valve.
4. Air Volume Control Units: Test and record air flow and pressure, IN and OUT, of air volume control units, for all modes of operation.
 - a. Recalibrate factory setting of air flow on units, if it differs from Contract Documents.
5. Fan and Pump Systems: For systems controlled by static pressure, verify by test and record that devices, including high-limit controls, are calibrated to perform in compliance with Contract Documents.
 - a. In cooperation with the Building Automation System (BAS) Supplier, adjust the static pressure settings, no higher than necessary, to achieve design flows at the most demanding location.
 - b. Furnish and coordinate system static pressure settings with the Building Automation System.

3.2 PROCEDURES

- A. Where variable or fixed sheaves have been provided, determine the correct fan speed (rpm), and advise the Contractor of the correct fan speed and the required fixed-sheave diameter.
 1. Size final fixed sheaves such that, upon final balancing, the balancing devices at the fan and in the highest pressure drop duct run are open.
 2. Do not "choke" excess fan capacity with dampers to achieve final system balance; instead, change the speed of the fan.
 3. Verify the fan speed after the Contractor's installation of fixed sheaves.
- B. Where variable-speed pump or fan devices have been provided, adjust and mark their controls for proper setting to produce the design water and air flow rates.
- C. Protect read-out instruments from damage, and return them in good working order to the Contractor.
- D. Only direct-flow measurement may be used. Do not use indirect calculations, such as a "heat balance" or "pressure drop."

++ END OF SECTION ++

SECTION 230700
HVAC INSULATION

PART 1 - GENERAL

1.1 SUMMARY

- A. This section includes insulation materials, fire-rated insulation systems, insulating cements, adhesives, mastics, sealants, factory-applied jackets, field-applied jackets and tapes.

1.2 SUBMITTALS

- A. Product Data: For each type of product indicated, include thermal conductivity, thickness, and jackets (both factory and field applied, if any).
- B. Shop Drawings:
 - 1. Detail application of protective shields, saddles, and inserts for each type of insulation and hanger.
 - 2. Detail application of field-applied jackets.
- C. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction, indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include date of test and test methods employed.

1.3 DELIVERY, STORAGE AND HANDLING

- A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.
- B. Protect insulation against dirt, water, and mechanical damage.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.
- B. Fire-Test response Characteristics: Insulating and related materials shall have fire-test response characteristics indicated, as determined by testing identical products per ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing and inspecting agency.
 - 1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

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

1.5 COORDINATION

- A. Coordinate size and location of supports, hangers, and insulation shields specified in Division 23 Section "Hangers and Supports."
- B. Coordinate clearance requirements with piping Installer for piping insulation application, duct Installer for duct insulation application, and equipment Installer for equipment insulation application. Before preparing piping and ductwork Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

1.6 SCHEDULING

- A. Schedule insulation application after pressure testing systems. Insulation application may begin on segments that have satisfactory results.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

- A. Comply with requirements in Part 3 schedule articles for where insulating materials shall be applied.
- B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

2.2 FIBERGLASS PIPE INSULATION

- A. Acceptable Manufacturers, subject to compliance with requirements:
 1. CertainTeed Corp.
 2. Johns Manville, Micro-Lok.
 3. Knauf Insulation GmbH, Pipe Insulation.
 4. Owens-Corning, FIBERGLAS.
- B. Pipe insulation, meeting ASTM Standard C 547, consisting of inorganic glass fibers bonded with thermosetting resin, molded into tubular sections split lengthwise, approximately 3.5 lb per cu ft, thermal conductivity of 0.23 Btu·in/h·sq ft·F at 75 deg F.
- C. Jackets shall be factory-applied, composite with insulation, with maximum water vapor permeance of 0.02 perms, fabricated from white kraft paper bonded to aluminum foil, reinforced with fiberglass scrim. Acceptable Manufacturer, subject to compliance with requirements: Johns-Manville AP-T.

2.3 FLEXIBLE DUCT WRAP INSULATION

- A. Acceptable Manufacturers, subject to compliance with requirements:
 - 1. CertainTeed Corp., SoftTouch
 - 2. Johns Manville Corp.
 - 3. Knauf Insulation GmbH, Friendly Feel
 - 4. Owens Corning, SOFTR
- B. Flexible blanket-type insulation shall consist of fiber glass bonded with thermosetting resin to form resilient blanket, with factory-applied foil-scrim-kraft facing of aluminum foil reinforced with fiber glass yarn and laminated to 40 pound chemically-treated fire-resistant kraft, approximately 0.75 pound per cubic foot, with thermal conductivity of 0.29 Btu·in/h·sq ft·deg F at 75 deg F.

2.4 FLEXIBLE ELASTOMERIC INSULATION

- A. Acceptable Manufacturers, subject to compliance with requirements:
 - 1. Aeroflex USA, Inc.
 - 2. Armacell AP Armaflex.
 - 3. K-Flex USA.
 - 4. Nomaco.
 - 5. Rubatex.
- B. Flexible elastomeric cellular insulation, meeting ASTM Standard C 534, in sheet or tubular form, thermal conductivity of 0.27 Btu·in/h·sq ft·deg F at 75 deg F.
- C. Use two (2) coats of "WB Armaflex Finish" water-based latex enamel by Armacell on elastomeric insulation installed outdoors.
- D. Adhesive for elastomeric insulation shall be Armacell Model 520.

2.5 PRE-MOLDED PIPE-FITTING INSULATION AND COVERS

- A. Acceptable Manufacturer, subject to compliance with requirements:
 - 1. Pre-Molded Pipe Fitting Insulation: ICA Fittings' HAMFAB AB.
 - 2. Pipe Fitting Covers:
 - a. Foster SEALFAS 30-36AF.
 - b. Knauf Proto.
 - c. Johns Manville Zeston 2000.
- B. Pre-Molded Insulation: Fiberglass, molded in two matching half-sections, matching the

density, thermal conductivity and thickness of the adjoining pipe insulation.

C. Covers: Polyvinyl chloride (PVC), 20 mils thick, meeting Federal Specification L-P-535E. Provide 2-layer precut insulation inserts matched to pipe insulation, vapor barrier, and required mastic adhesives and tapes.

1. Acceptable Manufacturers: Johns Manville, model Zeston 2000; Foster, model Sealfas Smoke-Safe 25/50; or Proto, model LoSmoke.

2.6 ALUMINUM JACKETS

A. Comply with ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105 or 5005, Temper H-14.

1. Sheet and roll stock ready for shop or field sizing or factory cut and rolled to size.
2. Jacketing shall be 0.016 inch minimum aluminum with moisture barrier, secured in accordance with the jacket manufacturer's recommendations. Joints shall be applied so they will shed water and shall be sealed completely.
3. Moisture Barrier for Outdoor Applications: 3-mil thick, heat bonded polyethylene and kraft paper.
4. Factory-Fabricated Fitting Covers:
 - a. Same material, finish, and thickness as jacket.
 - b. Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
 - c. Tee covers.
 - d. Flange and union covers.
 - e. End caps.
 - f. Beveled collars.
 - g. Valve covers.
 - h. Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

2.7 PIPE INSULATION PROTECTION SHIELDS

A. Provide pipe insulation protection shields as specified in Section 230529.

2.8 TAPES

A. Acceptable Manufacturer, subject to compliance with requirements: PermTape by Compac.

B. Vapor barrier type, self-sealing, with release paper, non-corrosive, fire-retardant, 3/4-inch and 3-inches wide by 6.9 mils thick.

PART 3 - EXECUTION

3.1 GENERAL

- A. Apply insulation on clean, dry surfaces after leakage and other tests have been completed.
- B. Piping, ductwork and equipment located within shafts, above removable or hard ceilings, in crawl spaces, and in pipe trenches shall be considered as "concealed". All other piping, ductwork and equipment shall be considered "exposed".
- C. Install insulation neatly, accurately and without voids, in accordance with manufacturer's instructions and NIAC National Commercial and Industrial Insulation Standards.
- D. Insulate fittings, strainers, valves and flanges using pre-molded covers with pre-cut insulation inserts, or with removable insulation jackets.
- E. Do not use staples in vapor barrier jackets.
- F. Strainers and valves for heating hot water: Insulation is not required when the pipe diameter is 1-inch or less and the equipment is located more than eight (8) feet above the finished floor.
 - 1. Insulate other strainers and valves with removable insulation jackets. Do not insulate strainer blowoff valves.

3.2 FIBERGLASS PIPING INSULATION

- A. For Refrigerant, Condensate Drains for Air Conditioning Equipment, Hot Water Heating Piping Systems
 - 1. For piping located indoors apply insulation as specified and seal butt joints with fire-retardant tape.
 - 2. For piping located outdoors, apply insulation as specified, seal butt joints with fire-retardant tape, and cover with a stainless steel jacket and fitting covers. Provide 1-1/2-inch overlap at the circumferential joints of metal jacket.

3.3 EXISTING INSULATION

- A. Repair existing pipe and ductwork insulation damaged through installation of the new work or alterations or connection to existing work. Match insulation material, thickness and method of application with existing.

3.4 PIPE INSULATION SCHEDULE

- A. Insulate piping in accordance with the following schedule:

PROJECT No. 14-18-4745-01
Health Care Center #10 – Interior and Exterior Improvements
230700-5
HVAC INSULATION

| SERVICE | COMMENT | PIPE DIAMETER | MATERIAL | THICKNESS (INCHES) |
|-------------------------|----------------------|---------------|-------------|--------------------|
| Refrigerant | Suction | Less than 1" | Elastomeric | 0.75 |
| | | 1" and larger | Elastomeric | 1.0 |
| | Liquid Outdoors | All | Elastomeric | 1.0 |
| Cooling Coil Condensate | | All | Fiberglass | 1/2 |
| Heating Hot Water | 200 deg. F. or lower | Less than 4" | Fiberglass | 1.5 |

3.5 FLEXIBLE DUCT WRAP INSULATION

A. Impale the insulation on pins welded to all four sides of the ductwork. Locate and weld pins on maximum 18-inch centers and no less than 3-inches from the edges of the ductwork. Secure insulation to pins with 1-inch diameter hold-down washers.

1. As an alternate to welded pins, provide "Gripnail" mechanical surface fasteners by Gripnail Corporation using pneumatic hammer especially designed for this work.

3.6 DUCTWORK INSULATION SCHEDULE

| SERVICE | COMMENT | MATERIAL | THICKNESS (INCHES) |
|---|-----------|-----------------|--------------------|
| SUPPLY AIR: <ul style="list-style-type: none"> • Supply Ductwork • Fire and Smoke Dampers • Coil Casings, Duct-Mounted | Concealed | Fiberglass Wrap | 1.5 |

++ END OF SECTION ++

SECTION 230900
INSTRUMENTATION AND CONTROLS FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes control equipment for HVAC systems and components, including control components for terminal heating and cooling units not supplied with factory-wired controls.

1.2 DIRECT DIGITAL CONTROL SYSTEM

- A. Application Specific Controllers (ASC's) and Programmable Control Units (PCU's) as herein specified and as indicated on the BAS drawings. Provide I/O and ancillary devices as herein specified, as indicated on the BAS drawings, and as necessary to perform the sequences of operation. The following equipment shall be controlled:

- 1. Equipment outlined herein or on the Mechanical and Electrical Drawings.

- B. Provide JACE controllers (if existing controller has no additional capacity), Web Supervisor JACE seat license for each JACE provided, coordinate the quantity and type of devices and properly install the JACE controllers as part of this project.

- C. The JACE's shall provide global supervisory control functions over the control devices connected to each JACE. The JACE shall be capable of executing application control programs to provide:

- 1. Calendar functions.

- 2. Scheduling.

- 3. Trending.

- 4. Alarm monitoring and routing (locally and to Web Supervisor).

- 5. Time synchronization.

- 6. Integration of LONWORKS® controller data, BACnet data, Modbus data and others as required (proprietary).

- D. The JACE must provide the following hardware features as a minimum

- 1. One Ethernet Port - 10 Mbps.

- 2. One RS-232 port.

- 3. One LONWORKS® Interface Port – 78KB FTT-10A.

- 4. One Modbus or BacNet MSTP port.

5. Battery Backup.
6. Flash memory for long term data backup. (If battery backup or flash memory is not supplied, the controller must contain a hard disk with at least 1 gigabyte storage capacity.)
7. The JACE must be capable of operation over a temperature range of 0° to 55°C.
8. The JACE must be capable of withstanding storage temperatures of between 0° and 70°C.
9. The JACE must be capable of operation over a humidity range of 5% to 95% RH, non-condensing.

1.3 SUBMITTALS

- A. Product Data: For each control device indicated.
- B. Shop Drawings:
 1. Schematic flow diagrams.
 2. Power, signal, and control wiring diagrams.
 3. Details of control panel faces.
 4. Damper schedule.
 5. Valve schedule.
 6. DDC System Hardware: Wiring diagrams, schematic floor plans, and schematic control diagrams.
 7. Control System Software: Schematic diagrams, written descriptions, and points list.
- C. Samples: For products mounted in visible locations, submit color chips from manufacturer's full range of colors for selection by Architect.
- D. Software and firmware operational documentation.
- E. Field quality-control test reports.
- F. Operation and maintenance data.

1.4 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

PART 2 - PRODUCTS

2.1 APPLICATION SPECIFIC CONTROLLERS

- A. Each terminal unit shall have a DDC Application Specific Controller (ASC) designed to provide the specified sequences. The controller shall store all specific control sequences and program settings in non-volatile memory.
- B. Each ASC shall perform all intended temperature control functions in a 'standalone' mode should the unit incur a loss of communications.
- C. The complete ASC including accessory devices such as relay, transducers, power supplies, etc., shall be factory-mounted, wired and housed in a NEMA 1 enclosure or as required by the location and local code requirements.
- D. All ASC's shall be provided as self sufficient units to maximize reliability and shall include internal 'soft' clock, operating systems, communication timing and interrupt controls, and shall be suitable for the specified applications.
- E. In the event of a power outage or controller reset, each ASC shall enter a preprogrammed state on power re-application. Upon application of power to the ASC, all control conditions will start from an 'off' / 'closed' position or the default state. This state will be maintained for an automatically adjusted amount of time. Once this time delay has passed, the ASC control sequence shall resume according to current values.
- F. All ASC's shall be provided with a communications port to allow connection of any industry standard laptop PC and custom configuration tools. Program access via this communications port allows direct field modification of the configuration parameters.
- G. Digital Inputs
 - 1. All digital inputs shall be over voltage protected.
 - 2. Digital input types supported:
 - a. Normally open contacts (24V and 120V).
 - b. Normally closed contacts (24V and 120V).
 - c. Current/no current.
 - d. Voltage/no voltage.
 - e. Pulse/Totalizer contacts.
- H. Digital Outputs
 - 1. All digital outputs shall be 24 volt AC, current sinking, 0.5 amp opto-isolated triacs.
 - 2. Digital outputs shall be capable of handling maintained as well as pulsed outputs for momentary or magnetic latching circuits. It shall be possible to configure outputs for 3-mode control (fast-slow-off) and 2-mode control.
- I. Analog Inputs

1. All analog inputs shall be over voltage protected.
2. The analog to digital resolutions shall be a minimum of 10 bit.
3. Analog inputs shall accept the following temperature types: 10K Ohm thermistor, 20K Ohm thermistor, or 1K Ohm RTD.
4. Inputs shall be configurable to accept a wide range of inputs including: 4-20mA, 1-5Vdc, 2-10Vdc, etc.

J. Analog Outputs

1. The ASC shall accommodate true analog outputs. Voltage (0-10V) and current (4-20 mA) outputs shall be accommodated.
2. All analog outputs shall be proportional current or voltage type.
3. The digital to analog resolution shall be a minimum of 10 bit.
4. Outputs shall be configurable so that 0-100% output commands can represent any portion of the output voltage/current range.
5. Outputs shall be reversible so that an increasing output command yields a decreasing electrical signal.

K. In addition to local physical or internal I/O, each ASC shall support distributed, or 'bound' I/O. This bound I/O can be used to allow the ASC to provide I/O data to another controller on the LON or to allow another controller to provide data to the controlling ASC.

L. The following modes of control shall be incorporated into each ASC:

1. Occupied shall be a mode designed for normal occupied control of an area during regular business hours. This mode shall have unique heating and cooling setpoints associated with it.
2. Unoccupied shall be a mode designed for after hours control of an area. This mode shall have unique heating and cooling setpoints associated with it.
3. Override shall be a mode designed to invoke normal occupied control during after hours of an area. This mode shall use the occupied heating and cooling setpoints.
4. Economy shall be a mode designed for normal occupied times when energy demand usage is high and control setpoints need to be adjusted for lower energy use. This mode shall have unique heating and cooling setpoints associated with it.
5. Morning Warm-Up on units with a outdoor air economizer shall be a mode designed for the pre-heat/pre-cool time before normal occupancy occurs. This mode shall allow heating or cooling as required by the occupied setpoints but it will prevent outdoor air from entering the space. The outdoor air will move to its

minimum position once the morning warm-up mode is over and the occupied mode is activated.

2.2 PROGRAMMABLE CONTROL UNITS (PCUs)

- A. DDC Programmable Control Unit (PCU) shall be provided where required to perform the sequence of operation. The PCU shall be fully configurable by configuration tool and fully up-loadable; download only programmable controllers are strictly prohibited. The controller shall store all specific control sequences and program settings in non-volatile memory.
- B. Each PCU shall perform all intended temperature control functions in a 'standalone' mode should the unit incur a loss of communications.
- C. The complete PCU including accessory devices such as relay, transducers, power supplies, etc., shall be factory-mounted, wired and housed in a NEMA 1 enclosure or as required by the location and local code requirements.
- D. All PCU's shall be provided as self sufficient units to maximize reliability and shall include internal 'soft' clock, operating systems, communication timing and interrupt controls, and shall be suitable for the specified applications.
- E. In the event of a power outage or controller reset, each PCU shall enter a preprogrammed state on power re-application. Upon application of power to the PCU, all control conditions will start from an 'off' / 'closed' position or the default state. This state will be maintained for an automatically adjusted amount of time. Once this time delay has passed, the PCU control sequence shall resume according to current values
- F. All PCU's shall be provided with a communications port to allow connection of any industry standard laptop PC and custom configuration tools. Program access via this communications port allows direct field upload, download and modification of the configuration parameters.
- G. Digital Inputs
 - 1. All digital inputs shall be over voltage protected.
 - 2. Digital input types supported:
 - a. Normally open contacts (24V and 120V).
 - b. Normally closed contacts (24V and 120V).
 - c. Current/no current.
 - d. Voltage/no voltage.
 - e. Pulse/Totalizer contacts.
- H. Digital Outputs
 - 1. All digital outputs shall be 24 volt AC, current sinking, 0.5 amp opto-isolated triacs.

2. Digital outputs shall be capable of handling maintained as well as pulsed outputs for momentary or magnetic latching circuits. It shall be possible to configure outputs for 3-mode control (fast-slow-off) and 2-mode control.

I. Analog Inputs

1. All analog inputs shall be over voltage protected.
2. The analog to digital resolutions shall be a minimum of 10 bit.
3. Analog inputs shall accept the following temperature types: 10K Ohm thermistor, 20K Ohm thermistor, or 1K Ohm RTD.
4. Inputs shall be configurable to accept a wide range of inputs including: 4-20mA, 1-5Vdc, 2-10Vdc, etc.

J. Analog Outputs

1. The ASC shall accommodate true analog outputs. Voltage (0-10V) and current (4-20 mA) outputs shall be accommodated.
2. All analog outputs shall be proportional current or voltage type.
3. The digital to analog resolution shall be a minimum of 10 bit.
4. Outputs shall be configurable so that 0-100% output commands can represent any portion of the output voltage/current range.
5. Outputs shall be reversible so that an increasing output command yields a decreasing electrical signal.

K. In addition to local physical or internal I/O, each ASC shall support distributed or 'bound' I/O. This bound I/O can be used to allow the PCU to provide I/O data to another controller on the LON or to allow another controller to provide data to the controlling ASC.

L. The following modes of control shall be incorporated into each PCU:

1. Occupied shall be a mode designed for normal occupied control of an area during regular business hours. This mode shall have unique heating and cooling setpoints associated with it.
2. Unoccupied shall be a mode designed for after hours control of an area. This mode shall have unique heating and cooling setpoints associated with it.
3. Override shall be a mode designed to invoke normal occupied control during after hours of an area. This mode shall use the occupied heating and cooling setpoints.
4. Economy shall be a mode designed for normal occupied times when energy demand usage is high and control setpoints need to be adjusted for lower energy

use. This mode shall have unique heating and cooling setpoints associated with it.

5. Morning Warm-Up on units with a outdoor air economizer shall be a mode designed for the pre-heat/pre-cool time before normal occupancy occurs. This mode shall allow heating or cooling as required by the occupied setpoints but it will prevent outdoor air from entering the space. The outdoor air will move to its minimum position once the morning warm-up mode is over and the occupied mode is activated.

- M. All PCUs must have database naming conventions that match the items that they are controlling, i.e. the proportional gain on a PID algorithm should have a database name that reflects that it is a proportional gain. There must be a level of clarity in the database naming convention that would not allow a Zone Setpoint "ZSP" to be confused with Zone Static Pressure "ZSP".

2.3 ASC AND PDU MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.
 1. Johnson Controls, Inc.; Controls Group.
 2. Siemens Building Technologies, Inc.
 3. Honeywell International Inc.; Home & Building Control.

2.4 ELECTRONIC SENSORS

- A. Temperature Sensors
 1. Single-point rigid Stem Sensors (TD, TW)
 - a. RTD sensors for air duct or liquid application shall be ceramic or epoxy encapsulated wire wound platinum element, encased in copper or stainless steel sheath. Leadwires shall terminate on an enclosed terminal block.
 - 1) Accuracy at the sensor shall be within +/- 0.5% of range.
 - 2) Sensors used in liquid measuring applications shall be installed in a brass well with thermal compound.
 - 3) Provide rigid sensor manufactured by Rosemount, Foxboro, Hycal, Omega, or approved equal.
 - b. Thermistor sensors for air duct or liquid application shall be a rugged point sensitive, waterproof sensor housed in a 304 stainless steel probe

with ½" NPT male NPT brass fitting.

- 1) Accuracy shall be $\pm 0.36^{\circ}\text{F}$ over sensor range. Sensor range for air duct application shall be -30°F to 160°F . Sensor range for liquid application shall be 10°F to 230°F .
- 2) Sensors used in liquid measuring applications shall be installed in a 304 stainless steel well with thermal compound.
- 3) Matched pair temperature sensors shall be required for liquid measuring applications used for energy calculations.
- 4) Provide rigid sensor manufactured by Precon, Mamac, Veris Industries, or approved equal.

2. Averaging Sensors (TA)

a. RTD sensors for air duct application shall be continuous nickel, platinum or Balco element encased in a copper capillary, minimum length 8 feet. Element shall terminate on an enclosed terminal block.

- 1) Averaging sensors shall be used where duct area is 14 square feet or greater. Where duct dimension is 60 inches or greater in either width or depth, or where specified or shown.
- 2) Capillary shall be firmly supported by a system of mechanical clips.
- 3) Accuracy at the sensor shall be within $\pm 0.75\%$ of sensor range.
- 4) Provide averaging sensor manufactured by Minco or Hycal.

b. Thermistor sensors for air duct averaging application shall be sensing elements sealed in 3/16" soft-drawn copper coiled tube attached to a standard junction box with mounting bracket attached. A minimum of 4 sensing elements shall be used for averaging elements of 8' and 12.5' and a minimum of 9 sensing elements shall be used for averaging elements of 25'.

- 1) Accuracy shall be $\pm 0.36^{\circ}\text{F}$ over a range of 32°F to 160°F .
- 2) Averaging sensors shall be used where duct area is 14 square feet or greater, where duct dimension is 60 inches or greater in either width or depth, or where specified or shown.
- 3) Coil tube shall be firmly supported by a system of mechanical clips.
- 4) Provide averaging sensor manufactured by Precon.
- 5) Provide one linear foot of averaging temperature sensor for each square foot of coil face area. Wire multiple temperature sensors in a series/parallel circuit to one BAS analog input. For multiple sensors, utilize four or nine averaging temperature sensors, as required for proper coil temperature sensing.

3. Space Temperature Sensors (TS, TSA)

a. Space temperature sensors shall utilize either RTD or thermistor sensing elements. The sensor shall have the following specifications:

- 1) Temperature monitoring range: +20/120°F.
 - 2) Output signal: Variable resistance
 - 3) Accuracy: +/- .36°F.
- b. Stainless steel plate space temperature sensors shall be utilized in public areas and classrooms.
 - d. Office area and exam room space temperature sensors only shall have a setpoint adjustment slider, to provide a configurable (from BAS workstation) number of degrees of adjustment to the room temperature setpoint. This shall initially be set to +/- 5°F.
 - e. Provide room temperature sensor manufactured by Kele, Mamac, Veris Industries, Honeywell, Alerton, Johnson Controls, Andover, or Siemens.
4. Outside Air Temperature Sensors (TO)
- a. Outdoor air sensors shall utilize either an RTD or thermistor sensing element, have an integral sun shield and be attached to a NEMA 3R junction box. The sensor shall be mounted on the building north face and the location shall be coordinated with the CM and AE prior to installation. The sensor shall have the following specifications:
 - 1) Temperature range: -58°F to 122°F.
 - 2) Output signal: Variable resistance or 4-20mA DC.
 - 3) Accuracy: +/- 0.36°F.
 - b. Provide outdoor air temperature sensor manufactured by Kele, Minco or Honeywell.

B. Temperature Transmitters (TT)

1. Temperature transmitters for RTD elements shall output a 4-20 mA linear signal over the specified range. Zero point and span shall be adjustable over a minimum of 75% of range.
2. Temperature transmitters shall meet the following performance standards as a minimum.
 - a. Accuracy: +/- 0.5% of span.
 - b. Linearity: +/- 0.2% of span.
 - c. Isolation: Input to output, 600 VDC or VAC peak.
3. Housings for transmitters mounted on supply ducts or in non-hazardous spaces shall be NEMA 1. Housings for transmitters in outdoor air, on outdoor air plenums or intake ducts, or in spaces whose ambient temperature is below 55 deg. F, shall be gasketed die-cast aluminum, NEMA 3R minimum.
4. Transmitter range shall suit the application and shall be 100 deg. F. for ducts, 150 deg. F. for outdoor air sensing, 100 deg. F. for chilled water and 200 deg. F. for

hot water.

5. Provide approved sun shields for transmitters in outdoor air.
 6. Provide transmitters manufactured by Foxboro, Minco, Hycal or approved equal by BAS manufacturer.
- C. Room Sensor Cover Construction: Manufacturer's standard locking covers.
1. Set-Point Adjustment: Concealed.
 2. Set-Point Indication: Concealed.
 3. Color: As selected from manufacturer's full range.

2.5 CONTROL VALVES

- A. All control valves shall be of the throttling plug type for water service.
- B. General: Select body and trim materials in accordance with manufacturer's recommendations for design conditions and service shown.
- C. Control valves shall be sized to meet the heating and cooling flows as specified. Control valve pressure drop at design flow conditions in water systems shall be based upon pressure drop of the controlled equipment or system.
- D. Control Valve ratings, materials and construction set forth herein are a minimum. Body pressure rating and connection type shall conform to pipe schedules in the Mechanical plans and specifications. Actuators shall shutoff valves tightly against 120% of maximum system pressure in both fail open and fail closed positions.
- E. Control valves shall be quiet in operation and arranged to fail-safe in the open or closed position in the event of power failure or control air failure.
- F. Control valves shall have unions installed before and after for service.
- G. Control Valves. Control valves providing two-position service shall be flat seat/quick opening. Two-way control valves shall have replaceable disc or ball.
 1. Close-off (Differential) Pressure Rating. Control valve actuator and trim shall provide the following minimum close-off pressure ratings.
 - a. Two-way: 150% of total system (pump) head.
 - b. Three-way: 300% of pressure differential between ports A and B at design flow or 100% of total system (pump) head
 2. Ports. Control valves providing modulating service shall have equal percentage ports.
 3. Sizing:

- a. Two-position service: line size
 - b. Two-way modulating service: select control valve assembly such that the pressure drop across the control valve is greater than or equal to the pressure drop across the associated coil and not to exceed 3 PSIG.
 - c. Three-way modulating service: select control valve assembly such that the pressure drop across the control valve is greater than or equal to the pressure drop across the associated coil and not to exceed 3 PSIG.
 - d. Coordinate control valves flow rates with final, approved equipment submittals prior to sizing the control valves assemblies and before submission to the A/E.
4. Fail Position. Water control valves shall fail normally open or closed as follows unless otherwise specified.
- a. Heating coils : normally open.
5. Accepted Manufacturers: Belimo HTCCV Characterized Ball Valves, Johnson Controls or Valve Solutions, Inc. Series V-Ball.
- H. Self-Contained Control Valves: Bronze body, bronze trim, two or three ports as indicated, replaceable plugs and seats, and union and threaded ends.
- 1. Rating: Class 125 for service at 125 psig and 250 deg F operating conditions.
 - 2. Thermostatic Operator: Liquid-filled remote sensor with remote adjustable dial.

2.6 General Use Electric Control Valve Actuators

- A. Actuators shall be separately powered from a 24 VAC source, extended from the location of the 2nd tier controller. Provide 120/24 VAC step-down transformer at the 2nd tier controller location as needed to power actuators.
- B. Current or voltage signal actuators shall be spring return on power/signal failure, either normally open (N.O.) or normally closed (N.C.). Floating point actuators for reheat control valves shall fail to last commanded position.
- C. Actuators shall have adequate stroke to provide the full travel of the control valve from 0 to 100% and shall have the available torque to provide closing of the end element to the specified leakage rating. Timing for the full stroke angle of rotation shall be no more than 90 seconds.
- D. Provide linkages for control valves as required for the installation. Provide the number of actuators required to meet torque requirements and end to end accuracies.
- E. Actuators shall be integrally mounted by the supplied linkage to the control valve as a single unit. The actuator and linkage shall be capable of operation in an ambient temperature of -40°F to 120°F.
- F. Actuators for steam or hot water control valves shall be installed per manufacturers' recommendations regarding angle of deflection from direct vertical mounting to avoid heat damage to actuator.

- G. Accepted Manufacturers: Belimo, Johnson Controls, Siemens.

2.7 WIRING AND RACEWAYS

- A. General. Provide copper wiring, plenum cable, and raceways as specified in applicable sections of Division 26.
- B. Insulated wire shall use copper conductors and shall be UL listed for 200°F minimum service.
- C. Provide all conduit, wiring, connectors, hangers, enclosures, junction boxes, transformers, as described under Division 26 unless otherwise specified. If installation materials required for this contract are not specified under this Specification Section or in Division 26, provide materials of consistent quality to those specified.
- D. Ensure that all communication cables installed meet the specification requirements put forth by the manufacturer of the control system. This extends to wire types used for any open protocol interfaces.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Verify location of thermostats and other exposed control sensors with Drawings and room details before installation. Install devices 60 inches above the floor.
 - 1. Install averaging elements in ducts and plenums in crossing or zigzag pattern.
- B. Install guards on thermostats in the following locations:
 - 1. Where indicated.
- C. Install automatic dampers according to Division 23 Section "Air Duct Accessories."
- D. Install damper actuators on outside of duct in warm areas, not in locations exposed to outdoor temperatures.
- E. Install labels and nameplates to identify control components.
- F. Install hydronic instrument wells, valves, and other accessories according to Section 232113.
- G. Install refrigerant instrument wells, valves, and other accessories according to Division 23 Section "Refrigerant Piping."
- H. Install duct volume-control dampers according to Section 233300.
- I. Install electronic and fiber-optic cables according to Division 26, as applicable.

3.2 ELECTRICAL WIRING AND CONNECTION INSTALLATION

- A. Install raceways, boxes, and cabinets according to Division 26 Section "Raceway and Boxes for Electrical Systems."
- B. Install building wire and cable according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- C. Install signal and communication cable according to Division 26.
 - 1. Conceal cable, except in mechanical rooms and areas where other conduit and piping are exposed.
 - 2. Install exposed cable in raceway.
 - 3. Install concealed cable in raceway.
 - 4. Bundle and harness multiconductor instrument cable in place of single cables where several cables follow a common path.
 - 5. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
 - 6. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.
 - 7. Install wire and cable with sufficient slack and flexible connections to allow for vibration of piping and equipment.

3.3 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections and prepare test reports:
 - 1. Test and adjust controls and safeties.
 - 2. Test calibration of controllers by disconnecting input sensors and stimulating operation with compatible signal generator.
 - 3. Test each point through its full operating range to verify that safety and operating control set points are as required.
 - 4. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.
 - 5. Test each system for compliance with sequence of operation.
 - 6. Test software and hardware interlocks.
- B. DDC Verification:
 - 1. Verify that instruments are installed before calibration, testing, and loop or leak

checks.

2. Check instruments for proper location and accessibility.
 3. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.
 4. Check pressure instruments, piping slope, installation of valve manifold, and self-contained pressure regulators.
 5. Check temperature instruments and material and length of sensing elements.
 6. Check control valves. Verify that they are in correct direction.
 7. Check DDC system as follows:
 - a. Verify that DDC controller power supply is from emergency power supply, if applicable.
 - b. Verify that wires at control panels are tagged with their service designation and approved tagging system.
 - c. Verify that spare I/O capacity has been provided.
 - d. Verify that DDC controllers are protected from power supply surges.
- C. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.
- 3.4 DEMONSTRATION
- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC instrumentation and controls.

++ END OF SECTION ++

SECTION 232113
HYDRONIC PIPING

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section describes pipe and pipe fittings used in HVAC Systems.

1.2 SUBMITTALS

- A. Submit the following to the Architect for review:
1. Product Data: Manufacturer's technical product literature for pipe, fittings, and bolting.
 2. Quality Assurance Submittals
 - a. Field Quality Control Reports.
 - b. Chemical Cleaning Effluent Disposal Plan.

1.3 DELIVERY, STORAGE AND HANDLING

- A. Protect flange faces with wood, plastic or soft metal.
- B. Factory apply plastic piping end-caps. Maintain end-caps in place until pipe is erected.
- C. Store pipe and fittings inside for protection from moisture and dirt, or with weatherproof packaging.

PART 2 - PRODUCTS

2.1 PIPING PRODUCTS

- A. Use the following piping products schedule.

| ITEM | SERVICE |
|---|---|
| | HYDRONIC (INCLUDING AQUEOUS GYLCOL SOLUTIONS) PIPING, REFRIGERANT VENT, SAFETY VALVE VENT AND DRAIN PIPING |
| Piping - 2-1/2" and smaller | Schedule 40 seamless or welded carbon steel, ASTM A 53/A 53M, Grade B, ANSI B36.01M; or hard-drawn seamless copper Type L tubing, ASTM B 88. |
| Fittings - 2-1/2" and smaller | - Steel Pipe: Malleable iron threaded fittings, Class 150, ANSI B16.3 - Copper Tubing: Wrought copper solder joint pressure fittings, ANSI B16.22. |
| Joining Materials - 2-1/2" and smaller | DuPont Teflon tape or paste, or 95/5 (tin/antimony) solder, conforming to ASTM B32. |
| Unions - for Piping 2-1/2" and smaller | Brass solder or steel. |

| ITEM | SERVICE |
|---------------------|---|
| | HYDRONIC (INCLUDING AQUEOUS GYLCOL SOLUTIONS) PIPING, REFRIGERANT VENT, SAFETY VALVE VENT AND DRAIN PIPING |
| Dielectric Fittings | Isolation flanges, unions and nipples. Use steam service gaskets for fluids over 100 deg F, and standard service gaskets elsewhere. Acceptable Manufacturers, subject to compliance with requirements: EpcO, Perfection |

| ITEM | SERVICE |
|---|--|
| | PUMPED OR GRAVITY COOLING COIL CONDENSATE PIPING [In locations other than mechanical rooms] |
| Piping - 2-1/2" and smaller | Hard-drawn seamless copper tubing, Type L, ASTM B88. |
| Fittings - 2-1/2" and smaller | Wrought copper solder joint pressure fittings, ANSI B16.22; |
| Joints - 2-1/2" and smaller | Soldered, 95/5 (tin/ antimony), ASTM B32; |
| Unions - for Piping 2-1/2" and smaller | Wrought copper solder unions, ANSI B16.22. |
| Dielectric Fittings | Isolation flanges, unions and nipples. Use steam service gaskets for fluids over 100°F, and standard service gaskets elsewhere. Acceptable Manufacturers, subject to compliance with requirements: EPCO, Calpico, Perfection |

| ITEM | SERVICE |
|---|--|
| | REFRIGERANT |
| Piping - 2-5/8" and smaller | Seamless copper air-conditioning and refrigeration tubing, Type ACR, Hard-drawn, ASTM B280. |
| Joints - 2-5/8" and smaller | Brazed, per AWS Brazing Manual |
| Fittings - 2-5/8" and smaller | Wrought copper brazing fittings, ANSI B16.22 |
| Joining Materials - 2-5/8" and smaller | AWS classification BCuP5 alloy (15% silver, 5% phosphorus, 80% copper) per AWS A5.8. Acceptable Manufacturers, subject to compliance with requirements: Handy and Harmon Silfos 15. Acceptable Manufacturer, subject to compliance with requirements: Handy and Harmon "Handy Flux." |

2.2 NIPPLES

- A. Pipe nipples shall be of the same material as the pipeline in which they are installed and shall conform to ASTM A 733.
- B. Unthreaded part shall not be less than 1-1/2".

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Unless shown otherwise, route piping in the most direct manner, parallel to building lines.
- B. Locate piping to maintain clearance around equipment, and minimum piping headroom of 7 feet, except where otherwise shown.
- C. Space piping so that insulation and flanges, if any, have at least 2 inch clearance after maximum movement.
- D. Where a well or control instrument is installed in piping 2-1/2 inches and smaller, increase the pipe size by at least one pipe size to avoid restricting the flow in the pipe, unless otherwise indicated.
- E. Close open ends of piping and equipment, when it is not being worked on, with flange covers, caps or plugs.
- F. In liquid systems, connect branch lines to the bottom half of the line, unless otherwise indicated.
- G. Do not use pipes smaller than 3/4-inch, unless otherwise indicated.
- H. Do not bend steel pipe.
- I. Clean piping materials before installation to remove grease, loose dirt, mill scale and other foreign matter.
- J. Provide valved vents at all high points of water piping, and valved drains at all low points of water piping for draining and flushing. Locations shall be determined by the Contractor.
- K. Provide escutcheons at locations where piping, installed exposed to view, penetrates walls, partitions, floors and ceilings.
- L. Install automatic control valves and accessories furnished under other specification sections.
- M. Provide unions or companion flanges where indicated, and in following locations whether or not indicated:
 - 1. In bypasses around control valves and equipment.
 - 2. In connection to equipment between shutoff valves and equipment, on the supply and return piping connections.

- N. Maintain the following minimum pitches:
- | | |
|-----------------------------------|-----------|
| Safety and relief valve discharge | 1" in 4' |
| Cooling coil condensate drain | 1" in 8' |
| Hydronic heating and cooling | 1" in 50' |
| All other | 1" in 50' |
- O. Do not install pipes in electrical equipment rooms, elevator machine rooms or similar areas containing electrical equipment, other than branches serving equipment in these rooms.
- P. Do not install pipes over electrical equipment, unless permitted by the National Electrical Code (NEC), and written permission is obtained in advance from the Owner.
1. Where (NEC) does permit piping to be installed above electrical equipment, provide galvanized steel drip pans over the electrical equipment at no additional cost to the Owner.
- Q. Do not use bullhead tees in hydronic supply systems.
- R. For hydronic piping systems, and for hydrostatically tested systems supported by vibration isolators or other spring supports, adjust hangers or use pre-compressed supports as applicable to prevent damage to building construction and pipe insulation as systems are filled with water.
1. On failure to do so, repair damage caused to building construction and pipe insulation, at no additional cost to the Owner.

3.2 THREADED PIPE JOINTS

- A. Seal threaded joints with a non-corrosive, non-hardening compound or PTFE tape applied on the male thread. Do not caulk threaded joints.
- B. Threadolets, or similar ASME code-approved fittings, are acceptable for branch connections. Branch connectors may be one pipe size smaller than the main or branch main.
- C. Ream or file pipe ends to size of bore, remove chips and cuttings. Cut pipe ends square.

3.3 SOLDERED PIPE JOINTS

- A. For hydronic piping connections, provide lead-free 95/5 (tin/antimony) solder. Make solder joints in accordance with the ASTM B 828.
- B. As an alternative, "tees" for on-site tube branches can be mechanically pulled out of copper pipe, in lieu of tee fittings, by the use of T-DRILL, a product of T-DRILL Industries. Use in accordance with manufacturer's instructions. Joints must be brazed, not soldered.

- C. For refrigeration copper piping connections, comply with ANSI/ASME B31.5. Braze joints on refrigeration piping, do not solder.

3.4 FLANGED CONNECTIONS

- A. Lubricate bolts or studs over entire thread length with anti-seize compound consisting of copper flakes and graphite dispersed in water-resistant grease.
 - 1. Acceptable Manufacturer, subject to compliance with requirements: Jet-Lube Koper-Kote.

3.5 EQUIPMENT PIPING

- A. Provide piping from cooling coil drain pans, relief valves, any pump glands, and other drainage, to spill over open sight drains, floor drains, or other discharge points, and terminate with plain end, 45 degree bevel cut, unthreaded pipe.

3.6 ELECTROLYSIS CONTROL

- A. See Section 230529 for isolation between piping and pipe supports.
- B. Isolate non-ferrous piping passing through openings in structural steel with nonconductive material permanently attached to the pipe.
- C. Make connections between non-ferrous metallic piping and ferrous piping, fittings, or equipment with dielectric fittings, nipples or unions specified in this Section.

3.7 PIPING SYSTEM DRAINS

- A. Pitch each piping system to low points where entire system can be emptied through drains.
- B. Pitch outside water piping so that water can be drained from underground piping through drains installed in building served.

3.8 PIPING SYSTEM TESTING

- A. Before testing, complete the installation of each pipe line, including final supports and anchors. Clean piping and equipment of foreign matter as they are installed and in accordance with all applicable codes and standards.
- B. Pressure vessels, tanks, pumps, rotating and other mechanical equipment shall not be subject to the piping field pressure test.
- C. Equipment, instruments and piping specialties which are not to be included in the test shall be either disconnected from the piping and the end of the pipe, blanked off by a blind flange, plug or cap, or isolated by insertion of a line blind or spool piece as required. Disconnect instrument air lines and close openings.
- D. Test piping in sections as required.

- E. Provide systems to be pressurized with gauges and pressure-relieving devices.
- F. Lines containing check valves shall have the source of test pressure located on the high-pressure side of the valves.
- G. Line control valves shall be set and maintained in a wide-open position.
- H. Refrigerant Piping and Tubing: Perform pneumatic testing in accordance with ANSI/ASME B31.9, except for the following:
 - 1. Perform pneumatic test using dry nitrogen.
 - 2. Prior to application of full pneumatic test pressure, conduct a preliminary test at 10 psig for 10 minutes before applying final test pressure.
 - 3. Test pressure shall be 200 psig.
 - 4. After the preliminary test, apply pressure gradually in stages of not more than 25 psig until test pressure is reached, allowing a minimum of 10 minutes between stages. Maintain test pressure for a minimum of thirty (30) minutes without fluctuation; then reduce pressure to operating pressure and begin checking for leaks.
 - 5. Check all joints, welds, valves, etc. for leaks with a thick soap-water solution or with a special fluid made specifically for this purpose. Hold pressure for minimum of eight (8) hours.
 - 6. Provide protection of persons and property during leak testing.
- I. Hydronic Piping: Perform hydrostatic testing in accordance with ANSI/ASME B31.1 and B31.9, as applicable, except for the following:
 - 1. Test pressure shall be as indicated elsewhere in this Section.
 - 2. Maintain test pressure for thirty (30) minutes before examining all joints, welds, valves, etc. and hold test pressure for four hours.
 - 3. Test pressures shall be as tabulated below:

| SYSTEM | HYDROSTATIC TEST PRESSURE (PSIG) | DURATION (HOURS) | SEE NOTE NO. |
|-----------------------------------|----------------------------------|------------------|--------------|
| Heating Hot Water | 125 | 4 | ---- |
| Relief Valve Vent and Drain Water | 125 | 4 | ---- |
| Cooling Coil Condensate | Static Fill - No Leakage | 0.5 | See below. |

NOTE: Test pressure shall be 150 psig, or 150 percent of the operating pressure, whichever is greater.

J. Testing of Cooling Coil Condensate Piping

1. Test the piping system by plugging the lowest point, filling with water to the top of the drain pan, and allowing to stand for 15 minutes. Repair leaks and retest until no leaks exist.
2. If leaks occur during testing, stop the test, repair the leaks by replacing defective sections and fittings, and repeat the entire test. Repairs made by caulking are not acceptable.
3. Repair damage to the building, contents and work of other trades caused by leaks, flooding or draining during testing.

3.9 FLUSHING OF PIPING SYSTEMS

- A. Complete pressure testing before flushing piping systems.
- B. Flush clean with new potable water, and drain at all low points. Connected equipment, including coils, shall be isolated and flushed individually with a hose.
- C. Flushing for piping and equipment shall be complete when water samples taken at all low points indicate clean discharge with no visible solids. If not clear, continue flushing and sampling until discharge is clear.

3.10 CLEANING OF PIPING SYSTEMS

- A. Complete flushing before cleaning piping systems. Cleaning shall be performed in accordance with the following procedures:
 1. For Other Services Not Identified Below: Fill piping system with water and alkaline cleaning material at a concentration recommended by the chemical treatment contractor to remove dirt, oil and grease. Include all connected equipment in the cleaning. Heat water to 140 degrees F and circulate for 24 hours.
 2. After 24 hours, flush system with clean potable water and sample effluent at all low points until discharge is clear, with no visible solids). Flush all equipment again separately.
 3. For Refrigerant Piping: Provide nitrogen at design pressure to blow free of dirt and debris.
- B. Clean all strainers every eight hours during cleaning procedures.

3.11 PAINTING OF PIPING

- A. Prime and field paint outdoor, weather-exposed, uninsulated steel piping with rust preventive metal paint.

- B. Prime and field-paint indoor, exposed, uninsulated steel piping, installed in finished spaces.

3.12 AIR VENTS

- A. Provide at high points.

3.13 CONTROL VALVE PIPING AND VALVE BYPASS PIPING

- A. Valves and strainers at automatic control valves shall be full line size indicated on the contract drawings.

1. Reduce pipe size at the inlet and outlet of control valves with reducing fittings.
2. Provide straight length of inlet and outlet piping as recommended by the control valve manufacturer, or as shown on drawings, whichever is greater.

- B. Provide bypass pipe around automatic control valves where shown on the contract drawings.

1. For a control valve assembly with one control valve, bypass pipe shall be the same size as control valve.
2. For a control valve assembly with two or more control valves, bypass pipe shall be the same size as largest control valve.
3. Bypass piping shall have a full line size manual throttling valves, normally closed.

3.14 INSTALLATION WORK FOR AUTOMATIC CONTROLS

- A. Provide work specified in Section 230900.

++ END OF SECTION ++

SECTION 233113
METAL DUCTS

PART 1 - GENERAL

1.1 SUMMARY

- A. This section describes metal and flexible ductwork for HVAC duct systems, including fittings and sealants.

1.2 SUBMITTALS

- A. Submit for review:

1. Sheet Metal Shop Drawings:

- a. After coordination with trades, prepare floor plan drawings at minimum 1/4-inch to 1 ft. scale and Mechanical Room drawings at minimum 3/8-inch to 1 ft. scale, of all sheet metal and flexible round ducting, showing the following:

- 1) Fittings, access doors, and duct-mounted equipment such as fire, smoke, automatic control and balancing dampers, sound attenuators, airflow control valves, smoke detectors and fans.
- 2) Elevation views, locating dimensions from column lines or other references.
- 3) Duct acoustical lining or external insulation.
- 4) Pressure classification and seal class.
- 5) Reflected ceiling plans, room names and numbers.
- 6) Major building and structural elements.
- 7) Major equipment and piping for Mechanical Rooms.
- 8) Interferences between ductwork and piping, lights or structure.

2. Leak test procedures, including test pressures, ductwork system definition and method for approving a total system.

- B. Submit for record:

1. Leak Test Field Reports (refer to Part 3 of this section)
2. Duct Cleaning Debris Disposal Plan (refer to Part 3 of this section)

1.3 DELIVERY, STORAGE AND HANDLING

- A. Deliver sealants, mastics and fire-stopping materials to site in original unopened containers with labels displaying manufacturer, product name and designation, approved use, color, date of expiration or manufacture date, curing times, and mixing instructions for multi-component materials.
- B. Store and handle sealants, mastics and fire-stopping materials in compliance with manufacturers' recommendations.

1.4 QUALITY ASSURANCE

- A. All ductwork shall be free from pulsation, chatter and vibration. If any of these defects appear after a system is in operation, correct by removing and replacing, or reinforcing the ductwork at no additional cost to the Owner.
- B. Close the open ends of ducts during construction to prevent dirt and debris from entering.
- C. Touch-up all welded and scratched galvanized steel surfaces with zinc-rich paint.

1.5 WARRANTY

- A. Generator Engine and Boilers Exhaust System: Manufacturer of these exhaust system shall warrant their exhaust system against defects in material and workmanship, in normal use, for ten (10) years from the date of delivery to the construction site, when installed, maintained and used in accordance with his specifications.
 - 1. Any portion of the exhaust system, repaired or replaced, under this warranty shall also be warranted for the remainder of the original ten (10) year warranty period.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Sealants, mastics, adhesives, coatings, acoustical lining materials, and other non-metallic components shall have maximum allowable flame spread value of 25, and a maximum smoke developed rating value of 50, in accordance with the referenced ASTM Standard E 84.
- B. Package and mark sheet metal in accordance with the referenced ASTM Standard A 700.

2.2 GALVANIZED SHEET METAL DUCTWORK

- A. Construct ducts of galvanized steel sheet with a G60 coating, with gauges in accordance with the more stringent of the requirements of the SMACNA HVAC Duct Construction Standards, the International Mechanical Code, and this specification.
- B. For rectangular ducts, the minimum gage shall be not less than 26.
- C. Provide mill phosphatized finish where ducts are exposed.

2.3 ROUND SINGLE WALL DUCTWORK

- A. Acceptable Manufacturers, subject to compliance with requirements:
 - 1. Eastern Sheet Metal, LLC.
 - 2. Lindab USA, Inc.
 - 3. SEMCO, Inc.
 - 4. United McGill Corp.

- B. Provide factory-fabricated round ducts. Gauges and construction details shall comply with the referenced SMACNA HVAC Duct Construction Standards and SMACNA Round Industrial Duct Construction Standards.
- C. Provide ducts of spiral lock-seam construction.
- D. Use slip joints, joints with a double-lipped EPDM jacket, or the following joining system for transverse duct joints and fittings.
 - 1. Up to 20 inch diameter: Interior slip coupling beaded at center and fastened to duct with screws shall be used to join ducts. Seal joint with a sealing compound, continuously applied around joint prior to assembling and after fastening, making certain that majority of sealant resides on interior of the joint.
 - 2. 21 inch to 72 inch diameter: Install using a three-piece, gasketed flanged-joint consisting of two internal flanges, with integral mastic sealant, and one external closure band to compress the gasket between the internal flanges. Acceptable System: Ductmate Spiralmate.

2.4 ROUND DUCT FITTINGS

- A. Provide matching fittings with continuously welded seams and joints.
- B. Elbows for 3 through 12 inch diameter and 90° bends shall be two-section stamped with welded seams. All other elbows shall be constructed of mitered sections with all seams and joints welded in accordance with the following schedule:
- C. Construct all elbows with a centerline radius equal to 1.5 times the diameter.
- D. Make all take-off connections to duct headers using tee (90°), lateral (45°), tee cross, lateral cross and "Y" branch fittings of the conical type. All fittings fabricated as separate fittings shall have continuous welds along all seams and joints.
- E. The use of two-piece, mitered, vaned elbows is permitted only where long radius elbows cannot be installed.
- F. The use of bullhead tee fittings without turning vanes is not permitted.

2.5 INSULATED FLEXIBLE ROUND DUCTS

- A. Acceptable Manufacturers, subject to compliance with requirements: Cleavflex Type DB Acoustical, Flexmaster Type 6B Acoustical.
- B. Acoustical insulated flexible round ducts shall be UL 181 listed as Class 1 Air Ducts, and comply with requirements of NFPA Standards 90A and 90B.
- C. Inner Core: Perforated and corrugated aluminum with interlocked seams or SPUNBOND nylon fabric mechanically locked.
- D. Helix: Galvanized steel construction, mechanically locked to the inner core.

- E. Vapor Barrier: Fire retardant polyethylene.
- F. Vapor Barrier Permeance: Maximum of 0.17 perm when tested in accordance with ASTM E96, Method A.
- G. Operating Temperature Range: 10 deg. F to 200 deg. F.
- H. Insulation: Flexible fiberglass wrap, thermal resistance of $R \geq 6.0$.
- I. Flame Spread: Less than 25.
- J. Smoke Developed: Less than 50.
- K. Working Pressure: Minimum of 2 in. w.g. positive and negative for all sizes.
- L. Burst Pressure: Minimum of 4 in. w.g.
- M. Maximum Air Velocity: 3,000 FPM.

2.6 TAPE SEALANTS

- A. Acceptable Manufacturers:
 1. McGill Airflow Uni-Cast System.
 2. Hardcast (Carlisle HVAC Products) Indoor/Outdoor Tape Rolled Sealant Foil-Grip 1402.
- B. Sealing Tape: Aluminum backing, modified butyl rolled sealant, mold & mildew resistant, water resistant, 0 g/l VOC, meets Seal Class A, suitable for use on duct joints up to Pressure Class 10 inches w.g. UL 773S classified.
- C. Adhesive: Non-flammable, clear-drying and compatible with sealing tape.
- D. Service Conditions: Sealing system shall be UL-listed with Flame Spread of 10 and Smoke Developed of 0, suitable for operation between 0°F and 200°F.

2.7 MASTIC SEALANTS

- A. Acceptable Manufacturers, subject to compliance with requirement:
 1. Ductmate Proseal.
 2. Elgen Manufacturing.
 3. Hardcast Iron-Grip 601.
 4. United McGill Corp. "United Duct Sealer".
- B. Mastic shall be one-part, acid-curing, elastomeric type, complying with ASTM C 920, Type S, Grade NS, Class 25, Use O.

2.8 FIRE-STOPPING SEALANTS

- A. Acceptable Manufacturers, subject to compliance with requirements:
 - 1. Dow Corning Fire Stop Foam and Fire Stop Sealant.
 - 2. 3M Fire Barrier Caulk CP-25.
- B. Provide two-part, foamed-in-place fire-stopping silicone or one-part, elastomeric fire-stopping, sealant formulated for use in fire-stop system for filling openings around duct penetrations through walls, floors and partitions where a fire damper is not required. System shall have fire-resistance ratings as required by UL.

2.9 DUCT JOINTS AND SEAMS

- A. Except for ductwork specified to be welded, duct transverse joints shall be selected and used consistent with the static pressure class, applicable sealing requirements, materials, duct support intervals and other provisions for proper assembly of ductwork outlined in the SMACNA HVAC Duct Construction Standards - Metal and Flexible, Transverse Joint T-15 through T-24, shown in Figure 1-4 of SMACNA HVAC Duct Construction Standards - Metal and Flexible, are acceptable construction.
- B. Transverse duct joints may also be constructed with a factory-fabricated 4-bolt connection system with manufacturer-furnished gaskets for ducts deeper than 6 inches. Construct these connections in accordance with Construction Standard T-25 a/b in the referenced SMACNA Duct Construction Standard.
- C. Except for ductwork specified to be welded, transverse duct joints for ducts with a depth of 6 inches and less shall be slip-and-drive.
- D. Type L-2 (button punch snap lock) or Type L-3 (grooved seam) longitudinal seams, are not acceptable.
- E. Seams shall be the Pittsburgh type (Type L-1), in accordance with the referenced SMACNA HVAC Construction Standard.

PART 3 - EXECUTION

3.1 GENERAL

- A. Except indicated otherwise, construct straight duct lengths, elbows, transitions, offsets, branch connections, and other fittings, of galvanized sheet steel in accordance with the referenced SMACNA HVAC Duct Construction Standards. Comply with this standard for metal thickness, reinforcement types and intervals, tie rod applications, and joint types and intervals.
 - 1. Should any ductwork remain inadvertently unsized on the drawings, size it at a pressure loss of 0.08 IWG per 100 ft.
 - 2. Straight tap branch duct connections are not permitted.

3. Provide offsets per SMACNA HVAC Duct Construction Standards.
- B. Where ducts pass through floors or partitions required to have a fire-resistance rating and fire, smoke, or combination fire/smoke dampers are not required, the opening in the construction around the duct shall not exceed 1 inch average clearance on all sides and shall be filled solidly with a UL listed through-penetration firestop sealant capable of preventing the passage of flame and hot gases. Provide angle collars and galvanized steel sheet metal safing as required to cover gap between ductwork and opening. Angle collars shall be required when safing is used for duct support at floors.
 - C. Where ducts pass through floors or partitions required to have a fire-resistance rating and fire, smoke, or combination fire/smoke dampers are required, the ductwork shall not be installed continuous through the opening in the construction, but shall connect on each side of the opening to a damper installed in a sleeve or frame secured by perimeter mounting angles on both sides of the opening. Refer to Part 3 of this section for specific details regarding sleeve thickness. For perimeter angle dimensions, size and frequency of fasteners, clearance of expansion, duct-sleeve connections, and fire damper access doors, refer to NFPA standard 90A and the fire damper manufacturer's installation instructions.
 - D. Where ducts pass through floors or partitions not required to have a fire-resistance rating, the opening in the construction shall be packed with mineral fireproofing and sealed on both sides. Provide angle collars and galvanized steel sheet metal safing as required to cover gap between ductwork and opening. Angle collars shall be required when safing is used for duct support at floors.
 - E. Rectangular Duct Elbows
 1. Supply Air Ductwork to Inlet of Air Volume Control Units: Provide only long radius elbows or short radius elbows with (3) splitter turning vanes.
 2. Supply Air ductwork from Discharge Outlet of Air Volume Control Units, and for Air Systems containing no Air Volume Control Units: Provide long radius wherever possible; square throat elbows with turning vanes only where physical space restrictions do not permit installation of long radius elbows.
 - a. Exception: Provide only long radius elbows or short radius elbows with (3) splitter turning vanes for Conference Rooms, Meeting Rooms and Exam Rooms.
 3. Exhaust Air and Return Air Ductwork for Air Systems containing no Air Volume Control Units: Provide long radius elbows wherever possible; square throat elbow with turning vanes only where physical space restrictions do not permit installation of long radius elbows.
 - a. Exception: Provide only long radius elbows or short radius elbows with (3) splitter turning vanes for Conference Rooms, Meeting Rooms and Exam Rooms.
 4. Long Radius Elbows: Construct with centerline radius equal to 1-1/2 times the duct width in plane of bend.
 5. Square Throat Elbows with Turning Vanes: Construct with single thickness

turning vanes up to a duct width of 36 in.; double wall vanes for wider ducts.

- F. Round Duct Elbows: Provide long radius elbows wherever possible; mitered elbows with turning vanes only where physical space restrictions do not permit installation of long radius elbows.
- G. Branch to Main Duct Connections:
 - 1. Rectangular-to-Rectangular Ducts: Provide SMACNA 45 deg. "boot" connections. Depth of "boot" shall increase with the width of the duct per SMACNA Duct Construction Standards.
 - 2. Round-to-Rectangular Ducts: Provide round to rectangular transitions modified to SMACNA 45 deg. "lead-in" connection construction.
 - a. At the point of connection to the main duct, "lead-in" cross-sectional area shall be at least 125% that of the branch duct.
 - 3. Round-to-Round Ducts: Provide 45 deg. laterals or United McGill's "LOLOSS" tees; conical tees only where physical space restrictions do not permit installation of aforementioned laterals or tees.
- H. Dampers: Provide duct collars and flanges for automatic dampers. Install automatic dampers provided under other Sections.
- I. Provide metal sleeves for air transfer openings in partitions and floors. Fabricate sleeves of galvanized sheet metal of gauges corresponding to similar duct sizes, as detailed in SMACNA Duct Construction Standards.
- J. Provide roof curbs as specified in Sections that specify roof mounted equipment. Counterflash ductwork over curbs.
- K. Locate ducts, except as otherwise indicated, vertically and horizontally, parallel and perpendicular to building lines. Avoid, where possible, diagonal runs. Install duct systems in shortest route that does not obstruct useable space or block access for servicing building and its equipment. Contract drawings are diagrammatic.
- L. Route ducting to avoid passing through transformer rooms, and electrical equipment spaces and enclosures.
- M. Do not install piping and conduit penetrating ductwork.
- N. At Contractor's option, and subject to fit in available space, round spiral lock-seam ductwork of equivalent or greater cross section area, as determined from the ASHRAE "Equivalent Rectangular Duct Dimensions" table, may be provided.

3.2 INSULATED FLEXIBLE ROUND DUCTS

- A. Where acoustical flexible round duct is used, provide 60 to 84 inches length of duct. Otherwise, limit flexible duct to 60 inches maximum.
- B. Install in accordance with the more stringent of manufacturer's installation instructions or

SMACNA HVAC Duct Construction Standards, latest edition.

- C. When located at the end of a duct run, limit the number of 90 degree bends to one. Bends shall be made with not less than 1 duct diameter centerline radius.
- D. Support ducts with minimum 1-inch wide straps or hangers, spaced no more than 5 feet apart, so that horizontal runs do not sag more than 1/2-inch per foot of horizontal spacing between supports.
- E. Attach insulated flexible round duct to sheet metal duct collars or sleeves having a "bead" or "lances".
 - 1. Apply adhesive over the collar or sleeve and/or inside the duct core before pulling the internal core at least 2 in. over them.
 - 2. Secure the internal core to the collar or sleeve with a draw band, applying additional adhesive over the connection. Use of duct tape instead of draw bands is unacceptable.
 - a. For vertical connections, install at least 3 screws below the strap to prevent it from slipping off.
 - 3. Pull insulation and vapor barrier to completely cover the collar or sleeve, and mechanically fasten them with another draw band. Use of duct tape instead of draw bands is unacceptable.

3.3 LEAKAGE TESTS

- A. Indoors: Leak test each ductwork system, 4 in. w.g. SMACNA Duct Pressure Class Construction and higher, before ductwork is insulated and concealed.
- B. Outdoors: Leak test each ductwork system, all SMACNA Duct Pressure Class Constructions, before ductwork is insulated.
- C. For positively-pressurized ductwork follow general procedures (Chapter 3) and use apparatus (Chapter 5) as outlined in the referenced SMACNA HVAC Air Duct Leakage Test Manual. For negatively-pressurized ductwork, follow general procedures (Chapter 3) and use apparatus (Chapter 5) as outlined in the referenced SMACNA HVAC Air Duct Leakage Test Manual, except that the test blower shall exhaust air from the ductwork being tested.
 - 1. Test all duct risers enclosed in shafts which extend more than one floor.
 - 2. Test one section, not in shafts, on each floor for each duct construction pressure classification for each individual supply, return and exhaust air system.
 - 3. In addition, test five (5) more duct sections on each floor as selected by the Owner or Owner's Representative.
- D. Duct construction pressure classifications for all ductwork are shown in the Ductwork Schedule at the end of this Section.

1. Test all ductwork at 100 percent of the specified pressure classifications, not the working pressure.
- E. The maximum allowable leakage shall be the percent of total rated airflow (cfm) capacity for each ductwork system as indicated in Ductwork Schedule at the end of this Section.
- F. All devices, including access doors, airflow measuring devices, sound attenuators, damper casings, sensors, test ports, etc. that are installed in duct systems shall be included as part of the duct systems leakage allowance and tested accordingly.
 1. Air leakage for equipment, such as fans, air handling units and terminal boxes, has been accounted for separately and all equipment has been specified to meet specific air leakage criteria.
 2. Independently leak test all equipment after installation to assure compliance with specifications, and isolate this equipment during ductwork leak testing.
 3. As an alternate, equipment may be leak tested as part of the duct system, provided that this is noted on the report forms and that leakage rate allowances for ductwork and equipment are identified separately on the forms.
- G. If tests show that ductwork system leakage is greater than that allowed, ductwork shall be resealed and retested until allowable leakage is not exceeded, at no additional cost to the Owner. All tests may be witnessed and results verified by the Owner's Representative.
 1. Submit field test report certifying that the ductwork does not exceed the maximum SMACNA allowable leakage.

3.4 SEALANTS

- A. Clean metal surfaces with cleaning agent as recommended by duct sealing system manufacturer.
- B. Apply duct sealing components in accordance with manufacturer's written instructions.
- C. Seal all duct transverse joints and all longitudinal seams, SMACNA Seal Class A, with mastic and/or tape sealants as required to meet specified maximum allowable leakage rates.

3.5 UNINSULATED DUCTWORK INSTALLED OUTDOORS

- A. Do not locate longitudinal seams on top of horizontally installed uninsulated ductwork
- B. Unless uninsulated ductwork is specified to be constructed of aluminum, stainless steel or PVC-coated galvanized steel, provide ductwork constructed of A60 galvanized steel sheet, produced in accordance with ASTM A653. Clean, prime and paint the galvanized steel ductwork, and its supports, with two coats of a white rust-resistant enamel. Do not provide galvanized steel ductwork outdoors.

3.6 INSTALLATION WORK FOR BUILDING AUTOMATION CONTROLS

- A. Provide work specified in Section 230900.

3.7 DUCTWORK SCHEDULE

- A. Construct duct systems to the following duct pressure classifications and maximum allowable leakage rates using the scheduled materials, unless otherwise noted on the contract drawings.
- B. Drawings and general provisions of the Contract, including General and Supplementary Conditions apply to this Section.

| AIR SYSTEM | DUCTWORK MATERIAL | PRESSURE CLASSIFICATION (IN W.G.) | MAX. ALLOW LEAK RATE (%) |
|------------------------------------|--------------------------|--|--------------------------|
| Supply Air from Air Handling Units | Indoors-Galvanized steel | +2 downstream of constant or variable air volume control boxes or valves | 3 |
| Return Air to Air Handling Units | Indoors-Galvanized steel | -2 upstream of fan +2 downstream of fan | 3 |

++ END OF SECTION ++

SECTION 233300
AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section describes
 - 1. Dampers.
 - 2. Manual volume dampers.
 - 3. Backdraft dampers.
 - 4. Turning vanes.
 - 5. Duct access doors.
 - 6. Flexible duct connectors.
 - 7. Round branch duct connections.
 - 8. Grilles, registers, and diffusers.
 - 9. Other duct-mounted accessories.

1.2 SUBMITTALS

- A. Dampers:
 - 1. Product Data: Showing damper materials, gauges, pressure drops.
 - 2. Shop Drawings: Dimensions, and fabrication, design and installation details.
 - 3. Certifications: AMCA and UL Certifications.
 - 4. Installation instructions.
 - 5. Operation and Maintenance Data.
- B. Turning Vanes, Access Doors, Flexible Connections, :
 - 1. Product data: Show published catalog data.
 - 2. Installation instructions.
 - 3. Operation and Maintenance Data.

C. Grilles, Registers and Diffusers:

1. Product data: Show published catalog data.
 - a. Include performance data for each size air terminal scheduled.
 - 1) Inlet static pressure in inches w.g.
 - 2) Maximum and minimum airflow in cfm.
 - 3) Throw in feet at maximum cfm and 25 percent of cfm for terminal velocities of 50 and 100 fpm.
 - 4) Noise Criteria (NC) curve at maximum air terminal cfm rating with blades in full-open and closed positions.

D. Samples: For products that can be furnished in different colors, submit color chips from full range of manufacturer's standard colors for selection by Architect.

1.3 QUALITY ASSURANCE

- A. Construct damper in contact with the airstream from the same material as the ductwork in which it is installed.
- B. Design dampers to withstand the duct pressure classification and the design air velocity.

PART 2 - PRODUCTS

2.1 DAMPERS

A. Acceptable Manufacturers: Subject to compliance with requirements, products of the following are acceptable. Shop-fabricated dampers are not acceptable:

1. Dampers:
 - a. Cesco.
 - b. Ruskin.
 - c. Nailor.
 - d. Air Balance.
 - e. Pottorff.
 - f. Greenheck.
 - g. NCA Manufacturing.
 - h. American Warming and Ventilating.
2. Damper Hardware:
 - a. Ventlok.
 - b. Duro-Dyne.
 - c. Young.

2.2 MANUAL VOLUME DAMPERS

A. For round ducts up to 24 inches in diameter, provide butterfly-type manual volume

dampers with the following features:

1. Frame: No. 20 gage galvanized steel, 10 inches long.
 2. Blade: Circular, double-thickness galvanized steel; No. 14 gage, equivalent thickness, butterfly type.
 3. Blade Seal: One-piece neoprene or EPDM, sandwiched between two sides of blade.
 4. Finish: Mill galvanized.
 5. Axle: 1/2-inch diameter, galvanized or plated steel.
 6. Bearings: Oil-impregnated bronze sleeve, nylon or stainless steel sleeve pressed into frame.
 7. Control Shaft: Axle, extending 6 inches beyond frame exterior.
 8. Stop: Galvanized steel angle at open and closed positions.
 9. Maximum Size: 24 inch diameter.
 10. Minimum Size: 4 inches diameter.
 11. Quadrant: 3/8-inch or 1/2-inch, 16 gage, cold rolled steel base plate, die-cast handle, and 1/4-inch, chrome-plated wing nut for locking the handle in place.
 - a. 2 Inch Stand-Off Mounting Bracket: Furnish for insulated ducts.
- B. For rectangular ducts, provide following manual volume dampers with the following features:
1. Frame: 5 inch by 1 inch by No. 16 gage galvanized steel channel with corner braces. Low profile top and bottom 3-1/2-inch by 3/8-inch by No. 16 gage galvanized steel channel for units 9 inches high and under.
 2. Blades: 8 inch maximum, galvanized steel.
 3. Finish: Mill galvanized.
 4. Axles: 1/2-inch hexagon or 1/2-inch diameter.
 5. Bearings: Molded synthetic.
 6. Control Shaft: 3/8-inch square or 1/2 inch diameter plated steel.
 7. Maximum Size: 48 inches by 48 inches.
 8. Minimum Size: 6 inches by 5 inches.

- a. Dampers 11 inches high and smaller shall be single-blade type.
 - b. Dampers 12 inches high and larger shall be multi-blade, opposed-blade type.
- 9. Attach damper blade to control shaft with regulator mounted on the surface of the duct. Acceptable model: Ventlok 555 or 560.
 - a. 2 Inch Stand-Off Mounting Bracket: Furnish for insulated ducts.
- C. Provide following manual volume dampers for square or rectangular ducts in exhaust systems served by toilet exhaust fans if duct width is 36 inches or less, duct height is 12 inches or less, and duct velocity is less than 1500 feet per minute.
 - 1. Frame: No. 22 gauge galvanized steel.
 - 2. Blades: Galvanized steel, No. 22 gauge for dampers having a width of 18 inches or less; No. 16 gauge for dampers having a width greater than 18 inches.
 - 3. Control Shaft/Hand Quadrant: 3/8" square-axle shaft extending beyond frame with factory-supplied, field-mounted locking hand quadrant. Acceptable Model: Ventlok 635.
 - a. 2 Inch Stand-Off Mounting Bracket: Furnish for insulated ducts.
 - 4. Bearings: Molded synthetic.
 - 5. Finish: Mill galvanized.

2.3 BACKDRAFT DAMPERS

- A. Dampers shall be low-leakage, parallel-blade type. Damper sizes shall be suitable for duct sizes noted on the contract drawings. The dampers shall be suitable for a minimum 4000 fpm velocity.
- B. Damper frames shall be minimum No. 12 gage galvanized steel and blades shall be minimum No. 16 gage galvanized steel or Type 6063T5 aluminum with press-fit ball bearings.
- C. Dampers shall be complete with adjustable counterweights and linkage for the duty.
- D. Provide neoprene or silicone rubber blade seals.

2.4 TURNING VANES

- A. Acceptable Manufacturers, subject to compliance with requirements:
 - 1. Aerodyne.
 - 2. Ductmate model Pro-Rail.

3. Elgen Mfg. Co.
- B. Provide turning vanes in all square-throat rectangular duct elbows, offsets greater than 30 degrees, curved throat elbows with a centerline less than 1.5 times the duct width, and where shown in other locations.
- C. Construct turning vanes of the same material as the ductwork in which they are installed.
- D. Turning vanes shall be one of the following designs:
 1. Double-thickness, airfoil design with a smoothly rounded entry nose and an extended trailing edge. Sound power level: 54 dB in Band 4 at 2000 fpm in a 24 x 24 duct.
 2. Harper double wall turning vanes. Mounting rails shall have friction insert tabs that align the vanes automatically.
 - a. Tab spacing shall be as specified in latest edition SMACNA Manual, "HVAC duct Construction Standards, Metal & Flexible".
 - b. Vanes shall be capable of supporting 250 pounds when secured according to the manufacturer's instructions.

2.5 DUCT ACCESS DOORS

- A. Acceptable Manufacturers, subject to compliance with requirements:
 1. Ductmate Industries, Inc.
 2. Elgen Mfg. Co.
 3. Flexmaster USA, Inc.
 4. Kees, Inc.
 5. McGill Airflow LLC
 6. Nailor Industries, Inc.
 7. Ruskin Co.
- B. Provide with matching insulation or acoustical lining where duct is insulated or lined at locations where the following equipment is installed in the ductwork:
 1. Fire, Smoke and Control Dampers and Damper Linkages.
 2. Reheat Coils (inlet side).
 3. Other Duct-Mounted Devices, including instrumentation and control devices and smoke detectors provided under other Sections.

4. Other locations shown on the Contract Drawings.
- C. Paint duct access doors serving a fire damper, smoke damper or combination fire-smoke damper with not less than 1/2-inch high red letters reading "FIRE DAMPER" "SMOKE DAMPER" or "COMBINATION FIRE-SMOKE DAMPER".
 1. No external ductwork insulation shall conceal a fire damper access door unless there is a label attached to the insulation indicating the exact location of the access door.
- D. Provide building access panels required for access to duct-mounted access doors.
- E. Fabricate access doors of the same material as the ductwork they're to be installed in, with closed cell neoprene gaskets around the entire perimeter and quick fastening locking devices.
- F. Furnish double-wall access doors with internal insulation for insulated (or acoustically lined) ductwork. Insulation thickness to be not less than the thickness of adjacent ductwork or casing insulation.
- G. Furnish access doors in a minimum size of 18" x 18", unless otherwise indicated. Where the size of the duct will not accommodate this size, furnish access doors as large in size as the ducts will permit to be installed.
- H. Access doors, installed in ducts rated for a Pressure Class of 3 inches w.g. and less, shall be hinged and cam-locked, square-framed type.
- I. Access doors, installed in ducts rated for Pressure Class 4 inches w.g. and higher, shall be of sandwich-type construction in compliance with the SMACNA Manual, "HVAC Duct Construction Standards, Metal & Flexible", latest edition.

2.6 FLEXIBLE DUCT CONNECTORS

- A. Indoor Installation: UL listed, fire retardant neoprene or vinyl-coated woven fiberglass fabric. Minimum density 30 oz./sq. yd. Rated to constant maximum temperature of 200 deg F.
 1. Acceptable Manufacturers, subject to compliance with requirements:
 - a. VentFabrics, Inc., model "Ventglas".
 - b. Duro-Dyne Corp, model 10012 MF6N Specification Grade Neoprene, Super Metalfab".
 - c. Ductmate Industries, Inc., model PROflex.
- B. Outdoor Weather-Exposed Installation: UL listed, ozone and UV-resistant Hypalon-coated woven fiberglass fabric. Minimum Density 24 oz./sq. yd.. Rated to constant maximum temperature of 250 deg F.
 1. Acceptable Manufacturers, subject to compliance with requirements:

- a. VentFabrics, Inc., model "Ventlon."
- b. Duro-Dyne Corp, model "#10011 MF6D Durolon or Dynalon Super Metalfab".
- c. Ductmate Industries, Inc., model PROflex.
- d.

2.7 ROUND BRANCH DUCT-TO-RECTANGULAR DUCT CONNECTIONS

- A. Acceptable Manufacturers, subject to compliance with requirements:
 1. Buckley Air Products, Inc. models 3300, BM or M-BM.
 2. Elgen Mfg. Co. HET.
 1. Spiral Fittings, Inc.
 2. Spiral Manufacturing Co., Inc.
- B. Furnish, in order of preference, 45° high efficiency take-off, full bellmouth or mini-bellmouth round branch connections of all welded construction with a dense polyethylene or neoprene gasket and pre-drilled mounting holes.
 1. Always furnish higher preference fittings where their installation is physically possible.
 2. Material of construction (G-60 or G-90 galvanized steel, stainless steel or aluminum) to match that of ductwork.
 3. Without damper, suitable for use in all pressure class ductwork up to 10" W.G. construction.
 4. Residential products are not acceptable.
- C. Furnish manual volume dampers where shown on drawings, and as specified elsewhere in this section.
 1. 2 Inch Stand-Off Mounting Bracket: Furnish for insulated ducts.

2.8 GRILLES, REGISTERS, AND DIFFUSERS

- A. Acceptable Manufacturers: Subject to compliance with requirements:
 1. Anemostat (a Mestek Co.).
 2. Krueger.
 3. Nailor Industries, Inc.

4. Price Industries.
 5. Titus (ASCD Companies).
 6. Tuttle & Bailey (T & B).
- B. General:
1. Grilles, registers and diffusers, except where indicated otherwise on the drawings, shall be steel, factory finished with baked enamel finish of color selected by Architect.
- C. Ceiling Diffusers
1. Furnish all diffusers with an equalizing deflector and volume damper. If diffuser is to be used for return or exhaust air, omit equalizing deflector. If diffuser is to be used as a return or exhaust air grille, omit volume damper. Gasket supply diffusers to prevent streakage, unless installed in T-bar ceiling or where duct collar is female to diffuser collar. Blank-off diffusers to prevent airstream from contacting obstructions. Diffuser frames and margins shall be compatible with ceiling construction.
 2. Diffusers shall be round, square, rectangular, or linear square or rectangular neck as indicated on Drawings.
 - a. Architectural Square Plaque Ceiling Diffuser:
 - 1) Diffuser shall have a 22 gage steel face panel that captures a secondary 22 gage panel. Face panel removable by means of four hanger brackets. Exposed surface of the face panel shall be smooth, flat, and free of visible fasteners. Face panel shall project 1/4-inch below the outside border of the diffuser back pan. Back of the face panel shall have an aerodynamically shaped, rolled edge to ensure a tight horizontal discharge pattern.
 - 2) Ceiling diffusers with a 24 x 24 inch full face shall have no less than and 18 x 18 inch face panel size.
 - 3) Ceiling diffusers with a 12 x 12 inch full face shall have no less than a 9" x 9" face panel size.
 - 4) Back pan shall be one piece precision die-stamped, shall include an integrally drawn inlet, and shall be constructed of 22 gauge steel.
 - 5) Diffuser neck shall have a minimum of 1-1/4-inch depth available for duct connection.
 - 6) Finish shall be #26 white, baked anodic acrylic paint.
 - 7) Round damper shall be constructed of heavy gauge steel.
 - 8) Damper must be operable from the face of the diffuser.
 - 9) Furnish directional blow clips to restrict the discharge air in certain directions.

D. Grilles and Registers

1. Supply Air Grilles and Registers:

- a. Registers shall be double deflection type with individually adjustable vertical face bays and horizontal back deflector blades and key operated opposed dampers.
- b. Omit opposed blade volume dampers for supply air grilles.

2. Return, Transfer and Exhaust Air Grilles and Registers:

- a. Registers shall be single deflection with opposed-blade damper and fixed blades set at 40 degrees.
- b. Omit opposed blade dampers for return, transfer and exhaust grilles.
- c. Provide aluminum control grids at the rear of each supply air grille to product uniform air distribution over the entire grille. Each blade of the control grid shall be reinforced and individually adjustable. Attach control grid frame to grille collar.
- d. Provide an integral single or multiple blade volume control damper at the rear of each supply, return, relief and exhaust grille.
- e. Ceiling-mounted return and exhaust registers shall be suitable for installation in the ceiling type indicated on the Architectural Reflected Ceiling Plans. Where a grille or register is mounted on a plaster, dry wall, tile furred, concrete block or precast concrete surface, provide a plaster-stop flush-mounting frame. Furnish frame with latex foam or sponge rubber gasket to prevent air leakage. Grilles on exposed ducts will not require a frame.
- f. Where grilles or registers are installed on sheet metal collars, provide mounting frame with 1-inch wide flange. Provide collars of the minimum size and depth required to install a controller that will produce uniform airflow over the face of the grille or register.
- g. Where grille or register is larger than normally manufactured in a single section, provide two or more equal sections with matching angle frames to join grille or register sections together.

PART 3 - EXECUTION

3.1 DAMPERS

- A. Install dampers in accordance with manufacturer's instructions and as indicated on the Drawings.
- B. After duct system has been adjusted, tested and balanced, lock manual volume dampers in position. Make a permanent mark on the quadrant to indicate correct position.
- C. Damper actuators that are located in plenums shall be mounted on damper frames. Damper actuators shall not be installed inside ducts or fresh-air intakes.

- D. Install fire dampers of proper rating where indicated on the Drawings, in accordance with the conditions of their approval and tests by Underwriters Laboratories, Inc. Install fire dampers so that damper blades are positioned up in recessed hat section of frame and do not protrude into the airstream. Make necessary repairs to walls, floors and ceilings after the dampers are installed to restore integrity of fire rating.
- E. Automatic and Smoke Dampers:
 - 1. Install dampers in accordance with manufacturer's recommendations.
 - 2. Coordinate size and location of dampers before fabricating or installing associated ductwork.
 - 3. Support dampers either by properly reinforcing the ductwork at damper locations to carry the weight of the dampers, or by supporting them independently of the ductwork from the floor or building structure, as required by conditions at the site.

3.2 TURNING VANES

- A. Weld turning vane runners and turning vanes to the duct where applicable.

3.3 FLEXIBLE CONNECTIONS

- A. Install flexible duct connections at the inlet and outlet connections of fans, except at double-inlet fans free-standing in plenums, inlet and outlet connections of fan-powered boxes, at building expansion joints, and other locations where indicated on the Drawings or required by Section 230548.
- B. The clear space between connected parts shall be minimum 3 inches, and the connection shall have minimum additional 1.5-inches slack material.
- C. Ductwork or plenum openings shall be squarely aligned with the fan discharge, fan intake or adjacent duct section prior to installation of the flexible duct connection, so that the clear length is approximately equal all the way around the perimeter.
 - 1. Do not install flexible duct connections until this provision is met.
 - 2. The fan unit or adjacent duct section shall be able to move 1 inch in any direction without causing metal-to-metal contact or stretching taut the flexible duct connection.

3.4 GRILLES, REGISTERS AND DIFFUSERS

- A. Install air terminals in accordance with manufacturer's recommendations.
- B. Review Architectural Specification and Drawings describing the types of walls, floors and ceilings required for the project.
- C. Coordinate with work of related Sections for selecting the proper type of frame and mounting for each air terminal.

- D. Support grilles registers and diffusers independently. Do not support from the ceiling construction.

++ END OF SECTION ++