

SECTION 23 31 00
HVAC DUCTS AND CASINGS

PART 1 – GENERAL

1.01 SECTION INCLUDES

- A. Sheet metal ductwork.
- B. Registers, grilles, and diffusers.
- C. Electric duct heaters.
- D. Manual volume dampers.
- E. Fire dampers.
- F. Combination fire/smoke dampers.
- G. Backdraft dampers.
- H. Access doors.
- I. Hangers and supports.
- J. Sealants.
- K. Duct plenums.
- L. Flexible connections.
- M. Air extractor.
- N. Turning vanes.
- O. Casings.
- P. Fibrous glass ducts.
- Q. Kitchen hood exhaust ductwork.

1.02 RELATED SECTIONS

- A. Section 01 33 00, Submittal Procedures.
- B. Section 01 33 23, Shop Drawings, Product Data, and Samples.
- C. Section 01 78 23, Operation and Maintenance Data.
- D. Section 07 90 00, Joint Protection.

- E. Section 08 31 00, Access Doors and Panels.
- F. Section 09 91 00, Painting.
- G. Section 20 30 13, Vibration Isolation and Seismic Control.
- H. Section 23 05 93, Testing, Adjusting, and Balancing for HVAC.
- I. Section 23 81 00, Unitary HVAC Equipment.

1.03 MEASUREMENT AND PAYMENT

- A. Separate measurement or payment will not be made for the Work required under this Section. Costs in connection with the Work specified herein shall be considered to be included as part of the Contract lump sum price indicated in the Bid Schedule of the Bid Form for the related item or items of Work.

1.04 REFERENCES

- A. Air Diffusion Council (ADC):
 - 1. AMCA 500 Test Method for Louvers, Dampers and Shutters
 - 2. ADC1062: GRD Test Code for Grilles, Registers and Diffusers
 - 3. ARI 650 Air Outlets and Inlets
- B. American Society of Heating, Refrigerating and Air Conditioning Engineers Inc. (ASHRAE):
 - 1. ASHRAE Handbook, HVAC Applications
 - 2. ASHRAE Handbook, Fundamentals
 - 3. ASHRAE Handbook, HVAC Systems and Equipment
- C. American Society for Testing and Materials (ASTM):
 - 1. ASTM A36/A36M Specification for Structural Carbon Steel
 - 2. ASTM A90 Weight of Coating on Zinc-Coated (Galvanized) Iron or Steel Articles
 - 3. ASTM A123 Specification for Zinc (Hot Dip Galvanized) Coatings on Iron and Steel Products
 - 4. ASTM A153/A153M Specification for Zinc Coating (Hot Dip) on Iron and Steel Hardware
 - 5. ASTM A525 General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot Dip Process

6. ASTM A653/A653M Specification for Steel Sheet, Zinc Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvanized) by the Hot Dip Process
- D. American Welding Society (AWS):
1. AWS D1.1 Structural Welding Code Steel
 2. AWS D9.1 Sheet Metal Welding Code
- E. National Fire Protection Association (NFPA):
1. NFPA 90A Standard for the Installation of Air Conditioning and Ventilating Systems
 2. NFPA 90B Installation of Warm Air Heating and Air Conditioning Systems
 3. NFPA 92A Smoke Control System
- F. Sheet Metal and Air Conditioning Contractors National Association Inc. (SMACNA):
1. SMACNA Ducted Electric Heat Guide for Air Handling Systems
 2. SMACNA Fire, Smoke and Radiation Damper Installation Guide for HVAC Systems
 3. SMACNA HVAC Air Duct Leakage Test Manual
 4. SMACNA HVAC Duct Construction Standards – Metal and Flexible
 5. SMACNA HVAC Systems Duct Design
 6. SMACNA HVAC Duct Systems Inspection Guide
 7. SMACNA Seismic Restraint Manual Guidelines for Mechanical Systems
- G. Underwriters Laboratories Inc. (UL):
1. UL 33 Heat Responsive Links for Fire-Protection Service
 2. UL 181 Factory Made Air Ducts and Air Connectors
 3. UL 555 Fire Dampers
 4. UL 555S Smoke Dampers

1.05 SUBMITTALS

- A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures.
- B. Shop Drawings: Submit Shop Drawings showing the following information:
 - 1. Ductwork layout including diffusers, registers, and grilles;
 - 2. Fire damper installation details and locations;
 - 3. Access door installation details and locations;
 - 4. Duct sizes, materials, sheet metal gages, duct reinforcement schedules, duct supports, duct support spacing, and fabrication methods; and
 - 5. Volume dampers, motorized dampers, turning vanes, and extractors, installation details and locations.
- C. Product Data: Submit manufacturers' product data and certificates of compliance for specified materials and equipment.
- D. Test Reports: Submit certified field test reports verifying successful air duct leak testing.
- E. Operation and Maintenance Data: Submit operation and maintenance data, for the equipment provided, in accordance with Section 01 78 23, Operation and Maintenance Data.

1.06 QUALITY ASSURANCE

- A. Provide fabricated duct systems complete as shown on drawings. Duct sizes, types, routing, and locations shall be as indicated. Wherever possible, ducts shall use long radius sweep elbows in lieu of internal turning vanes.
- B. Ductwork shall conform to the applicable requirements of NFPA 90A and NFPA 90B, SMACNA and ASHRAE Handbooks, the California Mechanical Code, Chapter 10, and the equipment manufacturer's recommendations.
- C. Duct sizes shall refer to the inside clear dimensions. No insulating (noise or thermal) materials shall be used on inside of supply or return ducts.
- D. Change in duct size or shape necessitated by interference with other work shall be made using sizes of equivalent friction loss.
- E. Where pipe, structural member, or other obstruction passes through a duct, provide a streamlined sheet metal collar around member and increase duct size to maintain net area. Fit collar and caulk to make airtight.

- F. Galvanized surfaces damaged by welding shall be repaired in accordance with manufacturer's written instructions.
- G. Submit detailed fabrication drawings of ductwork showing dimensions, construction, welding, fittings, and configurations, and receive approval prior to start of work.
- H. Qualify welding processes and welding operators in accordance with AWS D1.1 for hangers and supports, and AWS D9.1 for sheet metal.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Duct sections shall be covered and stored on skids above grade.
- B. Duct sections that come in contact with dirt shall be cleaned inside and outside.
- C. Use all means necessary at the site to protect the materials from dirt, dust, moisture, physical abuse before and during the installation. All installed duct work openings shall be covered during the construction period.

1.08 SITE CONDITIONS

- A. Inspect surfaces and structures where air distribution and duct system will be installed before the work of this Section begins. Provide surfaces and structures capable of supporting the system and its weight.
- B. Coordinate the installation of the air distribution and duct system with other building systems and components so as to avoid conflicts of installation. Drawings are diagrammatic and not necessarily to scale.

PART 2 – PRODUCTS

2.01 SHEET METAL DUCTWORK

- A. Ducts shall be designed and constructed in accordance with SMACNA HVAC Systems Duct Design and HVAC Duct Construction Standards of lock forming quality galvanized steel sheet conforming with ASTM A653/A653M, ASTMA525, A527 with zinc coating G90 for each side of sheet, unless otherwise indicated.
- B. Ducts embedded in concrete shall be constructed of one fourth inch thick carbon steel plate, and shall be welded in accordance with AWS D1.1. Fabricated ducts shall be hot dip galvanized after fabrication in accordance with ASTM A123 and shall be structurally reinforced. Zinc coating designation shall be G90.
- C. Duct fabrication, metal gages, and reinforcement shall conform with the SMACNA HVAC Duct Construction Standards - Metal and Flexible. Pressure classification of sheet metal ducts shall be two inches water gage, negative or positive, as appropriate, except that ductwork in subways shall be classified at six inches of water gage, positive or negative, whichever is more stringent.

- D. Provide 300 Series (18-8) stainless steel ductwork for battery room exhaust system and for ductwork passing through battery rooms.
- E. Design and fabricate ductwork in accordance with the following requirements:
1. Size round ducts installed in place of rectangular ducts from ASHRAE table of equivalent rectangular and round ducts. No variation of duct configuration or sizes will be permitted without written approval of the Engineer.
 2. Duct sizes 19 inches wide and larger that have more than 10 square feet or unbraced panel shall be beaded or cross-braced unless ducts will have insulation covering. This requirement is applicable to 20 gage or less thickness and pressure class of three inches water gage or less. It is not necessary to break or bead all sides unless each duct dimension requires it.
 3. Lap metal ducts in direction of airflow. Hammer down edges and slips to leave a smooth duct interior. Seal duct seams and joints in accordance with the California Mechanical Code.
 4. Construct tees, bends, and elbows with radius of not less than one and one half times width of duct on centerline. Rectangular elbows shall be avoided, if not possible then airfoil type galvanized steel turning vanes shall be used.
 5. Increase duct sizes gradually, not exceeding 15 degrees divergence whenever possible. Maximum divergence upstream of equipment shall be 30 degrees and convergence downstream shall be 45 degrees.
 6. Rigidly construct metal ducts with joints air tight, braced and stiffened so as not to breathe, rattle, vibrate, or sag. Caulk duct joints and connections with sealant as ducts are being assembled.
 7. Modify ducts where ductwork conflicts with piping and structures. Where modifications result in duct area reductions exceeding 10 percent duct area, split into two ducts maintaining original duct pressure losses.
 8. Provide necessary baffling in mixed air plenums to ensure good mixed air temperature with variations of not more than plus or minus two degrees Fahrenheit under operating conditions.
 9. Construct plenums of galvanized panels joined by standing seams on outside of casing riveted or bolted on approximately 12 inch centers. Reinforce with steel angles and provide diagonal bracing. Tightly fit at apparatus and seal with sealant.
 10. Fabricate continuously welded round and oval duct fittings two gages heavier than duct gages indicated in SMACNA Standard. Joints shall be minimum four inch (100 mm) cemented slip joint, brazed or electric welded. Prime coat welded joints.
 11. Provide standard 45 degree lateral wye takeoffs, unless otherwise indicated, where 90 degree conical tee connections may be used.

12. Provide openings in ductwork and casings where required to accommodate thermometers and controllers. Provide pivot tube openings where required for system testing and balancing, complete with metal cap and spring device or screw to ensure against air leakage. Where openings are provided in insulated ductwork, install insulation material inside a metal ring.
13. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.
14. Set plenum doors 6 to 12 inches above floor. Arrange door swings so that fan static pressure holds door in closed position.
15. Where indicated, connect diffusers and registers to ducts with flexible duct. Provide ducts tested and classified by Underwriters Laboratories, Inc., as Class 1 Air Duct, and labeled in accordance with UL 181. Provide flexible duct installed in fully extended condition free of sags and kinks, using only minimum length required to make connection. Single bends shall have inside angles of not less than 90 degrees. Flexible duct shall not be longer than five feet.
16. Do not install duct sealants when temperatures are less than those recommended by sealant manufacturers.
17. Maintain temperatures during and after installation of duct sealants.

2.02 REGISTERS, GRILLES, AND DIFFUSERS

A. Product Requirements:

1. **Standard Products:** Except as otherwise indicated, provide manufacturer's standard registers, grilles, and diffusers where shown; of size, shape, capacity and type indicated; constructed of materials and components as indicated, and as required for complete installation.
2. **Performance:** Provide registers, grilles, and diffusers that have, as a minimum, temperature and velocity traverses, throw and drop, and noise criteria ratings for each size device as listed in manufacturer's current catalogs.
3. **Ceiling and Wall Compatibility:** Provide registers, grilles, and diffusers with border styles that are compatible with walls and ceiling systems, and that are specifically manufactured to fit into ceiling module or wall construction with accurate fit and adequate support. Refer to Contract Drawings and Specifications for types of wall construction and ceiling systems.
4. **Painting:** Registers, grilles, and diffusers shall be finished with a baked white enamel finish unless otherwise approved. Paint must pass ASTM B117, Corrosive Environments Salt Spray Test, ASTM D870, Water Immersion Test, and ASTM B2794, Reverse Impact Cracking Test.
5. **Construction:** Registers, grilles, and diffusers shall be factory fabricated of aluminum, plate or extruded. Exposed edges shall be rolled, extruded, or otherwise stiffened. All components shall be product of one manufacturer.

6. Air Distribution: Supply air diffusers and registers shall distribute specified quantity of air evenly over space intended without causing noticeable draft, air movements faster than 50 fpm in occupied zone, or dead spots anywhere in the ventilated area.
 7. Sound Ratings: Inlets and outlets shall be sound rated and certified in accordance with ADC1062: GRD, in sound power level, decibels reference 10 - 12 W, in octave bands 2 6. The rated NC sound pressure level index, computed by deducting 8 dB room attenuation, shall not exceed NC 35.
- B. Diffusers:
1. Internal parts of each diffuser shall be removable as a unit. Removable parts shall be constructed so that they cannot be reassembled in a manner that will produce an incorrect air distribution pattern. The internal assembly shall be either circular, square, or rectangular and shall be removable and capable of being reassembled without special tools. Sheet metal air duct or plenum connection to diffusers shall be secured in accordance with the diffuser manufacturer's instructions. Sponge rubber or neoprene gasket shall be provided between ceiling and surface mounted diffusers.
 2. Provide ceiling diffusers of the rectangular, square, or linear face type as indicated. Diffusers shall be equipped with baffles to provide the air distribution pattern. Provide factory fabricated turning-vanes at each diffuser, branch duct and take off, except where flexible ductwork is used. Vanes shall be removable through the diffuser. Each diffuser shall have a factory fabricated, single key, opposed blade volume damper constructed so that the required air flow can be obtained without affecting the air distribution pattern; the volume damper key operator shall be operable through diffuser face without removing air distribution baffle.
- C. Supply Registers: Provide multi-directional-control type register with a factory-fabricated volume damper. Volume dampers shall be group-operated, opposed blade type and shall be key adjustable. Volume damper adjustment shall be made by inserting key through face of register. Operating mechanism shall not project through the register face. Registers shall be provided with sponge rubber or neoprene gaskets between flanges and wall or ceiling.
- D. Exhaust and Return Registers: Exhaust and return registers shall be as specified for supply registers herein, except provide exhaust and return registers with a single set of fixed, non see-through, non-directional face blades or louvers having the same appearance as the supply register.
- E. Grilles: Grilles shall be as specified for registers, except without volume control dampers. Exhaust outlets for battery rooms shall be constructed of type 316 stainless steel.

2.03 ELECTRIC DUCT HEATERS

- A. Electric duct heaters shall be flanged type heaters in accordance with applicable requirements of Section 23 81 00, Unitary HVAC Equipment.

2.04 MANUAL VOLUME DAMPERS

- A. Requirements: Provide adjustable balancing dampers of minimum 16 gage galvanized steel construction, conforming with applicable requirements of SMACNA HVAC Duct Construction Standards-Metal and Flexible, with locking quadrants. Manually adjustable balancing dampers shall be provided at points on supply systems where branches are taken from larger ducts and in branch duct to individual diffusers, grilles, and registers, as required for air balancing.
1. Damper axles shall be continuous square rods not smaller than 3/8-inch, with machined ends and bearings at both ends. Damper blades shall not be more than six inches wide by 48 inches long.
 2. Single-blade dampers shall be provided for duct sizes up to nine-inches by 30-inches. Multi-blade dampers of opposed blade pattern shall be provided for duct sizes larger than nine-inches by 30-inches.
- B. End Bearings: Except in round ductwork 12 inches (300 mm) and smaller, provide end bearings. On multiple blade dampers, provide oil-impregnated nylon or sintered bronze bearings.
- C. Quadrants:
1. Provide locking, indicating quadrant regulators on single and multi-blade dampers.
 2. On insulated ducts, mount quadrant regulators on stand-off mounting brackets, bases, or adapters.
 3. Where rod lengths exceed 30 inches (750 mm) provide regulator at both ends.
- D. Splitter Dampers: Provide only where indicated. Splitter dampers shall be constructed of double thickness galvanized steel sheet shaped to streamline and stiffened to avoid vibration. Splitter dampers shall be sized on the basis of straight air volume proportioning, and shall be operated by quadrant operators.

2.05 FIRE DAMPERS

- A. Fire dampers shall be UL Class A rating and constructed in accordance with UL 555 and SMACNA Fire, Smoke and Radiation Damper Installation Guide for HVAC Systems. Fusible links on fire dampers shall be constructed in accordance with UL 33. Provide fire dampers in accordance with NFPA 90A where ducts and outlets pass through fire-rated walls, and where indicated. Fire damper assembly shall be complete with required perimeter mounting angles, sleeves, breakaway duct connections, and stainless steel springs, bearings, bushings, and hinges.
- B. Fire dampers shall be curtain type and fabricated of galvanized steel, weighted to close and remain in closed position when released by fusible link. Fabricate fire dampers with linkage readily adjustable with damper in open position. Curtain type fire dampers shall have blades retained in a recess so free area of connecting

ductwork is not reduced. Fire dampers shall have the same (or higher) fire rating as the fire rated walls where ducts pass through.

- C. Set or select fusible links for 165 degrees Fahrenheit release unless otherwise indicated.

2.06 COMBINATION FIRE/SMOKE DAMPERS

- A. Provide fire and smoke combination dampers in accordance with UL 555S, Leakage Class II, with a leakage rating of not more than ten cfm per square foot at one inch water gage pressure differential across closed damper. Provide two position dampers, equipped with an electric damper operator and with firestat that electrically locks damper in a closed position when ambient (duct) temperatures exceed 165 degrees Fahrenheit.
- B. Damper shall be capable of interfacing electrically with a smoke detector and remote indicating and control station. Where indicated, provide conventional fusible link connection between damper and operator instead of a firestat.

2.07 BACKDRAFT DAMPERS

- A. Provide 16-gage aluminum, multiblade, gravity type, backdraft dampers having balanced parallel action, one half inch steel axles with keyways spaced nine inch centers, with one half inch ball bearings, blades, and flexible vinyl sealing edges. Weighted relief dampers shall be used where it is required to maintain positive pressure by forced air supply and gravity exhaust.

2.08 ACCESS DOORS

- A. Provide access doors or panels for maintenance of filters and coils, control dampers, on either side of each fire and smoke damper, and at thermostats, temperature controllers, and other apparatus requiring service and inspection. Locations shall be approved prior to duct fabrication. Fabricate rigid, close-fitting doors of galvanized steel with sealing gaskets and quick fastening locking devices. For insulated ductwork, install minimum one-inch thick insulation with sheet metal cover. Provide two hinges and two sash locks for sizes up to 18 inches high, two hinges and two compression latches with outside and inside handles for sizes up to 24 by 48 inch. Height of access doors shall be four to six inches smaller than the duct dimension by 16 inches wide, but not less than 6 inches by eight inches. Provide an additional hinge for larger sizes. Refer to Section 08 31 00, Access Doors and Panels, for detailed requirements for wall and ceiling mounted access doors and panels to access concealed ducts.
- B. Access doors in plenums of air-conditioning systems shall be hinged and furnished with latches operable from both inside and outside. Edges shall rest against neoprene or felt for airtight closure. Plenum access doors shall open to the outside of housing on the fan suction side and to the inside on the fan discharge side.

2.09 HANGERS AND SUPPORTS

- A. Requirements: Provide hangers and supports of steel shapes and rods conforming to ASTM A36/A36M, galvanized in accordance with ASTM A123. Hardware for hangers and supports shall be galvanized in accordance with ASTM A153/A153M. Hangers and supports shall be fabricated in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible, and SMACNA HVAC Systems Duct Design.
- B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural steel fasteners appropriate for building materials. Do not use powder-actuated concrete fasteners for lightweight aggregate concretes or for slabs less than 4 inches thick.
- C. Hangers: Galvanized sheet steel, or round, uncoated steel, threaded rod.
- D. Straps and Rod Sizes: Conform with Table 4-1 in SMACNA HVAC Duct Construction Standards - Metal and Flexible, for sheet steel width and gage and steel rod diameters.
- E. Duct Attachments: Sheet metal screws, blind rivets, or self-drilling, self-tapping metal screws; compatible with duct materials.
- F. Longitudinal and Transverse Seismic Bracing of Ductwork: Conform to SMACNA Seismic Restraint Manual Guidelines for Mechanical Systems and ASHRAE Handbook, HVAC Applications, except base the design of restraints on a force equal to 100 percent of the weight of the ductwork acting in either direction.

2.10 SEALANTS

- A. Provide as specified in Section 07 90 00, Joint Protection, with sealants conforming to SMACNA HVAC Duct Construction Standards - Metal and Flexible.
- B. The sealant must be mildew resistant, non-flammable, and meets NFPA 90A and 90B requirements.

2.11 DUCT PLENUMS

- A. Provide duct plenums fabricated in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible, Section VI, Equipment and Casings.

2.12 FLEXIBLE CONNECTIONS

- A. Provide UL-listed flexible connections conforming to NFPA 90A. Fabric shall be unpainted glass fiber cloth weighing not less than 32 ounces per square yard. Cloth shall be coated with fire resistant neoprene on both sides. Flexible portion shall be 6 inches long. Perimeter connection on each end shall be three inch wide galvanized sheet steel, and shall be mechanically bonded to the fabric. Fasteners shall be either screws or bolts. Flexible connectors shall be mechanically secured, at both ends, to provide airtight joints.

2.13 AIR EXTRACTOR

- A. Where more than one outlet is installed in a duct, and where there is inadequate space for installing multi-blade volume damper, an air extractor with locking adjustable quadrant shall be provided, just upstream of each outlet, for noise control and proper diversion of air flow to outlets further downstream. Air extractors shall be movable blade pivoted type. No extractor is required for the last outlet of the system. Extractor and quadrants shall be constructed of galvanized steel.

2.14 TURNING VANES

- A. Fabricated Turning Vanes: Provide fabricated single blade, sheet metal turning vanes and vane runners, constructed in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible.
- B. Manufactured Turning Vanes: Provide single blade, sheet metal turning vanes constructed of 1-1/2 inches wide curved blades set at 3/4 inch on centers, supported with bars perpendicular to blades set at two inches on centers, and set into side strips suitable for mounting in ductwork.

2.15 CASINGS

- A. Fabricate casings in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible and construct for operating pressures indicated.
- B. Mount floor mounted casings on four-inch (100 mm) high concrete curbs. At floor, rivet panels on eight-inch (200 mm) centers to angles. Where floors are acoustically insulated, provide liner of 18 gage (1.20) galvanized expanded metal mesh, supported at 12-inch (300 mm) centers, turned up 12 inches (300 mm) at sides with sheet metal shields.
- C. Reinforce door frames with steel angles tied to horizontal and vertical plenum supporting angles. Install hinged access doors where indicated or required for access to equipment for cleaning and inspection. Provide clear wire glass observation ports, minimum six-inch by six-inch (150 x 150 mm) size.
- D. Fabricate acoustic casings with reinforcing turned inward. Provide 16 gage (1.50 mm) back facing and 22 gage (0.80 mm) perforated front facing with 3/32 inch (2.4 mm) diameter holes on 5/32-inch (4 mm) centers. Construct panels 3 inches (75 mm) thick packed with 4.5 lb/cu ft (72 kg/cu m) minimum glass fiber media, on inverted channels of 16 gage (1.50 mm).

2.16 FIBROUS GLASS DUCTS

- A. Fabricate in accordance with SMACNA Duct Construction Standards, except as indicated.
- B. Machine-fabricate fibrous glass duct and fittings. Make only minor on site manual adjustments.

- C. Staple duct joints and tape with two-inch (50 mm) wide by 3-mil (0.75 mm) thick aluminum pressure sensitive tape, UL approved.
- D. Do not use fibrous glass ducts within 12 inches (300 mm) of electric or fuel fired heaters.

2.17 KITCHEN HOOD EXHAUST DUCTWORK

- A. Fabricate in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible and NFPA 96.
- B. Construct of 16 gage (1.37 mm) carbon steel or 18 gage (1.09 mm) stainless steel, using continuous external welded joints.

PART 3 – EXECUTION

3.01 INSTALLATION

- A. Installation Standards: Ductwork and accessories shall be installed in accordance with NFPA 90A, ASHRAE Handbook, and SMACNA HVAC Duct Construction Standards - Metal and Flexible, as applicable. Mounting and supporting of equipment, ducts, accessories, and appurtenances shall be provided, including structural supports, hangers, stands, clamps, and brackets. Equipment shall be installed in accordance with the manufacturer's installation instructions.
- B. Sheet Metal Ductwork:
 - 1. Ductwork shall be installed in accordance with the Contract Drawings and approved Shop Drawings. Sections to be installed shall be cleaned of dirt, dust, and debris before installation.
 - 2. Elbows, turning vanes, take offs, branch connections, transitions, splitters, duct volume dampers, fire dampers, combination fire and smoke dampers, flexible connectors, and access doors shall conform with SMACNA HVAC Duct Construction Standards - Metal and Flexible, SMACNA Ducted Electric Heat Guide for Air Handling Systems, and SMACNA Fire, Smoke and Radiation Damper Installation Guide for HVAC Systems, as applicable.
 - 3. Field changes to ductwork, such as those required to suit the size of factory fabricated equipment, shall minimize losses in pressure and performance caused by sudden expansion and contraction. Transitions shall be used in field changes as well as modifications to connecting ducts.
 - 4. Locking type quadrant operators for dampers, installed on ducts to be thermally insulated, shall have stand off mounting brackets, bases or adapters to allow for a clearance not less than the thickness of the insulation between duct surface and the operator. Stand off mounting items shall be integral with the operator or standard accessory of the damper manufacturer. Locking devices shall be located on ends of actuator arms, as far as possible from pivot point of dampers.

5. Install backdraft dampers in the discharge duct of exhaust fans and where indicated except in battery room exhaust duct system.
6. Duct sleeves and prepared openings shall be provided where ducts penetrate floors, walls, ceilings or roofs, and shall be installed during construction of the floor, wall, ceiling or roof. Branch take off connections shall be provided in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible.
7. Duct sleeves shall be fabricated from minimum 20 gage galvanized sheet steel. Sleeve shall have one inch clearance between the duct and the sleeve, or one inch clearance between the insulation and the sleeve for insulated ducts. Duct sleeves embedded in concrete shall be one fourth inch plate in accordance with Article 2.01.B, herein.
8. Duct penetrations through fire rated walls and floors shall meet requirements imposed by the jurisdictional Fire Marshal if more restrictive than the specified SMACNA requirements.
9. Prepared openings shall have one inch clearance between the duct and the opening, or 1 inch clearance between the insulation and the opening for insulated ducts, except at grilles, registers, and diffusers.
10. Closure collar shall be not less than four inches wide, and shall be installed on each side of walls or floors where sleeves or prepared openings are provided. The collar shall be installed against the surface of the wall or floor. The edges of the collar shall be ground smooth. Collars shall be fabricated from minimum 20 gage galvanized sheet steel for ducts with a maximum side of 15 inches, and from minimum 18 gage galvanized sheet steel for ducts with a side of over 15 inches.
11. Space between the sleeve or opening and the duct or duct insulation shall be packed airtight with felt, neoprene, or plastic sealing strips.

C. Duct Hangers and Supports:

1. Install duct hangers and supports spaced on each side of duct in accordance with SMACNA HVAC Duct Construction Standards, Metal and Flexible. Supports on risers shall allow free vertical movement of the duct. Duct shall be installed and supported so as to be completely free from vibration and sagging under all conditions of operation.
2. Supports shall be attached only to structural framing members or concrete beams and slabs. Where supports are required between structural framing members, intermediate metal framing shall be provided. Where C clamps are installed, retainer clips shall be installed.
3. Ducts shall be seismically restrained in accordance with requirements of Section 20 30 13, Vibration Isolation and Seismic Control for Facility Services.

4. Hangers and devices in exterior locations exposed to the weather shall be painted with corrosion-resistant paint as specified in Section 09 91 00, Painting.
- D. Registers, Grilles, and Diffusers: Registers, grilles, and diffusers shall be installed only after all ceilings and walls are finished including final painting. Ceiling mounted units shall be installed with rims tight against ceiling. Wall mounted units shall be installed at least 6 inches below the ceiling unless otherwise indicated. Dampers provided with diffusers and registers shall not be used for system balancing. Inside of duct, behind see-through registers and grilles shall be painted black.
- E. Flexible Connections: Provide flexible connections located between fans and ducts and casings and ducts of dissimilar metals.
- F. Flashings: Provide flashings where ducts pass through exterior building walls and roofs. Flashings shall weatherproof the penetration.
- G. Duct Heaters: Where electric heaters are installed in air ducts, the duct shall be insulated with noncombustible insulation extending in each direction from the heater. Distance shall be as recommended by the heater manufacturer.

3.02 CLEANING

- A. After completion of ductwork, the entire system shall be cleaned of rubbish, plaster, dirt, dust, and other debris. After equipment has been installed and connections have been made, and before grilles, outlets, and registers are installed, the entire system shall be blown out with dampers and outlets wide open. Temporary screens or filters shall be provided to protect equipment during the cleaning operation.

3.03 FIELD QUALITY CONTROL

- A. Ductwork and accessories shall be leak tested before installing insulation. Tests shall be performed in accordance with and at the maximum pressure designation of SMACNA HVAC Air Duct Leakage Test Manual. Joints and seams shall be tested in the presence of the Engineer.
- B. Determine leakage from entire system or section of the system by relating leakage to the surface area of the test section.
- C. Maximum allowable leakage shall be as specified in ASHRAE Handbook, Fundamentals, "Duct Design". Comply with requirements for leakage classification three for round and flat oval duct, leakage classification 12 for rectangular, duct in pressure classifications less than and equal to two inches water gage (both positive and negative pressures), and leakage classification six for pressure classifications greater than two inches water gage and less than and equal to 10 inches water gage.
- D. Remake leaking joints as required and apply sealants to achieve tight joints with less leakage than the maximum allowable leakage.

- E. Perform volumetric measurements and adjust air systems as specified in ASHRAE Handbook, HVAC Systems and Equipment; ASHRAE Handbook, HVAC Applications; ASHRAE Handbook, Fundamentals; and Section 23 05 93, Testing, Adjusting, and Balancing for HVAC.
- F. Perform inspections, as necessary, to ensure compliance with NFPA standards and SMACNA HVAC Duct Construction Standards - Metal and Flexible, witnessed by the Engineer. Conduct inspection in accordance with SMACNA HVAC Duct Systems Inspection Guide. Results of inspections shall be documented and submitted for review.
- G. After testing and inspection, system shall be restored to its operating condition.

3.04 ADJUSTING AND BALANCING

- A. Refer to Section 23 05 93, Testing, Adjusting, and Balancing for HVAC, for requirements and procedures for adjusting and balancing air distribution and return systems.

END OF SECTION 23 31 00