

**SECTION 23 31 00
HVAC DUCTS AND CASINGS**

PART 1 – GENERAL

1.01 WORK INCLUDED

- A. The work of this Section shall include, but is not limited to, the following:
 - 1. Ductwork
 - 2. Plenums
 - 3. Fasteners and sealants
 - 4. Duct cleaning
 - 5. Access doors
 - 6. Duct testing
 - 7. Installation of equipment and materials furnished under other sections
 - 8. Duct drain piping
 - 9. Installation of duct smoke detectors

1.02 RELATED DOCUMENTS

- A. Section 23 05 01 – HVAC General Provisions
- B. Section 23 05 29 – Hangers and Supports for HVAC
- C. Section 23 05 48 – Vibration and Seismic Controls for HVAC
- D. Section 23 05 93 – Testing, Adjusting and Balancing for HVAC
- E. Section 23 07 00 – Insulation for HVAC
- F. Section 23 33 13 – Dampers
- G. Section 23 33 19 – Acoustics
- H. Section 23 37 00 – Air Outlets and Inlets
- I. Section 23 38 00 – Kitchen Exhaust Filtration and Fan System
- J. Section 23 40 00 – HVAC Air Cleaning Devices
- K. Section 23 82 16 – Air Coils

1.03 REFERENCE STANDARDS

Published specifications standards, tests or recommended methods of trade, industry or governmental organizations apply to work in this Section where cited below:

- A. ASHRAE – American Society of Heating, Refrigeration, and Air Conditioning Engineers
- B. SMACNA – Sheet Metal and Air Conditioning Contractors National Association
 - 1. HVAC Duct Construction Standards, Metal and Flexible

2. Fire, Smoke and Radiation Damper Installation Guide for HVAC Systems
 3. HVAC Systems Testing Adjusting and Balancing
 4. Seismic Restraint Manual, Guidelines for Mechanical Systems
 5. HVAC Air Duct Leakage Test Manual
- C. IMC – International Mechanical Code
- D. UMC – Uniform Mechanical Code Standard 6-2 - Standard for Metal Ducts
- E. AABC – Associated Air Balance Council
- F. ANSI – American National Standards Institute
- G. NFPA – National Fire Protection Association
1. NFPA 90A Standard for the Installation of Air-Conditioning and Ventilating Systems
 2. NFPA 90B Standard for the Installation of Warm-Air Heating and Air-Conditioning Systems
 3. NFPA 96 Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations
 4. NFPA 255 Standard Method of Test of Surface Burning Characteristics of Building Materials
- H. ASTM – American Society for Testing and Materials
1. ASTM E84 Standard Test Method for Surface Burning Characteristics of Building Materials
 2. ASTM B209 Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
 3. ASTM A653/A653M Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
- I. UL – Underwriters Laboratories Inc.
1. UL 181 Standard for Factory-Made Air Ducts and Air Connectors
 2. UL 181A Standard for Closure Systems for Use with Rigid Air Ducts
 3. UL 181B Standard for Closure Systems for Use with Flexible Air Ducts and Air Connectors
 4. UL 555 Standard for Fire Dampers
 5. UL 555C Standard for Ceiling Dampers
 6. UL 555S Standard for Smoke Dampers
 7. UL 723 Standard for Test for Surface Burning Characteristics of Building Materials
- J. Above-referenced standards may be superseded by notes and details on the Drawings and in any specification.
- K. Where two or more references conflict, the most stringent, as determined by Architect, shall take precedence.

1.04 QUALITY ASSURANCE

- A. Comply with NFPA 90A – Installation of Air Conditioning and Ventilation Systems unless otherwise specified or referenced.

1.05 PERFORMANCE REQUIREMENTS

- A. Sheet metal, ductwork, plenums and accessories shall meet or exceed the performance requirements specified in this section.

1.06 SUBMITTALS

- A. Submit the following for review:
 - 1. Submit ductwork shop fabrication and shop construction standards prior to submittal of ductwork shop drawings.
 - 2. Ductwork shop fabrication and shop construction standards shall include all applicable shop details and product data. Include the following:
 - a. Duct reinforcement tables for all pressure classes, duct materials **stainless steel** and ductwork shapes **rectangular, round**, to be used on this project
 - b. Duct reinforcement tables shall include material gauges, transverse joint reinforcement type and standard shop joint spacing
 - c. Transfer duct construction detail
 - d. Acoustical lining, perforated metal liner, adhesive, nosing and fastening cuts and details
 - e. Installation details for **[volume dampers] [single blade and multi-blade type] [remote- and cord-operated remote volume dampers] [control dampers] [fire dampers] [smoke dampers] [combination fire/smoke dampers] [backdraft dampers]**
 - f. Duct access doors
 - g. Duct fitting construction details such as rectangular and radius elbows, turning vanes, offsets, branch connections, etc.
 - h. Duct support and attachment details
 - i. Flanged duct connection details for all systems and each manufacturer used on project. Minimum duct construction gauges shall be as per SMACNA duct reinforcement tables. Duct gauges may not be reduced based on alternative jointing manufacturer's recommendations
 - j. Ductwork sealant
 - k. Diffuser ductwork connection details
 - l. Duct penetrating full height partition details
 - m. Flexible connection details
 - n. Duct and plenum construction details
 - 3. Product data including manufacturer's installation instructions, application, materials of construction, gauges, descriptive literature, and maintenance data for:
 - a. Ductwork and fittings
 - b. Plenums
 - c. Fasteners and sealants

- d. Access doors
- 4. Shop drawings:
 - a. Fully coordinated ¼-inch scale dimensioned duct layout drawings of all mechanical rooms, riser elevations, and floor plans, giving complete dimensions for location, elevation, and clearance, showing work of all other Sections and Divisions. Layout drawing shall be prepared with architectural floor plan and ceiling grid background indicating room numbers, ceiling heights, location and elevations of structural components, light fixtures, all piping and other equipment
 - b. ¼-inch scale dimensioned duct layout drawings of all mechanical rooms, riser elevations, and floor plans, giving complete dimensions for location, elevation, and clearance, showing work of other Sections and Divisions wherever necessary to show coordination
 - c. Access door details
 - d. Flexible connection details
 - e. Duct and plenum construction details
 - f. Provide a separate set of dimensioned drawings or a partial set at enlarged scale showing all penetrations required for ductwork through structural members, floor and roof slabs, concrete walls and precast walls
 - g. Duct materials, reinforcement and construction schedules
 - h. Duct support and attachment details
- 5. All sheet metal shop drawings shall be drawn in double line indicating actual dimensions of ductwork, fittings and equipment. Shop drawings submitted with ductwork drawn in single line shall be returned without review.
- 6. Sheet metal shop drawing shall indicate, as a minimum, the following data:
 - a. Ductwork sizes and section breaks
 - b. Location of acoustical lining
 - c. Bottom of duct elevations for all ducts or other services in conflict with ductwork
 - d. Diffuser face size, neck size and air quantity
 - e. All volume dampers
 - f. All air conditioning units
 - g. All terminal units
 - h. Dimensioned drawings showing penetrations required for ductwork through structural members, floor and roof slabs, concrete walls and precast walls
 - i. Duct support and attachment details
- 7. HVAC design drawings shall not be submitted as sheet metal shop drawings.

1.07 DUCT CLASSIFICATION

- A. Duct classification is based on pressure classification as scheduled in Table 1-1 and as described in the 3rd Edition, 2005 SMACNA HVAC Duct Construction Standards, Comply with NFPA 90A when ducts traverse through smoke zones. Comply with UBC/UMC when more stringent than NFPA 90A or SMACNA standards.
- B. Longitudinal Seams: Pittsburgh lock shall be used on all longitudinal seams; snap-lock or

button punch seams are not acceptable. If SMACNA seal class A or B is specified, the longitudinal seam shall be sealed from the inside.

- C. Minimum pressure classification for each duct system and appropriate SMACNA table references are as follows:

Duct System	SMACNA Table No.	SMACNA Pressure Classification (inches water gauge)	SMACNA Seal Classification
All rectangular supply ducts on systems with variable or constant volume terminal units from fan discharge to terminal unit	1-6	±3	A
All rectangular supply ducts on systems without terminal units from fan discharge to air outlet	1-5	±2	B
All rectangular ductwork downstream of terminal units. All rectangular return ducts and exhaust ducts	1-4	±1	B
All round supply ducts on systems with terminal units from fan discharge to terminal unit; and parts of smoke exhaust systems under positive pressure	3-2A	+4	A
All round supply ducts on systems without terminal units from fan discharge to air outlet, and all ductwork downstream of terminal units; and parts of return or exhaust ducts under positive pressure	3-2A	+2	B
All round return ducts and exhaust ducts, where not used for smoke exhaust; and parts of supply system under negative pressure	3-2B	-2	B

- D. Duct classification is applicable to all ductwork and associated sheet metal work except for the following:

- Grease, fume and vapor exhaust systems
- Field-constructed or factory-fabricated plenum partitions

PART 2 – PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- Spiral oval and round ducts: United McGill Uni-form”, Semco, Metco, Ductmate Industries Spiralmate and Ovalmate
- Duct connection systems: Ductmate Industries Ductmate 35 and Ductmate 45, Nexus, Ward
- Flexible connections: Ventfabrics Ventglas and Ventlon, Duro Dyne Insulfab, Advance Elastomeric Systems, Ductmate Industries PROFlex

- D. Flexible ducts: Automatic Industries Thermaflex M-KE, United McGill, Genflex IL
- E. Spring fasteners: Dzus, Simmons Quick-Lock
- F. Duct protective coatings: Wisconsin Protective Coating, Varni-lite of America
- G. Duct Sealants: Foster, Childers, Miracle Adhesive, United McGill, Hardcast, Ductmate Industries PROSeal
- H. Spin-in fittings: Young Regulator, Modular Metals
- I. Flexible duct clamps: Aeroquip Ideal, Tridon, Young Regulator
- J. Acoustical panel plenums: IAC, Rink, Vibro-Acoustics, United McGill
- K. Access doors, ducts: Ventfabrics, Duro Dyne, Ruskin with Ventlok No. 140 latches, Ductmate Industries, hinged type only
- L. Access doors, plenums: Ventfabrics, Duro Dyne, Elgen
- M. Duct joint tape: Hardcast
- N. Grease exhaust duct gasket: Ventfabrics Wire-Inserted Glass Cloth

2.02 MATERIALS

- A. Sheet metal:
 - 1. Steel sheets:
 - a. Cold rolled steel sheets, lock forming quality meeting ASTM A653/A653M-08
 - b. Black or galvanized as specified
 - c. Galvanizing: 0.9 ounces per square foot both sides
 - 2. Stainless steel sheets: ANSI type 316 as specified, with Finish No.2B or No.3
- B. Miscellaneous products:
 - 1. Screws and rivets:
 - a. Same material as sheet, except as noted
 - b. Zinc- or cadmium-plated with neoprene grommets, permitted on galvanized sheets
 - c. Minimum screw size: No. 10
 - d. Minimum rivet size: 4 pound
 - 2. Duct sealants:
 - a. Sealing compound shall be flexible, non-fibrated water-based adhesive sealant designed for use in all pressure classes. Sealant shall be UV-resistant, conform to ASTM E84, be UL 723 Listed and meet NFPA requirements for Class 1 ductwork.

- b. Flange Gasket: Provide a continuous butyl rubber gasket which complies with UL 181 and 723 testing and meets MIL-C 18969B and TTS-S-001657. This material shall not contain vegetable oils, fish oils, or any other type of materials that will support fungal or bacterial growth. Gasket width shall match duct flange or angle connection with a minimum thickness of $\frac{1}{8}$ inch. Ductmate Industries Model 440 gasket tape or approved equal.
 - c. Liner Adhesive used to adhere insulation to metal duct shall comply with NFPA 90A, ASTM C916, Type II and UL 723 specifications. Foster 85-60, Ductmate Industries PROtack Liner Adhesive or approved equal. Adhesive shall meet California Department of Public Health (CDPH) Standard Method version 1.1, 2010 Small Scale Environmental Chamber Test for VOCs for California Specification 01350
 - d. Lagging adhesive shall be applied to insulated ductwork where the insulated edge of the duct would otherwise be exposed to the airflow. Materials shall comply with ASTM E84, NFPA 255 or UL 723 testing. Foster 30-36, Childers CP-50AMV1, Ductmate Industries Lag-It or approved equal.
 - 3. Hard-setting joint tape shall be a UL Listed two-part tape consisting of woven fiber tape impregnated with activator/adhesive of polyvinyl acetate type.
 - a. Flame spread: 10 maximum
 - b. Smoke developed: 0
 - 4. Spring Fasteners: Self-ejecting oval head stud and receptacle with screwdriver slot.
 - 5. Provide angles, tie rods and structural steel shapes for reinforcing ducts in accordance with SMACNA HVAC Duct Construction Standards, except as noted.
 - 6. Slide-on Transverse Joint Connectors:
 - a. Prefabricated slide-on transverse duct connectors and components shall be accepted. Ducts constructed using pre-fabricated systems shall refer to the manufacturer guidelines for sheet gauge, intermediate reinforcement size and spacing, and proper joint reinforcement. Ductmate Industries, Ward, Nexus, or approved equal.
 - b. Formed-on flanges shall be constructed as T-25 A/B flanges, of which the construction guidelines are given in Figure 1-4 of the SMACNA HVAC Duct Construction Standards, Metal and Flexible, 3rd Edition, 2005. No other construction standards pertaining to formed-on flanges shall be accepted.
 - c. Formed-on flanges shall include the use of corner bolts, cleats and gaskets.
 - d. All components shall be metal unless other materials are required by code, or specified.
- C. Flexible connections shall be used where ductwork connects to rotating, vibrating or noise producing machinery. Connectors shall be attached in such a manner to provide an airtight and waterproof seal.
 - 1. Conform to NFPA 90A and SMACNA HVAC Duct Construction Standards, except as noted.
 - 2. Provide roll formed 1½-inch long minimum collar, or match length and width of

fan, plenum or machinery connection companion flange:

- a. Aluminum, 1 gauge heavier than ductwork, plenum, fan or machinery connected.
 - b. Galvanized steel, 26 gauge minimum or matching gauge of ductwork, fan, plenum or machinery connected.
 - c. Other materials same as gauge and material as ductwork, plenum, fan or machinery connected.
3. Provide 2-inch slack in fabric and install to allow minimum movement of 1 inch.
 4. Length of fabric connections: 4 inches minimum; 10 inches maximum.
 5. Materials:
 - a. Indoor installations shall be a UL Listed, fire-retardant neoprene- or vinyl-coated woven fiberglass fabric. Minimum density 30 ounces per square yard and rated to 200 degrees F.
 - b. Outdoor installations shall be a UL Listed ultraviolet light resistant Hypalon-coated woven fiberglass fabric. Minimum density 24 ounces per square yard and rated to 250 degrees F.
 - c. Flame spread rating: 25 maximum, smoke developed rating: 50 maximum
 - d. Insulated connections:
 - 1) Two layers of fabric with 1-inch thick fiberglass, 1½ pound density.
 - 2) Performance as previously specified in Paragraph 2.02-C-5-b.

D. Turning vanes:

1. Galvanized steel ductwork: Galvanized steel or painted black steel, except as noted.
2. Other ductwork: Same material as ductwork.
3. Construction shall meet or exceed SMACNA HVAC Duct Construction Standards.
 - a. Use of single wall vanes with ¾-inch trailing edge shall be limited to maximum air velocity of 2,000 feet per minute and a maximum duct dimension of 18 inches.
 - b. Double wall vanes shall be used in ducts where air velocity exceeds 2,000 feet per minute, or any duct with a dimension over 18 inches.
 - c. Vane length: Provide separate equal-size sections for vane length greater than those previously indicated in Paragraph 1.03: Referenced Standards.
 - d. Vane runners: SMACNA Type 1 or 2 acceptable.
 - e. Tab spacing shall be as specified in Figure 2-3 of the SMACNA Manual, HVAC Duct Construction Standards, Metal and Flexible, 3rd Edition, 2005. Rail systems with non-standard tab spacing shall not be accepted.

E. Rectangular main duct to round duct take-off fittings shall be factory-fabricated spin-in fittings.

1. Die-formed, same material as ductwork.
2. Pressure ratings shall be equal to the duct pressure rating in which they are installed.

3. Provide balancing damper with locking regulator.

2.03 ROUND DUCTWORK

A. General:

1. Provide factory-fabricated spiral lock-seam duct, except as otherwise indicated.
2. Factory-fabricated longitudinal seams are acceptable for ducts larger than standard factory sizes and are required where branch sizes, fitting sizes, air inlet or outlet sizes exceed the seam-to-seam dimension.
3. Round and oval ducts joints shall be constructed as follows:
 - a. Up to 20-inch equivalent diameter: Interior slip coupling beaded at center and fastened to the duct with screws. Seal joint with approved sealant continuously applied around joint prior to assembly and after fastening. Make certain that majority of sealant is on the interior of the joint.
 - b. From 21-inch to 72-inch equivalent diameter: Use joining system as described in Item 3-a. above, or join using a three-piece gasketed flanged joint consisting of two internal flanges, with integral mastic sealant and one external closure band which compresses the gasket between the internal flanges similar to Ductmate Industries Spiralmate or Ovalmate or approved equals.
4. Factory-fabricated fittings shall be same manufacturer as duct and the same material and construction as duct in which installed.
 - a. Tees: 45-degree conical tap with center-line take-off, unless otherwise indicated. Provide continuously welded seams.
 - b. Elbows:
 - 3) Segmented seams or standing segmented seams.
 - 4) Continuously welded for positive or negative 2-inch water gauge and greater:
 - a) 2 gores – less than 35 degrees
 - b) 3 gores – 36 degrees through 71 degrees
 - c) 5 gores – over 71 degrees to 90 degrees maximum

B. Single-wall ducts:

1. Materials of construction:
 - a. Black steel with plastic coating. Prime paint outer surfaces: Laboratory and fume exhaust ducts.

C. Factory-fabricated accessories:

1. Couplings
2. Volume dampers
3. Bellmouth fittings
4. End caps
5. Angle rings
6. Insulation ends: Connections of double- to single-wall ducts
7. Access doors: Hinged, framed or pressure relief per SMACNA HVAC Duct

Construction Standards Figure 2-10

2.04 FLEXIBLE DUCTS

- A. General:
 - 1. Provide UL 181 and UL 181B, Class I air duct with polymeric liner, labeled for compliance with UMC. Use only where indicated.
 - 2. Flexible ducts shall meet criteria as defined in Section 3 of the SMACNA Manual, HVAC Duct construction Standards, Metal and Flexible, 3rd Edition, 2005.
- B. Static pressure class up to 1-inch water gauge.
 - 1. Insulated flexible duct:
 - a. Maximum working pressure 1-inch water gauge
 - b. Nominal 1-inch insulation with vapor barrier
 - c. Maximum thermal conductivity 0.27 BTUH per square foot per degree F per inch at 75 degrees F
 - 2. Similar to Thermaflex M-KE
 - 3. Use at air inlets and air outlets
- C. Static pressure class over 1-inch up to 10 inches water gauge:
 - 1. Insulated flexible duct:
 - a. Maximum working pressure 10 inches water gauge
 - b. Nominal 1½-inch resilient glass fiber insulation with flexible vapor barrier jacket and wire reinforced inner core
 - c. Maximum thermal conductivity of 0.27 BTUH per square foot per degree F per inch at 75 degrees F.
 - d. Maximum length: 12 inches
 - e. Maximum offset: 2 inches
 - 2. Use at inlet connections to variable or constant volume terminal units, sized to match terminal unit.
 - 3. Similar to Thermaflex M-KE
- D. Provide factory-fabricated collar.
- E. Flexible ductwork clamps shall be adjustable screw type stainless steel straps approved for use with flexible ductwork.
- F. Regenerative noise due to air turbulence with the flexible duct shall not exceed the following sound power levels for a 12-inch diameter duct with an air speed of 1,000 feet per minute:

	Sound Power Levels, dB re: 10 ⁻¹² Watts, at Octave Band Center Frequency, Hz				
	125	250	500	1,000	2,000
Maximum Regenerative Noise	30	31	30	22	20

2.05 GREASE HOOD EXHAUST DUCT

- A. Construction:
 - 1. Black carbon steel 16-gauge minimum for ducts 4 square feet in cross-sectional area and smaller, 14-gauge for larger ducts.
 - 2. Minimum 18-gauge type 316 ELC stainless steel where exposed only.
- B. Provide continuously welded seams ground smooth on the interior of duct. Do not locate openings on bottom of duct. Allow a 2-inch margin on all 4 sides of opening.
- C. Gasketing shall be glass cloth rated for 1,500 degrees F.
- D. Reinforcing:
 - 1. 1½-inch by 1½-inch by 3/16-inch angles
 - 2. Maximum spacing: 4 feet on center from joint
- E. Clean-out doors shall be gasketed water-tight and grease-tight. Gaskets between door and frame as specified above.
 - 1. Door and frame: Same material and gauge as duct.
 - 2. Door capable of opening without tools.
 - 3. Doors shall be tight fitting and flush with inside of duct.

2.06 ACCESS DOORS

- A. Access doors shall comply with the SMACNA – Duct Construction Standards, Metal and Flexible, 3rd Edition, 2005, except as noted.
- B. Duct access doors shall be insulated or uninsulated, same as duct. Make completely accessible.
 - 1. Minimum Size:
 - a. 20 inches by 14 inches, 18 inches by 16 inches or larger.
 - b. Ducts less than 16 inches: one dimension 20 inches; other dimension 2 inches less than duct width or height.
 - c. Larger sizes where required for access.
 - 2. Systems designed for 2-inch water gauge and less (SMACNA Seal Class B or C) shall utilize a hinged and cam, square framed access door.
 - 3. All other systems shall utilize a hinged access door. Construct door in accord with Figure 2-10 of the SMACNA Manual HVAC Duct Construction Standards, Metal and Flexible 3rd Edition, 2005.
 - 4. Provide in following locations:

- a. Coils in ducts: entering and leaving side
 - b. Automatic dampers: linkage side
 - c. Balancing dampers and backdraft dampers
 - d. Fire dampers, smoke dampers and combination fire/smoke dampers
 - e. Duct-mounted smoke detectors, sprinkler heads, heat detectors
 - f. Duct humidifiers
 - g. Filter banks in ducts
 - h. Fan bearings enclosed in ducts
 - i. Inlet side of each single width centrifugal fan
 - j. Inlet and outlet sides of each in-line centrifugal and axial fan or sound attenuator
 - k. All controls, sensing, processing, transmitting and actuating devices
 - l. Duct drains
 5. Provide permanent label on all access doors identifying the concealed components as specified above.
- C. Casing and plenum access doors shall be uninsulated or insulated, same as casings and plenums.
1. Latches similar to Ventlok No. 202
 2. Minimum size: 24-inch by 60-inch
 3. Provide larger size where required for equipment access, service, maintenance, removal and replacement.
 4. Provide in following locations:
 - a. Fan or equipment enclosures
 - b. Coil and filter banks
 - c. Humidifier dispersion tubes and grids
 - d. Moisture eliminators and air blenders
 - e. Fire alarm devices, sprinkler heads
 - f. Dampers
 - g. All VFDs, controls, sensing, processing, transmitting and actuating devices
 - h. Doors to electronic filter chamber: Provide door-interlocked disconnect switch to break electric circuit when door is open.
 5. Doors shall open against pressure.
- D. Glass inspection panels:
1. Wired safety glass, gasketed and watertight.
 2. 12-inch by 12-inch, except as noted or specified.
 3. Provide in access doors, or where specified or indicated on the Drawings.
- E. Special access doors:
1. Grease exhaust duct access doors shall be grease-proof with high-temperature gasket rated for a minimum of 1500 degrees F, and shall be grease-tight. Fasteners such as bolts, weld studs, latches, or wing nuts, used to secure the access doors shall be carbon steel or stainless steel and shall not penetrate duct walls. Grind all edges of duct openings smooth.

PART 3 – EXECUTION

3.01 DUCTWORK INSTALLATION

A. General:

1. Construct with gauges, joints, bracing, reinforcing, and other details per latest IMC SMACNA, or NFPA unless specified otherwise. Comply with most stringent.
2. Ductwork shall not exceed the deflection limits established in UMC 6-2- Standard for Metal Ducts. Maximum allowable deflection for transverse joints and intermediate reinforcements shall not exceed 0.25-inch for duct widths up to 100 inches and shall not exceed 0.3 percent of the span for duct widths greater than 100 inches.
3. Construct ducts with NFPA 90A gauges when traversing smoke zones.
4. Construct of galvanized sheet metal, except where otherwise indicated or specified.
5. Duct dimensions indicated are net, inside, clear, dimensions. For internally lined ducts, add lining thickness to determine metal duct dimensions.
6. At exposed duct penetrations of walls, floors and ceilings, provide sheet metal angle type escutcheons fastened to the duct only.
7. Provide minimum 26-gauge sheet metal construction for ducts crossing fire-rated corridors. Refer to Architectural drawings for wall types and ratings.
8. Install exposed ducts as high as possible but within 48 inches of ceiling. Coordinate with other trades to maintain not less than 90 inches clearance above finished floor, unless indicated otherwise.
9. Transitions: pitch sides of duct in diverging or converging airflow.
 - a. Maximum of 15-degree included angle.
 - b. Exception: Provide 7½-degree concentric diverging velocity cones at the discharge of vane axial fans.
10. Duct openings: provide openings where required to accommodate thermometers, smoke detectors, controllers, wiring, conduit, tubing etc. Insert through air-tight rubber grommets.
 - a. Provide pitot tube openings where required for testing of systems:
 - 5) Include threaded metal cap, spring loaded cap or threaded plug to eliminate any air leakage.
 - 6) For Pitot tube tests install Ventlok No. 699 and 699-2 instrument test holes.
 - 7) Coordinate locations of openings with balancing contractor.
 - b. Where openings are provided in insulated ductwork for insertion of instruments, install insulation material metal sleeve, flanged on one end for use as plug. Reseal vapor barrier.
11. Duct lining: Install lining in ducts and plenums as specified in Section 23 33 19 – Acoustics.
12. Install flexible duct connections at connections to fans, sound attenuators, generator fan discharge, fan coils, heat pumps, air conditioning units and all air handling equipment, and s indicated on the Drawings or specified in other

sections.

13. Refer to SMACNA duct construction standards for outdoor flexible connection details.
14. Volume dampers:
 - a. Install damper as specified in Section 23 33 13 – Dampers and Section 23 37 00 – Air Outlets and Inlets.
 - b. Install damper in branch duct for all air inlets and outlets at accessible location most remote from air inlet or outlet.

B. Elbows:

1. Use radius elbows in rectangular ducts unless otherwise indicated. Centerline radius shall be a minimum of 150 percent of duct width.
2. Where space does not permit duct radius specified above, install short radius or square elbow with vanes per SMACNA duct construction standards.
3. Do not use turning vanes in the following applications:
 - a. Grease and vapor exhausts
 - b. Fume hood exhaust
 - c. Breeching
 - d. Toilet exhaust ducts
 - e. Any gravity ductwork
 - f. Clothes dryer exhaust
4. For 2-inch water gauge or above pressure class ductwork, spot weld turning vanes to duct.
5. For all 2-way splits in supply, return and exhaust systems, provide 2 elbows, proportionally sized per SMACNA Duct Standards, either radius or square. A single fitting is acceptable with turning vanes and duct openings sized as specified.

C. Rectangular duct joints and seams:

1. Provide standing, longitudinal seams, except where flush drive slip seam is specified.
2. Use grooved seam for exposed ducts except in garages, electrical or mechanical rooms, and where required for clearance.
3. Duct Connection System joints, may be used in lieu of standing seams. Plastic clips are only allowed for breakaway connections.
4. Fabricate ductwork and coordinate installation such that seams or joints shall not be cut or interrupted for the installation of branches, fittings, dampers, access doors, air inlets or air outlets.

D. Joint sealing:

1. Seal to SMACNA Seal Classifications previously specified by one of the following methods:
 - a. 6-ounce canvas strip, 6 inches wide adhered with lagging adhesive.
 - b. Hardcast Two Part II Duct Sealing System: DT-5400 tape with RTA-50 sealant.

- c. Applications as recommended by manufacturer.
- 2. Seal punched holes and corner cracks (Duct Tape Not Allowed).
- 3. After installation and testing, reseal joints found to be leaking.
- E. Ducts out-of-doors:
 - 1. Ducts shall be water-tight.
 - 2. Construct as follows to assure water run-off and no standing water.
 - a. Arrange standing seam, internal reinforcement, joints, flanges and access doors to prevent accumulation, ponding or pooling of water for both horizontal and vertical ductwork.
 - b. Locate longitudinal seams at bottom of duct.
 - c. Slope entire top of duct down toward sides. Coordinate duct slope with roof slope to avoid situations where roof slope and duct slope cancel each other out resulting in an unsloped top of duct.
 - d. Provide mastic within sheet metal joints.
 - 3. Installations and penetrations shall be in accordance with SMACNA Guidelines for Roof-Mounted Outdoor Air-Conditioner Installations.
 - 4. Provide sheet metal flashing or skirt at flexible connections to fans or HVAC units to avoid water accumulation.
 - 5. Coordinate exact duct routing and duct support locations on roofs with roofing contractor. Roof-mounted duct support details shall be approved by the roofing contractor and the Architect prior to fabrication and installation.
- F. Sound-rated duct packing:
 - 1. Wherever possible, avoid duct penetrations through sound-rated walls, floors and ceilings, in either Architectural elements or plenums specified under this Section.
 - 2. Provide packing specified in Section 23 33 19 – Acoustics for ducts penetrating sound-rated walls, floors or ceilings, and for unavoidable duct penetrations.
 - 3. Any interior walls, floors or ceilings that are internally insulated are considered sound-rated. Refer to Architectural Drawings for wall, floor and ceiling types.
- G. Electrostatic shielding:
 - 1. Provide shielding for ducts penetrating electrostatically shielded walls.
 - 2. Shielding shall be electrically discontinuous through a non-conductive flexible connection located outside of shielded room.
 - 3. Bond metallic portion of duct inside shielded room to wall shielding.
 - 4. Sheet lead in contact with concrete, mortar or plaster shall be coated with heavy bituminous or latex material.
 - 5. Joints shall be minimum 1-inch.
- H. Surgery ductwork:
 - 1. Supply and return ductwork serving the following areas:
 - a. Surgical operating
 - b. Surgical scrub-up
 - c. Surgical recovery

d. Surgical work rooms

2. Type 316 ELC stainless steel
3. Exhaust ducts may be galvanized steel

3.02 ROUND AND OVAL DUCTWORK

A. Joints between ducts:

1. Construct with beaded sleeve joints.
2. Mechanically fasten with sheet metal screws or pop rivets except for fume exhaust, dust collection, clothes dryer ductwork.
3. Duct sealer shall be applied to male end and over all joint-, screw- and rivet-heads.
4. Seal as specified for rectangular ductwork.

B. Joints, duct and fitting:

1. Slip projecting collar of fittings into duct with a minimum insertion length of 2 inches.
2. Apply duct sealer. Seal as specified for rectangular ductwork.
3. Mechanical fastener schedule:

Duct Diameter	End Lap	No. of Rivets/Screws in Slip Joint
8 inches	0.75-inch	4
9 to 16 inches	1.00-inch	6
17 inches & up	1.25-inch	7 plus 3 per inch of circumference

C. Junctions between ducts:

1. Branch take-off: conical 90 degrees
2. Branch connections to unlined rectangular ducts may be made with spin-in fittings as specified.

D. Horizontal supports shall be one-piece clamp band strap, minimum one strap per section. Support fittings as required by SMACNA.

E. Vertical supports shall be one of the following:

1. Clamp bands with extended ends supported at each floor.
2. Clamp bands with knee bracing.
3. Pedestal at base of vertical riser.

F. Use angle iron braces for duct reinforcing. Refer to the SMACNA HVAC Duct Construction Standards, Metal and Flexible, 3rd Edition, 2005, figure numbers 1-9 through 1-12.

3.03 FLEXIBLE DUCTWORK

A. Provide continuous, single pieces.

B. Maximum Length:

1. Above 1-inch water gauge static pressure: 12 inches or as specified.
2. Under 1-inch water gauge static pressure: 6 feet.
3. Local codes or union rules take precedence and may reduce the maximum lengths specified.

C. End Connections:

1. Connect to duct collars, terminal unit connections and round air outlets per manufacturer's instructions.
2. Secure with strap clamps specified above.

D. Installation:

1. Support per SMACNA.
2. Flexible duct is not allowed in lengths greater than that specified. Bends, twists or sagging of flexible duct is not acceptable.
3. Minimum inside bending radius shall be a minimum of two duct diameters. If minimum radius cannot be maintained, provide sheet metal plenum over air outlet and connect flexible duct to side of plenum. Paint interior flat black.
4. Maximum – one 90-degree turn.
5. Install as straight as possible.

E. Flexible duct is only allowed above lay-in type accessible ceilings only.

3.04 GREASE HOOD EXHAUST DUCTWORK

A. General:

1. Include from hood connection to fan discharge and through building to atmosphere.
2. Slope of duct:
 - a. One inch per foot toward hood or toward an approved grease reservoir.
 - b. Exception: ¼-inch per foot allowed if total length does not exceed 75 feet, toward hood or toward an approved grease reservoir.
3. Fire-rated duct enclosure is required from point of duct concealment to the exterior of the building.
 - a. Refer to Architectural drawings.
 - b. Coordinate location of enclosure access doors with duct access doors.
4. Dampers are not allowed in grease exhaust systems.

B. Construction:

1. Exposed in kitchen: stainless steel
2. Concealed: black carbon steel

C. Clean-out doors shall be provided in all the following locations. Bottom edge of duct opening shall be not less than 2 inches above bottom of duct:

1. Horizontal and Vertical Ducts:

- a. Maximum 12 feet on center in an accessible location
 - b. At all grease reservoirs
 - c. At all changes in direction
 - d. At fire protection devices
 - e. Upstream and downstream of exhaust fan, within 3 feet from fan
 - f. At each floor for vertical ducts
 - g. At base of vertical duct
 - h. Bottom edge not less than 2 inches above bottom of duct
2. Where clean-out doors are not accessible from a 10-foot ladder, openings on grease hood exhaust ducts shall be provided with safe access and a work platform.
 3. Size:
 - a. Maximum 24 inches by 24 inches
 - b. Minimum 18 inches one side, other side 3 inches less than duct height
 - c. Coordinate location and size with duct enclosure access doors

D. Joints shall be continuous liquid tight external welded.

3.05 DUCT HANGERS AND SUPPORTS

A. General:

1. Support horizontal ducts with hangers of size and spacing as indicated in SMACNA Duct Construction Standards.
2. Attachment to structure shall be as specified in Section 23 05 29 – Hangers and Supports for HVAC.
3. Vibration isolation and seismic restraints for ducts shall be as specified in Section 23 05 48 – Vibration and Seismic Controls for HVAC.
4. Seismic restraints shall comply with SMACNA or **IMC**, whichever is more stringent.

B. Horizontal Duct Supports:

1. Install hangers at each change in direction of duct.
2. Strap hangers:
 - a. Extend strap down both sides of ducts.
 - b. Turn under bottom two inches minimum. Provide a minimum of 2 screws per side.
 - c. Screw hangers to bottom, upper and lower sides of ducts at 12 inches on center maximum.
 - d. Seal all screw penetrations of ductwork.
3. Angle hangers:
 - a. Per SMACNA Guidelines for Seismic Restraints.
 - b. Seal all penetrations of ductwork.
4. Support rectangular fume, vapor and grease exhaust ducts on angle hangers. Do not penetrate duct with fasteners.

5. Support circular fume, vapor and grease exhaust ducts with shop-rolled flat bar bands around duct.
 - a. Bands shall be 16-gauge by 1-inch steel minimum, hot dipped galvanized or prime coated after fabrication.
 - b. Fasten top to hanger rod and bolt bottom of bands.

C. Vertical Duct Supports:

1. Support vertical ducts at every floor.
2. Use angles or channels riveted to ducts. Seal all duct penetrations.
3. Set angles or channels on floor slab or structural steel members placed in opening, unless otherwise noted.

3.06 PLENUM INSTALLATION

A. General:

1. Construct plenums with gauges, joints, bracing reinforcing, and other construction details in accordance with latest SMACNA, unless specified otherwise.
2. Construct with galvanized sheet metal of lock-forming quality.
3. Install hinged access doors where shown, specified, or required for access to equipment for cleaning and inspection. Minimum door dimension 60-inch by 18-inch with 12-inch by 12-inch minimum observation window, per SMACNA Figure 6-11 or Figure 6-12. Reinforce door frames with steel angles tied to horizontal and vertical plenum supporting angles.
4. Coat inside of plenums on discharge of air washers, humidifiers and spray coils with two coats of Bitumastic.
5. Slope floor to duct drain as specified.
6. Install sleeves and air-tight sealing grommets or resilient materials for all piping, conduit, tubing, wiring, shafts or other components penetrating plenum walls. Sealing method shall allow movement of component penetrating the wall.

B. Sheet Metal Plenum Construction:

1. Galvanized sheet metal shall be 16-gauge, unless otherwise indicated:
 - a. Galvanized angle bracing riveted or bolted to sheet metal as required.
 - b. Panels shall be cross-broken.
2. Seams shall be 2-inch standing seams, 24 inches on center and staggered at adjacent panels.
3. Reinforcing shall be 2-inch by 2-inch by ¼-inch galvanized angles riveted or bolted to back of sheet metal and perpendicular to the standing seams.
4. Install angles at all floor, wall, and ceiling corners and around openings.
5. Fasten reinforcing components to floors, ceilings and walls on 16-inch centers. Seams and joints shall be sealed with mastic and made airtight.

3.07 MISCELLANEOUS INSTALLATIONS

- A. Install the following equipment and materials furnished under other sections. Comply with manufacturer's installation instructions, code requirements, UL Listing and the

requirements of local authorities.

1. Backdraft and balancing dampers
2. Fire, smoke, and fire/smoke dampers
3. Control dampers, automatic louver dampers
4. Filters
5. Sound traps
6. Air monitors and flow measuring devices
7. Access doors. Allow for adequate length of duct to install access door for all dampers
8. Smoke detectors, flow switches, controls and fire alarm devices
9. Pressure, temperature, humidity sensors/transmitters

B. Duct Drains:

1. Provide a 1-inch Type L copper drain connection at low points for moisture collection.
2. Provide an S-trap (or P-trap) for water seal. Minimum depth of trap shall be 1.25 times maximum static pressure differential in duct section. Trap shall be tapped to accept a ½-inch trap primer connection.
3. Install piping from duct drain to nearest plumbing floor drain or floor sink. Terminate with 1-inch minimum air gap.
4. Provide tee connection in drain between duct and trap.
5. Connection from trap primer shall be furnished under Plumbing Section.

3.08 DUCT AND PLENUM PRESSURE TESTING

A. Scope of Pressure Testing:

1. Test ductwork, including plenums, as scheduled below, for leaks. Pressure testing shall include applicable supply, return and exhaust systems.
2. Apply positive pressure test to all ducts intended to operate under positive pressure of 2 inches water gauge or greater, such as:
 - a. Supply ducts from fans to air outlets
 - b. Supply ducts from fans to air terminal units
 - c. Discharge ducts from exhaust fans outside
3. Apply Negative pressure test to all ducts intended to operate under negative pressure, such as:
 - a. Return ducts from air intakes to fans except on portions of duct exposed in spaces served by duct
 - b. Toilet exhaust ducts from air inlets to fans
 - c. General exhaust ducts from air inlets to fans
 - d. Grease exhaust ducts from hoods to fans
 - e. Grease exhaust ducts from fans to duct termination point

B. General:

1. Advise Architect at least 2 weeks in advance of testing so that test can be

witnessed.

2. Use portable high-pressure blower and necessary instruments. Provide duct connections required for air flow and pressure testing.
3. Test before sections are concealed.
4. Furnish signed reports of results of tests to Architect.

a. 3 inches water gauge

C. Procedure:

1. Seal openings in ducts and plenums to be tested.
2. Connect test apparatus to test section using flexible duct connection or hose.
3. Close damper on blower suction side, to prevent excessive buildup of pressure.
4. Start blower and gradually open damper on suction side of blower.
5. Test for audible air leaks in ducts and plenums per referenced standards.
 - a. Repair and silence all audible leaks.
 - b. Do not retest until sealants have set.
6. Test for rate of air leakage in ducts and plenums per referenced standards. Determine amount of air leakage by make-up air flow measurements.
7. Repair air leaks as required and retest.
8. Visually mark tested sections with certification sticker and initials of field test inspector.

- D. Ductwork leakage rates shall comply with SMACNA HVAC Air Duct Leakage Test Manual 1st edition for leakage Class 6 for rectangular ductwork, and leakage Class 3 for round ductwork.

3.09 DUCT CLEANING

A. Clean Duct Systems:

1. Force air at high velocity through duct to remove accumulated dust.
2. Clean half system at a time.
3. Protect equipment, which may be harmed by excessive dirt with filters, or bypass during cleaning.
4. Seal all outlets dust tight. When closures are removed, avoid spilling dust in room.

- B. Repair any damage(s) resulting from duct-cleaning process.

END OF SECTION 23 31 00