

SECTION 23 31 13 - DUCTWORK

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

- A. The Conditions of the Contract and applicable requirements of Division 1, "General Requirements", and Section 23 01 00, "Mechanical General Provisions", govern this Section.

1.2 DESCRIPTION OF WORK:

- A. Work Included: Provide metal ductwork systems as shown on the Drawings and as specified herein.
- B. System Types: The types of ductwork systems specified in this Section include, but are not necessarily limited to the following:
1. Air conditioning supply and return air systems.
 2. Outdoor air supply systems.
 3. Mechanical exhaust systems.
 4. Air relief systems.
 5. Kitchen exhaust systems.
 6. Gas-fired equipment breeching and flue.
 7. Special exhaust systems.

[EDIT TO SUIT PROJECT REQUIREMENTS

- C. VAV Supply Air Ductwork Upstream of Terminal Units: Ductwork shall be sheet metal ductwork designed for velocities up to **[2500]** [] fpm and pressures up to **[+3"]** [] wg. Ductwork shall be **[externally insulated]**. **[Provide [one inch (1")] [2"] [external insulation] on air handling unit discharge where shown on the Drawings.]**
- D. Supply Air Ductwork Downstream of Terminal Units: Ductwork shall be sheet metal ductwork designed for velocities up to **[2500]** [] fpm and pressures up to **[+2"]** [] wg. Ductwork shall be **externally insulated**.
- E. Constant Volume Supply Air Ductwork: Ductwork shall be sheet metal ductwork designed for velocities up to **[2500]** [] fpm and pressures up to **[+2"]** [] wg. Ductwork shall be **[externally insulated]** **[Provide [one inch (1")] [2"] external insulation on air handling unit discharge where shown on the Drawings.]**
- F. Acoustic Supply Air Ductwork: Ductwork, where noted or shown on the Drawings shall be United McGill K-27 **[spiral]** **[longitudinal]** seam, welded galvanized sheet metal double wall round duct and fittings designed for velocities up to **[2500]** [] fpm and pressures up to **[+3"]** [] wg. Duct shall have **[one inch 1"] [1-1/2"]** insulation between the outer wall and the perforated sheet metal internal wall. NOTE: Round ductwork requires FP&C approval.
- G. Outside Air Ductwork: Ductwork shall be sheet metal ductwork designed for velocities up to **[2500]** [] fpm and pressures up to **[+3"]** [] wg. Ductwork shall be externally insulated.
- H. Garage Supply and Exhaust Ductwork: Ductwork shall be round or flat oval spiral seam sheet metal ductwork designed for velocities up to **[4000]** [] fpm and pressures up to **[+4"]** [] wg for supply and **[-4"]** [] wg for exhaust. Garage supply and exhaust ductwork shall not be insulated.
- I. Stairwell Pressurization Ductwork: Ductwork shall be sheet metal ductwork designed for velocities up to **[4000]** [] fpm and pressures up to **[+3"]** [] wg. Stairwell pressurization ductwork shall not be insulated.

- J. Return Air Ductwork: Ductwork shall be sheet metal ductwork designed for velocities up to **[2500]** [] fpm and pressures up to **[-1"]** [] wg. Ductwork used for return air boots and elbows and other return air ductwork where shown on the Drawings shall be shall be externally insulated with one inch (1") insulation.
- K. General Exhaust Ductwork: General exhaust ductwork shall include all exhaust ductwork which is not otherwise specified. Ductwork shall be sheet metal ductwork designed for velocities up to **[2500]** [] fpm and pressures up to **[-2"]** [-] " wg]. General exhaust duct shall be uninsulated, except that exhaust ductwork which passes through nonconditioned spaces shall be externally insulated **[and]** horizontal exhaust ductwork from/in toilets shall be externally insulated with one inch (1") insulation.
- L. Kitchen Exhaust Ductwork: Ductwork shall be welded **[316L stainless]** **[black]** steel designed for velocities up to 2500 fpm and pressures up to **[-3"]** [] wg and shall be in accordance with NFPA 96. Ductwork shall be wrapped with **[a 2" calcium silicate insulation as specified in Section 230700]** **[a rated fire blanket insulation as specified in Section 230700]** **[and]** **[a one (1)] [2] hour rated drywall enclosure]**.
- M. Dishwasher Exhaust Ductwork: Ductwork shall be welded 316L stainless steel or aluminum ductwork designed for velocities up to 2500 fpm and pressures up to **[-2"]** [] wg. Ductwork shall not be insulated, except that ductwork which passes through nonconditioned spaces shall be externally insulated.
- N. Smoke Exhaust Ductwork: Ductwork shall be sheet metal ductwork designed for velocities up to **[4000]** [] fpm and pressures up to **[-3"]** [-] " wg. Smoke exhaust ductwork shall not be insulated, **[except that ductwork within [10'] []' of building exterior wall penetrations shall be externally insulated]**.
- O. Laboratory Hood Exhaust Ductwork: Ductwork shall be **[welded 316L stainless steel]** **[fiberglass reinforced plastic (FRP)]** ductwork designed for velocities up to **[4000]** [] fpm and pressures up to **[-6"]** [-] " wg. Laboratory exhaust ductwork shall not be insulated except that ductwork which passes through nonconditioned spaces shall be externally insulated.
- P. Underground Supply and Return Ductwork: Ductwork shall be rigid round ductwork designed for velocities up to 2500 fpm and pressures up to **[+2"]** **[+]** wg for supply and **[-2"]** [-] wg for return. Supply and return ductwork shall not be insulated.
- Q. Flexible Ductwork: Ductwork connections to HVAC terminal units and air devices shall be made with flexible ductwork connection where shown on the Drawings. Additional connections may be made using flexible ductwork at the Contractors option, where approved in writing, in advance, by the Engineer.
- R. Breeching and Flue: Breeching and flue for **[boilers]** **[and]** **[water heaters]** shall be Type **["A"]** **["B"]** flue. **[Breeching and flue shall be insulated as specified in Section 23 07 00.]**
- S. Ductwrap Insulation: Refer to Section 23 07 00, "System Insulation", for external ductwrap insulation.
- T. Ductwork Accessories: Refer to Section 23 31 14, "Ductwork Accessories", for accessories and specialties related to ductwork systems and installation.
- U. Basic Materials and Methods: Refer to Section 23 03 00, "Basic Materials and Methods", for basic materials and methods related to mechanical construction.

1.3 QUALITY ASSURANCE:

- A. SMACNA Standards: Comply with Sheet Metal and Air Conditioning Contractors National Association (SMACNA), HVAC Duct Construction Standards, Metal and Flexible, Latest Edition recommendations for fabrication, construction, details, and installation procedures, except as otherwise indicated on the Drawings or in these Specifications.

- B. ASHRAE Standards: Comply with American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) standards and recommendations, except as otherwise indicated on the Drawings or in these Specifications.

1.4 SUBMITTALS:

- A. Shop Drawing submittals shall include, but not be limited to, the following:
1. Ductwork submittals shall include ductwork fabrication drawings and submittal data on ductwork specialties and construction details.
 2. Ductwork fabrication drawings shall be drawings to scale on **[1/8"] [or] [1/4"]** scale building floor plans and shall indicate duct sizes, duct material, duct insulation type, locations of transverse joints, fittings, ductwork bottom elevation, offsets, ductwork specialties, flexible connections, flexible ductwork, fire and fire/smoke dampers and all other information required for coordination with other trades and fabrication of ductwork. All fire and fire/smoke partitions shall be clearly designated on the ductwork shop drawings. Ductwork fabrication drawings shall be coordinated with other trades and building construction prior to submittal for approval.
 3. Duct specialties and construction details including, but not limited to information on duct construction and materials, transverse and longitudinal joints, cross-breaking or transverse beading, dampers, flexible connectors, fittings, transitions, elbows, control, fire and fire/smoke damper connections, branch taps, turning vanes, access doors and other required duct specialties and construction details.
 4. Cut sheets on flexible ductwork and related taps and accessories.
 5. Cut sheets on breeching and flue piping materials and accessories, including a complete flue design layout.
 6. Duct system leakage test procedures and reporting forms.
 7. Additional information as required in Section 23 01 00.

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Deliver ductwork materials to the site in suitable packaging to prevent damage and exposure to weather.
- B. Store ductwork in dry areas, where it is not exposed to damage. Crib stored ductwork off of floors to prevent water damage.
- C. Handle ductwork to prevent damage.

PART 2 - PRODUCTS

2.1 DUCTWORK MATERIALS:

- A. Sheet Metal: Ductwork shall be constructed using prime G90 galvanized lock-forming quality or coil steel in widths up to 60", conforming to ASTM A924/A924M-74, A653 and A653M, **[UMC requirements]** and using gauges selected by application, based upon applicable SMACNA Standards.
- B. Stainless Steel: Ductwork shall be constructed using 316L sheet or roll stainless steel in widths up to 60" and using gauges selected by application, based upon applicable SMACNA Standards **[and NFPA 96 requirements]**.
- C. Black Steel: Ductwork shall be constructed using sheet or roll black steel in widths up to 60" and using gauges selected by application, based upon applicable SMACNA standards and NFPA 96 requirements.
- D. Aluminum: Ductwork shall be constructed using sheet or roll aluminum in widths up to 60" and using gauges selected by application, based upon applicable SMACNA standards.

- E. Labeling: Ductwork materials shall be stenciled on maximum 10'centers with the manufacturer's name and material gauge. Stenciling shall be visible after duct is fabricated and installed.
- F. Exposed Ductwork Materials: Where ductwork is indicated to be exposed to view in occupied spaces, provide materials which are free from visual imperfections including pitting, seam marks, roller marks, oil canning, stains, discolorations, and other imperfections, including those which would impair painting.

2.2 MISCELLANEOUS DUCTWORK MATERIALS:

- A. General: Provide miscellaneous materials and products of the types and sizes indicated and where not otherwise indicated, provide type and size required to comply with ductwork system requirements including proper connection of ductwork and equipment.
- B. Duct Sealant: Provide nonhardening, nonmigrating mastic or liquid elastic sealant (type applicable for the fabrication/installation detail) as compounded and recommended by the manufacturer specifically for sealing joints and seams in ductwork. Sealers shall be as follows:
 - 1. Sealer shall have a high solids content.
 - 2. Sealer shall have a high adhesive and cohesive strength and shall bond to both degreased and non-degreased metals.
 - 3. Sealer shall conform to NFPA 90-A requirements and be UL-labeled for ductwork applications.
 - 4. Sealer and related installation materials and methods shall be:
 - a. Hardcast Type 601 Iron Grip Duct Sealant.
 - b. United McGill Corporation United Duct Sealer.
 - c. Foster Type 30-02 High Velocity Duct Seal.
 - d. Transcontinental Equipment Ltd. Multipurpose Water Based Duct Sealer.
- C. Ductwork Support Materials: Except as otherwise indicated, provide hot-dipped galvanized steel fasteners, anchors, rods, straps, trim, and angles for support of ductwork.
- D. Exposed Stainless Steel: Provide matching stainless steel supports for exposed stainless steel ductwork.

2.3 DUCTLINER:

- A. Acoustical Ductliner: Provide Schuller Permacote Linacoustic Standard/HP or Owens-Corning Aeroflex [1/2"] [1"] [1-1/2"] [2"] thick fiberglass ductliner with an NCR of [0.55] [0.70] [0.90] [1.00] or greater per ASTM C1071, a thermal conductivity of 0.31 BTU in/(hr ft² °F) and friction correction factor no greater than 1.02 at 500 fpm. All ductliner shall be guaranteed against delamination up to 3000 fpm velocities. Ductliner shall be have a surface coating formulated with an immobilized, EPA-registered, anti-microbial agent so it will not support the growth of fungus or bacteria.
- B. Ductliner Adhesive: Provide non-flammable adhesives 3M #37, St. Clair R41B, Foster 85-11 or Foster 85-20, which comply with NFPA 90A and ASC-A-7001 by The Adhesive and Sealant Council, Inc. (see SMACNA standards).
- C. Ductliner Fasteners: Comply with SMACNA requirements.

2.4 FLEXIBLE DUCT:

- A. General: Insulated flexible duct shall be a factory fabricated assembly consisting of an inner liner, fiberglass insulation and a vapor barrier outer jacket.
- B. Inner Liner: The inner liner shall consist of a galvanized steel helix mechanically securing an inner liner composed of a tri-laminate of aluminum foil, fiberglass and aluminized polyester for applications upstream of HVAC terminal units and shall consist of a galvanized steel helix mechanically securing

an inner liner composed of a SPUNBOND nylon fabric for applications downstream of HVAC terminal units.

- C. Insulation: Duct liner shall be wrapped with a nominal one inch (1") thick fiberglass insulation blanket with a maximum thermal conductance C Factor of 0.23 Btu/hr/sf/°F.
- D. Outer Jacket: Insulation shall be covered with a reinforced metalized aluminum vapor barrier jacket with a maximum permeability of 0.05 Perm per ASTM E96, Procedure A.
- E. Pressure Ratings: Flexible duct for applications upstream of HVAC terminal units shall be rated for a minimum of 12" positive and 5" negative internal working pressure. Flexible duct for air device applications shall be rated for 6" positive and 4" negative internal working pressure. Flexible duct shall be suitable for operation at temperatures up to 120°F.
- F. Sound Attenuation: Flexible duct for air device applications shall be designed to provide sound attenuation and a 9' length of 8" duct shall have typical insertion losses (IL), in dB, as follows:

Octave Band	2	3	4	5	6	7
Straight Duct at 2500 fpm flow	9	27	27	32	33	37
90° Bend Duct at 2500 fpm flow	18	31	34	37	34	38
- G. Codes/Standards: Flexible duct shall be listed as Class 1 Air Duct per UL 181 and shall comply with NFPA 90A and 90B.
- H. Fire Ratings: Flexible duct shall have a flame spread rating of less than 25 and a smoke developed rating of less than 50.
- I. Clamps: Terminal unit flexible duct inner liner shall be secured using Flexmaster LS Series or approved equal 1/2" wide positive locking stainless steel straps. Air device flexible duct outer jackets shall be secured using Panduit Corporation, Ideal or an approved equal 0.35" wide self-locking nylon straps.
- J. Terminal Unit Flexible Duct Taps: All take-offs for HVAC terminal units shall be conical bellmouth taps equal to a Flexmaster CB conical bellmouth fitting, or side take offs without dampers equal to a Flexmaster 45° STO fittings. Fittings shall be minimum 26 ga. Galvanized sheetmetal.
- K. Air Device Flexible Duct Taps: All round take-offs for air devices shall be made with a damper spin-collar, equal to a Flexmaster FLD dampered spin fitting. Where the duct height does not allow the use of a spin-in fitting, use 45° STOD side take offs with dampers, equal to Flexmaster 45° STOD STOD Fittings. Dampers shall be provided with full length 3/8" square shafts secured to the damper blade with a minimum of 2 U-bolts, nylon bearings, insulation build out, heavy duty locking hand quadrants and integral flexible duct retention beads. Fittings and damper blades shall be minimum 26 ga. galvanized sheetmetal for sizes up to 10" and minimum 24 ga. galvanized sheetmetal for sizes up 12" and larger.
- L. Manufacturers: Flexible duct for applications upstream of HVAC terminal units shall be Flexmaster Type 3M or an approved equal. Flexible duct for air device applications shall be Flexmaster Type 6M Acoustical or an approved equal.

2.5 UNDERGROUND DUCTWORK:

[SELECT ONE OF THE FOLLOWING]

- A. **[Coated Sheet Metal Ductwork: Provide a system of coated sheet metal ductwork as manufactured by Foremost Manufacturing Company, Southfield, Michigan or an approved equal.]**

[INSERT TEXT ON PRODUCT]

[OR]

- B. **[Rigid Round Fiberglass Ductwork:** Provide a system of [insulated] rigid round fiberglass ductwork as manufactured by Peabody Spunstrand or an approved equal.]
- C. **[Construction:** Ductwork and fittings shall be constructed of continuous fiberglass strands, impregnated with polyester corrosion resistant resin. Duct shall have ICBO, BOCA and SBCCI approvals including a Class 1 inner liner and compliance with UMC Standard 10-1 for non-metallic ducts in accordance with UL 181.]
- D. **[Duct joints shall be [made using an internal steel sleeve secured with sheet metal screws. Joints shall then be sealed using an extruded beam of Presstite No. 579.6 or an approved equal non-hardening waterproof mastic and then wrapping the entire joint including the screw heads with Polykin 260 foilastic tape, nUSHUA 357 TAPE OR AN APPROVED EQUAL.] [of the wet lay-up type in strict accordance with the manufacturer's instructions, including thoroughly cleaning and sanding the areas to be hjoined and using polyester resin and fiberglass mat and/or woven roving.]**
- E. **[Insulation:** Ductwork shall be factory insulated to an insulating value of R-[2] [4] [6] [8].]

2.6 FLUE AND BREECHING:

[VERIFY PROJECT REQUIREMENTS]

- A. **[Flues:** Flues for boilers shall comply with NFPA requirements for Type ["A"] or ["B"] flue as required. A UL factory-fabricated stack rated for such duty may be used or a stack fabricated of not less than 10 gauge steel, welded and insulated as specified under Section 23 07 00, "System Insulation", of these Specifications, including terminal caps may be used.
- B. **[Breeching:** Boiler breeching shall be in accordance with SMACNA Manual recommendations.
- C. **[Fabricated Flues:** Fabricated flues shall be 10 gauge black steel with continuously welded longitudinal and transverse joints. Provide full ring sized non-asbestos gaskets at all flanged connections. Each flue shall be constructed to allow for proper expansion and contraction. Flues shall be flashed and counterflashed with 16 gauge galvanized steel at roof penetrations. Refer to Section 23 07 00 for insulation of field-fabricated flues.]
- D. **[Type "A" Flues:** Factory-built flues shall be laboratory tested and listed by the Underwriters' Laboratories, Inc. for use with the specified equipment burning gas or liquid fuels as described in NFPA 211, which produces exhausted flue gases at a temperature not exceeding 1400°F under continuous operating conditions.]
 - 1. **[Construction:** Double wall flue shall have an outer jacket of [Type 304 stainless] or [aluminum coated] steel 0.025" thick for sizes 6" thru 24" and 0.034" thick for larger diameters. There shall be minimum one inch (1") air space between the walls. The inner gas carrying pipe shall be Type 304 stainless steel. The inner liner shall be 0.035" nominal thickness for all diameters. Flues shall comply with all national safety standards and building codes when installed according the manufacturer's preprinted installation instructions and the limits of its listing.]
 - 2. **[Joints:** Inner pipe joints shall be sealed by use of V bands and RTV Silicone Sealant for flue gas temperature up to 600°F. For flue gas temperatures above 600°F, joints shall be sealed with V bands and High Temperature Joint Cement as outlined in the installation instructions supplied by the manufacturer.]
 - 3. **[Manufacturers:** Flues shall be Model PS as manufactured by Selkite Metalbestos or approved equal.]
- E. **[Type "B" Flues:** Provide UL-listed and labeled Type "B" double wall gas vents with heavy gauge galvanized steel outer wall and aluminum inner wall. Male end of pipe shall be crimped and shall have locking clips. Female end of pipe shall have slots to receive the locking clips. Each assembly shall have all components necessary, including pipe sections, supports, tees,

elbows, adapters, spacers, increasers, plates, bands, roof or wall thimbles, roof flashings and storm collars, etc. and shall be by same manufacturer. Chimney shall allow installation by use of twist-lock threaded couplers or steel clamp type bands. Internal liner shall not be pierced by sheet metal screws and shall be installed in accordance with manufacturers' recommendations. Flues shall be as manufactured by Amer-i-vent, Thor-Vent or Dura-vent.]

- F. **[Termination: Flues extending above the roof shall be terminated as required by local codes or as required by NFPA 211, whichever is more stringent and shall be a minimum of 8' above the finished roof. Wind bracing or tiebacks shall be provided as required.]**
- G. **[Design: The actual design of each vent flue system shall follow the layout shown on the drawings but shall be completely laid out and calculated by the flue manufacturer to suit actual equipment served, field conditions and thermal expansion. The flue vent system shall be complete, including, but not limited to: straight sections, elbows, offsets, increasers, tees, equipment connections, supports, drains, ventilated roof thimble/flashing assemblies, stack caps and other required accessories. If recommended by the manufacturer for the proposed installation a drain section with drain piping and trap shall be provided on vertical stacks.]**
- H. **[Finish: All parts of the flues which are exposed outdoors and which are not stainless steel shall be protected by one base coat and two finish coats of series 4200-4300 Rust-O-Leum Corporation heat resistant paint. Paint color to be selected by approved the Architect.]**
- I. **[Flue Vent Caps: Terminate all flue vent [4'] or [as required by local code] above finished roof level with a fluecap. Fluecaps shall be stainless steel, Breidert Type "L" Air-X-Hausters or approved equal. Units shall have birdscreen and self-flashing galvanized bases. Provide special collars or adapters as required to fit cap to flue. Coordinate details of installation with all trades.]**

PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS:

- A. **Standards:** Round and rectangular sheet metal ductwork shall be constructed in accordance with SMACNA "HVAC Duct Constructions Standards", Latest Edition, ASHRAE Guide and Data Book, "Handbook of Fundamentals", latest edition, specifically Chapter 25 and NFPA Standard 90-A, "Standard for the Installation of Air Conditioning and Ventilating Systems". Duct sizes shown are clear inside dimensions. Where ductliner is specified, increase each dimension to accommodate liner.
- B. Route all duct tight to underside of structure, unless otherwise noted or required for coordination. All ductwork shall be top level with bottom and side transitions only. The Mechanical Contractor shall be held responsible for coordinating with all other trades prior to the construction or installation of ductwork. Some ductwork may require the use of S-drive joints, flat seams or offsets to allow installation of other ducts or equipment. Use 45 degree radius elbows (center line radius 1.5 times duct height) to rise up and drop down when crossing ductwork or other material. The Mechanical Contractor shall be responsible for coordination of all such work with the General Contractor and other Subcontractors as required. Minimum bottom of duct elevation above finished floor shall be as noted on the Drawings, where applicable.
- C. Adhere to the Drawings for routing and location of ductwork as closely as possible. Ductwork shop drawings shall be made after job site measurements are made and shall be coordinated with all other trade. Ductwork construction details and materials shall be submitted and approved prior to fabrication of any ductwork.
- D. All ductwork shown on the Drawings, specified or required for the heating, ventilating and air conditioning systems shall be constructed and erected in a first class workmanlike manner. The work shall be guaranteed for a period of one year from and after the date of acceptance of the job against noise, chatter, whistling, vibration, and free from pulsation under all conditions of operation. After the system is in operation, should these defects occur, they shall be corrected as directed by the Engineer.

- E. The interior surface of all ductwork shall be smooth with no parts projecting into the air stream unless specified to do so. All seams and joints shall be external. The inside of all ductwork shall be thoroughly cleaned and all fans operated to remove any debris prior to connection of air devices.
- F. All holes in ducts for damper rods and other necessary devices shall be either drilled or machine punched (not pin punched), and shall not be any larger than necessary. All duct openings shall be provided with sheet metal caps if the openings are to be left unconnected for any length of time.
- G. Where ducts, exposed to view (including equipment rooms), pass through walls, floors or ceilings, furnish and install sheet metal collars around the duct.
- H. When the Mechanical Contractor submits revised duct sizes for review by the Engineer or requests to substitute rectangular, round or flat oval duct sizes for rectangular, round or flat oval spiral duct, substitute sizes shall be based on equivalent hydraulic diameter as calculated by ASHRAE formulae for equivalent friction loss and airflow.
- I. **[The round and flat oval high pressure, high velocity ductwork on the project was sized using the static regain methods. Any significant deviations from the design shown on the drawings (as determined by the Engineer) will require that the Contractor submit static regain calculations for the entire duct system in which the change occurs.]**
- J. Sheet metal plenums shall be constructed and reinforced in accordance with SMACNA standards. Where plenums are connected to louvers, the plenum bottom shall be sloped to drain to the louver.
- K. Ductwork which is exposed to weather shall have soldered joints and seams and shall be painted with a suitable epoxy coating.

3.2 COORDINATION:

- A. Prior to submitting ductwork shop drawings, the Division 15 Contractor shall fully coordinate the routing and height of all ductwork with all other trades and with ceiling heights, lighting fixtures and building construction. Where ductwork is concealed, bottom of duct shall be a minimum of 8" above the ceiling unless otherwise noted. Where ductwork is exposed, bottom of horizontal duct shall be a minimum of 6'-6" above finished floor. Where ductwork is exposed in occupied areas it shall be tight to the structure and the bottom of the duct shall be minimum **80"** above finished floor.

3.3 GENERAL DUCTWORK FABRICATION:

A. Duct Gauge and Reinforcing:

1. Rectangular Ductwork: Minimum metal gauges and reinforcement shall be in accordance with SMACNA HVAC Duct Construction Standards (SDCS) Tables 1-3 through 1-13. Minimum aluminum gauges and reinforcement shall be in accordance with SDCS Tables 1-14 through 1-16. Reinforcing shall be installed per SDCS Fig. 1-9 through 1-12.
2. Round Ductwork: Minimum metal gauges for longitudinal and spiral seam round ductwork shall be in accordance with SDCS Table 3-2. Minimum aluminum gauges for longitudinal and spiral seam round ductwork shall be in accordance with SDCS Table 3-3. Longitudinal seam ductwork larger than 12" diameter shall not be permitted unless welded seams are used.
3. Cross-breaking: Cross-break or transverse bead all flat surfaces which are more than 12" wide. Transverse beading shall be on 12" centers and shall be a minimum of 1/8" deep at the center of the bead and 3/8" wide at the base of the bead.
4. Minimum Gauges: The metal gauges listed in the SDCS for round and rectangular ductwork are the minimum recommended. It shall be the Contractor's responsibility to select a metal gauge heavy enough to withstand the physical abuse of installation.

B. Duct Joints And Seams:

1. General: Make all joints airtight. The distance between transverse joints on any size duct shall not exceed 5'.

2. Rectangular Ductwork: Transverse joints and longitudinal seams in ductwork shall be constructed in accordance with SDCS Fig. 1-4 and 1-5. Drive slips may be used on rectangular ductwork on short sides only, up to 18" maximum. Gauge of drive slips shall be at least as heavy as ductwork on which they are installed. Bend drive slips over at least 3/4" at corners. Corner closures shall be in accordance with SDCS Fig. 1-13 through 1-18. All longitudinal seams shall be "Pittsburgh Lock" or button punch snap lock at corner seams and grooved seam or seam welded in sides between corners, in accordance with SDCS Fig. 1-5. At the Contractor's option, transverse joints may be transverse duct flange joints or Ductmate EP12/11 prefabricated galvanized "Ductmate" sections. The proposed gasket material, flange, corner piece and Ductmate details shall be submitted for approval.
3. Round Ductwork: Transverse joints for round ductwork shall be beaded sleeve type constructed in accordance with SDCS Fig. 3-2, properly secured and sealed. Draw bands shall not be used on round ductwork. Longitudinal and spiral seams shall be constructed in accordance with SDCS Fig. 3-1.
4. Ductwork Sealing: Seal all longitudinal and transverse ductwork joints and seams using SMACNA ductwork sealant and 3" wide open weave tape to provide positive seal. Sufficient sealant shall be used to completely imbed the cloth.

C. Connections and Take-offs:

1. Rectangular Ductwork: Parallel flow branches shall be constructed using radius elbow take-offs in accordance with SDCS Fig. 2-7. Branch duct connections shall be 45 degree entry expanded taps constructed in accordance with SDCS Fig. 2-8. Duct-mounted coil connections shall be constructed in accordance with SDCS Fig. 2-11.
2. Round Ductwork: Connections and takeoffs shall be made using 90 degree conical taps, 45 degree lateral taps or wye fittings constructed in accordance with SDCS Fig. 3-4 and 3-5. Use of 90 degree tees shall not be allowed.
3. Spin-in Fittings: Spin-in fittings may be used for duct taps to air supply and exhaust devices and shall include quadrant dampers even though a volume damper may be specified for the air device. Spin-in fittings shall be sealed at the duct tap with a gasket and compression fit or sealed with duct sealant. The location of spin-in fittings in the ducts shall be determined after terminal units are hung and the location of the light fixtures is known so as to minimize flexible duct lengths and sharp bends. Spin-ins shall be installed with their damper axis parallel to airflow.
4. Flexible Joints In Ductwork: Provide flexible connections where ductwork connects to air-handling units, fans, and similar powered equipment items and where required for expansion and contraction of the ductwork or the building structure. A minimum of one inch (1") slack shall be provided in all flexible connection to insure vibration isolation. Flexible joints are not required where equipment is connected with flexible duct. Flexible connections shall be rigidly connected to metal work on each side and shall be airtight. Bond flanges of flexible duct connectors to ducts and housings to provide airtight connections. Seal seams and penetrations to prevent air leakage.

D. Elbows and Tees:

1. Rectangular Ductwork: Provide radius or square elbows in ductwork, where shown on the Drawings. Where radius elbows are shown, radius elbows must be provided. Where square elbows are shown, square or radius elbows may be provided, at the Contractor's option. Elbows shall be constructed in accordance with SDCS Fig. 2-2. Turning vanes are required in all square elbows of 46 degrees or greater angle. Turning vanes are not required in radius elbows. Turning vanes shall be single vane type without a trailing edge and shall be constructed and installed in accordance with SDCS Fig. 2-3 and 2-4.
2. Round Ductwork: Provide radius elbows of the stamped or segmented type constructed in accordance with SDCS Fig. 3-3. Segmented elbows shall have a minimum of three segments for 45 degree elbows and five segments for 90 degree elbows.

- E. Offsets and Transitions: Where duct width increases, maximum angle of slope shall be 20 degrees (one inch (1") in 2.7"). Where duct width decreases, maximum angle of slope shall be 30 degrees (one inch (1") in 1.7"). Offsets and transitions shall be constructed in accordance with SDCS Fig. 2-9 (type 2 and 3 only) and 2-10 (exclude C and E).
- F. Air Device Connections: Make connections to air devices and fabricate air device plenums as detailed on the Drawings and in accordance with SDCS Fig. 2-16 through 2-18.

3.4 DUCTLINER:

- A. General: The liner shall be applied to the inside of the duct with heavy density side to the air stream and shall be secured in the duct with adhesive, completely coating the clean sheet metal. All joints in the insulation shall be "battered" and firmly butted tightly to the adjoining liner using fireproof adhesive. Where a cut is made for duct taps, etc., the raw edge shall be accurately and evenly cut and shall be thoroughly coated with fireproof adhesive. On ducts over 24" in width or depth, the liner shall be further secured with mechanical fasteners. The fasteners shall be A.J. Gerrard Company pronged straps, or approved equal, secured to the ducts by fireproof adhesive. The clips shall be 18" maximum spacing and shall be pointed up with fireproof adhesive. Liner shall be accurately cut and ends thoroughly coated with fireproof adhesive so that when the duct section is installed, the liner shall make a firmly butted and tightly sealed joint. [Where ducts are lined exterior insulation will not be needed unless otherwise noted, except that the two insulations shall lap not less than 24".] Ductliner for velocities over 2500 fpm shall be as specified except a perforated metal liner shall be used over ductliner for securement, in lieu of fasteners. Ductliner installation and fasteners shall comply with SDCS Fig. 2-22 through 2-25.

3.5 DUCTWORK INSTALLATION:

- A. General: Assemble and install ductwork in accordance with recognized industry practices which will achieve airtight and noiseless systems, capable of performing each indicated service. Install each run with a minimum of joints. Align ductwork accurately at connections, within 1/8" misalignment tolerance and with internal surfaces smooth. Support ducts rigidly with suitable ties, braces, hangers, and anchors of the type which will hold ducts true-to-shape and prevent buckling.
- B. Inserts: Install concrete inserts for support of ductwork in coordination with formwork, as required to avoid delays in the work.
- C. Completion: Complete fabrication of work at the project as necessary to match shop-fabricated work and accommodate installation requirements.
- D. Run Location: Locate ductwork runs, except as otherwise indicated, vertically and horizontally and avoid diagonal runs wherever possible. Locate runs as indicated by diagrams, grams, details, and notations or, if not otherwise indicated, run ductwork in the shortest route which does not obstruct usable space or block access for servicing the building and its equipment. Hold ducts close to walls, overhead construction, columns, and other structural and permanent-enclosure elements of the building. Limit clearance to 0.5" where furring is shown for enclosure or concealment of ducts, but allow for insulation thickness, if any. Where possible, locate insulated ductwork to assure 1.0" clearance of insulation. Wherever possible in finished and occupied spaces, conceal ductwork from view, by locating in mechanical shafts, hollow wall construction or above suspended ceilings. Do not encase horizontal runs in solid partitions, except as specifically shown. Coordinate the layout with suspended ceiling and lighting layouts and similar finished work.
- E. Coordination: Coordinate duct installation with installation of accessories, dampers, coil frames, equipment, controls, and other associated work of the ductwork system.
- F. Hangers and Supports:
 - 1. General: All ductwork supports shall be per Section IV of the SMACNA "HVAC Duct Construction Standards -Latest Edition" with all supports directly anchored to the building structure. Supports shall be on maximum 8'-0" centers with additional supports as required to prevent sagging.

2. Attachment to Structure: Provide hanger attachment to the building structure as specified in Section 230300, "Basic Materials and Methods", and in accordance with SDCS Fig. 4-1 through 4-3.
3. Hangers: Hangers shall be strap or rod sized in accordance with SDCS Table 4-1 and 4-2. Strap hanger attachment to rectangular duct shall consist of a turning strap under the duct a minimum of one inch (1") and securing the strap with one screw into the bottom of the duct and one screw to the side of the duct. Rectangular duct supported on trapeze hangers shall be attached to the trapeze. Round duct attachments shall be constructed in accordance with SDCS Fig. 4-4.
4. Horizontal Ducts: Ducts larger than 50" in their greatest dimension shall be supported by means of hanger rods bolted to angle iron or half round trapeze hangers. Duct shall have at least one pair of supports 8'-0" on centers according to the following:

<u>Angle Length</u>	<u>Angle</u>	<u>Rod Diameter</u>
4'-0"	1-1/2" x 1-1/2" x 1/8"	1/4"
6'-0"	1-1/2" x 1-1/2" x 1/8"	1/4"
8'-0"	2" x 2" x 1/8"	5/16"
10'-0"	3" x 3" x 1/8"	3/8"

5. Vertical Ducts: Ducts shall be supported where they pass through the floor lines with 1-1/2" x 1-1/2" x 1/4" angles for ducts up to 60". Above 60", the angles must be increased in strength and sized on an individual basis considering space requirements.

G. Flexible Ductwork:

1. General: Flexible ductwork shall be provided as shown on Drawings. Flexible ducts shall be installed in a fully extended condition free of sags and kinks, using only the minimum length required to make the connection, subject to the maximum lengths hereinbelow. Bends in any length of flexible duct shall not exceed 45 degrees for HVAC terminal unit connections or 90 degrees for air device connections and shall not exceed that recommended by the flexible ductwork manufacturer. Unless otherwise shown on the Drawings, the length of any one run of flexible ductwork shall not exceed 1'-6" for HVAC terminal unit connections or 8'-0" for air device connections. Where longer runs are required, provide externally insulated rigid duct extensions.
2. Supports: Where flexible duct extension exceeds 36", horizontally, a support shall be provided. Duct shall be suspended on 36" centers with a minimum 3/4" wide flat banding material and a minimum 6" wide sheet metal protective saddle. Refer to SDCS Fig. 3-9 and 3-10 and Page 3-17 for additional requirements.
3. Terminal Unit Flexible Duct Connections: All flexible duct connections upstream of HVAC terminal units shall be made by turning back the insulation and securing the inner liner with duct sealer and 1/2" wide positive locking stainless steel straps. The insulation shall then be placed over the joint and sealed on the exterior with self-locking nylon straps and an approved metalized duct tape. Refer to SDCS Page 3-13 and 3-15 for additional requirements.
4. Air Device Flexible Duct Connections: All air device flexible duct connections shall be made by turning back the insulation and securing the inner liner with 1/2" wide positive locking stainless steel straps or self-locking nylon straps and sealing with an approved metalized duct tape. The insulation shall then be placed over the joint and sealed on the exterior with an approved metalized duct tape. Spin-ins for air device taps shall be installed with their damper axis parallel to air flow. Refer to SDCS Page 3-13 and 3-15 for additional requirements.

H. Duct Mounted Devices:

1. Install duct mounted sensors and control devices furnished under [**Section 23 06 00, "Building Controls"**] [**Division 23**]. Provide access doors at each duct mounted control device.

Coordinate location of devices and installation requirements with the **[Section 23 06 00]**
[Division 23] Contractor.

2. Install duct type smoke detectors furnished under Division 16. Provide access doors at each sampling tube assembly. Coordinate location of detectors and installation requirements with Division 16.
3. Provide duct test **[ports]** **[holes]** in ductwork at locations shown on the drawings and as required to properly balance all air systems. Test ports shall be located per ANSI/ASHRAE Standard III to allow accurate pitot-tube traverse measurements in ductwork.

3.6 KITCHEN EXHAUST DUCTWORK:

- A. General: All kitchen exhaust ductwork serving kitchen hoods, ranges and ovens shall be fabricated of minimum **[18 gauge 316 stainless]** **[16 gauge black]** steel with liquid tight continuous external welds in accordance with NFPA 96 and applicable SMACNA Standards. Access doors of the type, size and spacing required by NFPA and as shown on the drawings shall be provided. No turning vanes or other interior intrusions shall be installed in kitchen exhaust ductwork. All changes in direction shall be with radius elbows (center line radius equals 1.5 x duct width). **[Refer to Section 23 07 00 for kitchen exhaust ductwork insulation.]** Slope duct towards hood connections and cleanout points as shown on the drawings. Coordinate required rated enclosure of kitchen exhaust duct with the General Contractor. Provide rated access doors for installation by the General Contractor at duct access door locations. Refer to Section 3.03 for general fabrication requirements.
- B. Coordination: Contractor shall not fabricate any final connections to kitchen equipment until he has received final shop drawings from the kitchen equipment Contractor. There shall be no turning vanes or other obstructions in kitchen equipment exhaust duct to accumulate grease. Braze or weld kitchen duct seams externally. Comply with NFPA and local codes.
- C. Drains: Ductwork for vapor-producing kitchen equipment shall be pitched to drain back to the kitchen equipment. In the event low points are required at points other than at the equipment, extend one inch (1") copper drains from low points to the nearest floor drain as an open-sight drain.

3.7 STAINLESS STEEL EXHAUST DUCT:

- A. General: Stainless steel exhaust duct shall be rectangular or round duct fabricated with minimum 20 gauge 316L stainless steel with liquid tight continuous external welds and shall conform in all respects to NFPA 45 and applicable SMACNA Standards. Ducts shall have access panels on the side of the duct large enough to permit inspection and cleaning at each change of direction and at 50' on center for horizontal runs. Access panels shall be of the same material or gauge as the duct and shall be liquid tight when in place. Refer to Section 3.03 for general fabrication requirements.
- B. Duct material shall be Type 316L stainless steel with welded air and water tight construction. Welding of duct work materials shall use a MIG or TIG welder and 316L stainless steel feed wire/rods. All welding shall be fully compatible with the materials being welded and finished welds shall have the same level of corrosion resistance which shall equal that of the material being joined. All duct welding shall be performed by certified welders.
- C. Metal gauges and construction shall be as specified in the SMACNA "Round Industrial Duct Construction" Manual for negative pressures up to **[6" wg]**. Minimum metal gauge shall be 20 gauge.
- D. Duct construction shall be straight longitudinal welded seam with welded transverse joints. Elbows shall be die-formed radius construction with a "straight" longitudinal seam and a minimum radius of 1.5 duct diameters. Round elbows shall be minimum five gore type.
- E. Tees and laterals shall be welded 45 degree or 90 degree saddle taps as shown on the Drawings.
- F. Fire dampers and control dampers (except exhaust terminal units and fan isolation dampers) shall not be installed in stainless steel exhaust ducts.

- G. Ductwork shall be supported per Section IV of the SMACNA "HVAC Duct Construction Standards-Metal and Flexible", Latest Edition. Duct hanger and support materials on the roof shall be constructed of 316L stainless steel.
- H. Exhaust plenums shall be constructed of 316L stainless steel welded air tight construction. Plenums shall be externally reinforced using stainless steel angle welded around the outside of the plenum to form a rigid frame. Finished and reinforced plenum shall be capable of withstanding negative pressures between [2" and 6"] [] S.P. without flexing or inward bowing.

3.8 UNDERGROUND DUCTWORK:

- A. General: Underground ductwork shall be suitable for use as shown on the Drawings.
- B. Installation: The ductwork shall be installed in accordance with the manufacturer's recommendations in a 4" bed of peagravel or dry sand with backfill using peagravel or dry sand to 8" above the top of the duct. Refer to Section 220000 for additional backfill requirements. All underground ductwork shall be leak-tested to 4" wg prior to cover-up. **[Ductwork coating damage shall be repaired as directed by the duct system manufacturer, prior to backfill.]** A slab moisture barrier shall be installed under the ductwork in the trench. Care shall be taken during backfill and pouring of the slab to avoid shock loads and passing of heavy equipment over the installed ductwork. Refer to SDCS Fig. 3-11 and 3-12 for additional requirements.

3.9 FLUE AND BREECHING:

- A. General: Install flues and breeching in accordance with the flue manufacturer recommendations and in accordance with SDCS Fig. 2-20.

3.10 CLEANING AND PROTECTION:

- A. General: Clean ductwork internally, section-by-section of dust and debris as it is installed. Clean external surfaces of foreign substances which might cause corrosive deterioration of the metal or, where ductwork is to be painted, might interfere with painting or cause paint damage.
- B. Repairs: Strip protective paper from stainless ductwork surfaces and repair finish or replace ductwork portion wherever it has been damaged.
- C. Temporary Closure: At ends of ducts which are not connected to equipment or air distribution devices at the time of ductwork installation, provide temporary closure of polyethylene film or other covering which will prevent the entrance of dust and debris until such time that connections are to be completed.

[VERIFY PROJECT REQUIREMENTS]

3.11 TESTING:

- A. General: Provide duct integrity and leakage testing for all supply [, return] and exhaust ductwork installed on the project. Testing shall be in accordance with the SMACNA HVAC Air Duct Leakage Test Manual, Latest Edition, (DLTM) and shall include, but not be limited to:
 1. Test Complete Systems: Duct systems shall be tested as complete systems (e.g. from air handling equipment to terminal units/air devices, from terminal units to air devices or from air devices to exhaust (return fans). Duct systems shall not be tested in partial sections, unless approved in writing by the Engineer.
 2. Preparation for Testing: Duct system installation must be complete, including, but not limited to, fittings, spin-ins, taps, access doors, hangers, test ports/holes, dampers and other system components. Temporary caps shall be installed at the system inlet (supply air system), system outlet (exhaust/return air systems) and at all terminal unit/air device taps.
 3. Leakage Calculations: Prior to testing a duct system, the permissible leakage rate in cfm shall be calculated based on the square feet of duct surface and the duct system leakage classification.

4. Test Configuration: The configuration for testing shall be similar to DLTM Fig. 3-1, using a variable volume blower as a test air source, an orifice plate meter with an inclined manometer to measure leakage cfm and a manometer to measure duct static pressure.
5. Acceptable Results: Duct systems shall be tested, resealed and retested until acceptable results are obtained, eg. the measured leakage rate is equal to or less than the calculated permissible leakage rate.
6. Documentation: Duct system leakage testing results shall be recorded on forms which include the following information as a minimum:
 - a. Duct System Tested.
 - b. System Leakage Classification.
 - c. Duct System Square Footage.
 - d. Permissible Leakage Rate in CFM.
 - e. Duct Test Pressure.
 - f. Orifice Size.
 - g. Measured Pressure Differential.
 - h. Measured Leakage Rate in CFM.
 - i. Measured Duct Pressure.
 - j. Test Performed By.
 - k. Date/Time of Test.
 - l. Temperature and Weather Conditions of Test.
 - m. **[Engineer or Owners Representative Signoff.]**
7. Duct leakage test reporting forms shall be submitted to the Engineer for approval.

B. Leakage Classifications:

1. VAV Supply Ductwork Upstream of Terminal Units: Ductwork shall be tested to leakage Class **[6]** at **[+3"]** wg.
2. Supply Ductwork Downstream of Terminal Units: Ductwork shall be tested at leakage Class **[12]** at **[+2"]** wg.
3. Constant Volume Supply Air Ductwork: Ductwork shall be tested at leakage Class **[12]** at **[+2"]** wg.
4. Acoustic Supply Air Ductwork: Ductwork shall be tested at leakage Class **[6]** at **[+3"]** wg.
5. Outside Air Ductwork: Ductwork shall be tested at leakage Class **[6]** at **[+3"]** wg.
6. Garage Supply Ductwork: Ductwork shall be tested at leakage Class **[6]** at **[+4"]** wg.
7. Garage Exhaust Ductwork: Ductwork shall be tested at leakage Class **[6]** at **[-4"]** wg.
8. Stairwell Pressurization Ductwork: Ductwork shall be tested at leakage Class **[6]** at **[+3"]** wg.
9. **[Return Air Ductwork: Ductwork shall be tested at leakage Class [12] at [-1"] wg.]**
10. General Exhaust Ductwork: Ductwork shall be tested at leakage Class **[12]** at **[-2"]** wg.
11. Kitchen Exhaust Ductwork: Ductwork shall be tested at leakage Class **[3]** at **[-3"]** wg.
12. Dishwasher Exhaust Ductwork: Ductwork shall be tested at leakage Class **[3]** at **[-2"]** wg.
13. Smoke Exhaust Ductwork: Ductwork shall be tested at leakage Class **[3]** at **[-3"]** wg.

14. Laboratory Hood Exhaust Ductwork: Ductwork shall be tested at leakage Class **[3]** at **[-6"]** wg.
15. Underground Supply Ductwork: Ductwork shall be tested at leakage Class **[3]** at **[+2"]** wg.
16. Underground Return Ductwork: Ductwork shall be tested at leakage Class **[3]** at **[-2"]** wg.

END OF SECTION 23 31 13