

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Duct Materials.
2. Flexible ducts.
3. Insulated flexible ducts.
4. Single wall spiral round ducts.
5. Single wall spiral flat oval ducts.
6. Double wall spiral insulated round ducts.
7. Double wall spiral insulated flat oval ducts.
8. Transverse duct connection system.
9. Casings.
10. Ductwork fabrication.
11. Fume hood exhaust ductwork fabrication.
12. Duct cleaning.

B. Related Sections:

1. Division 03 - Cast-In-Place Concrete: Product requirements for concrete for placement by this section.
2. Division 09 - Painting and Coating: Execution requirements for Weld priming, weather resistant, paint or coating specified by this section.
3. Division 11 - Foodservice Equipment: Product requirements for kitchen range hoods for placement by this section.
4. Section 23 05 29 - Hangers and Supports for HVAC Piping and Equipment: Product requirements for hangers, supports and sleeves for placement by this section.
5. Section 23 33 00 - Air Duct Accessories: Product requirements for duct accessories for placement by this section.

1.02 REFERENCES

A. ASTM International:

1. ASTM A36/A36M - Standard Specification for Carbon Structural Steel.

2. ASTM A90/A90M - Standard Test Method for Weight Mass of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings.
 3. ASTM A167 - Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
 4. ASTM A568/A568M - Standard Specification for Steel, Sheet, Carbon, and High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, General Requirements.
 5. ASTM A653/A653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
 6. ASTM A1008/A1008M - Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability.
 7. ASTM A1011/A1011M - Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability.
 8. ASTM B209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
 9. ASTM B209M - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (Metric).
 10. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.
- B. National Fire Protection Association:
1. NFPA 90A - Standard for the Installation of Air Conditioning and Ventilating Systems.
 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.
- C. Sheet Metal and Air Conditioning Contractors:
1. SMACNA - HVAC Air Duct Leakage Test Manual.
 2. SMACNA - HVAC Duct Construction Standard - Metal and Flexible.
- D. Underwriters Laboratories Inc.:
1. UL 181 - Factory-Made Air Ducts and Connectors.
- E. National Air Duct Cleaners Association
1. NADCA Standards for duct cleaning.

1.03 PERFORMANCE REQUIREMENTS

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

1.04 SUBMITTALS

- A. Division 01 - Submittal Procedures: Submittal procedures.
- B. Shop Drawings: Submit duct fabrication drawings, drawn to scale not smaller than 3/8 inch equals 1 foot, on drawing sheets same size as Contract Documents, indicating:
 - 1. Fabrication, assembly, and installation details, including plans, elevations, sections, details of components, and attachments to other work.
 - 2. Duct layout, indicating pressure classifications and sizes in plan view. For exhaust duct systems, indicate classification of materials handled as defined in this section.
 - 3. Fittings.
 - 4. Reinforcing details and spacing.
 - 5. Seam and joint construction details.
 - 6. Penetrations through fire rated and other walls.
 - 7. Terminal unit, coil, and humidifier installations.
 - 8. Hangers and supports, including methods for building attachment, vibration isolation, and duct attachment.
 - 9. Submit shop drawings indicating duct runs, material, extent of internal lining, fire dampers, volume dampers access doors and elevation of all ducts.
 - 10. Also submit a book of Shop Standards for Sheet metal Fabrication, for approval, before starting fabrication of any portion of ductwork.
- C. Product Data: Submit data for duct materials, duct liner and duct connectors
- D. Samples: Submit two (2) samples of typical shop fabricated duct fittings.
- E. Test Reports: Indicate pressure tests performed. Include date, section tested, test pressure, and leakage rate, following SMACNA HVAC Air Duct Leakage Test Manual.

1.05 CLOSEOUT SUBMITTALS

- A. Division 01 - Execution and Closeout Requirements: Closeout procedures.
- B. Project Record Documents: Record actual locations of ducts and duct fittings. Record changes in fitting location and type. Show additional fittings used.

1.06 QUALITY ASSURANCE

- A. Perform Work in accordance with SMACNA - HVAC Duct Construction Standards - Metal and flexible.
- B. Maintain one copy of each document on site.

1.07 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three (3) years documented experience.
- B. Installer: Company specializing in performing Work of this section with minimum three (3) years documented experience approved by manufacturer.

1.08 ENVIRONMENTAL REQUIREMENTS

- A. Division 01 - Product Requirements.
- B. Do not install duct sealant when temperatures are less than those recommended by sealant manufacturers.
- C. Maintain temperatures during and after installation of duct sealant.

1.09 FIELD MEASUREMENTS

- A. Verify field measurements prior to fabrication.

1.10 WARRANTY

- A. Division 01 - Execution and Closeout Requirements: Product warranties and product bonds.

PART 2 - PRODUCTS

2.01 DUCT MATERIALS

- A. Galvanized Steel Ducts: ASTM A653/A653M galvanized steel sheet, lock-forming quality, having G90 zinc coating of in conformance with ASTM A90/A90M. Ducts in areas without hung ceilings shall be paintable galvanized steel.
- B. Aluminum Ducts: ASTM B209; aluminum sheet, alloy 3003-H14. Aluminum Connectors and Bar Stock: Alloy 6061-T6 or of equivalent strength.
- C. Stainless Steel Ducts: ASTM A167, Type 304
- D. Fasteners: Rivets, bolts, or sheet metal screws.
- E. Hanger Rod: ASTM A36/A36M; steel, galvanized; threaded both ends, threaded one end, or continuously threaded.

2.02 INSULATED FLEXIBLE DUCTS

- A. Manufacturers: Subject to requirements of the specification, provide the following manufacturer's products by one of the following or approved equal:
1. Flexmaster, Type 8M
 2. Thermaflex
 3. Substitutions: Division 01 - Product Requirements.
- B. UL 181, Class 1, constructed with interior liner of round chlorinated polyethylene duct, with galvanized steel mechanical lock helix, exterior fiberglass insulation and reinforced metalized film vapor barrier, minimum 1 inch thick fiberglass insulation.
1. Pressure Rating: 10 inches wg (2.5 kPa) positive or 5 inches wg (1.25 kPa) negative.
 2. Maximum Velocity: 5000 fpm (20.3 m/s).
 3. Temperature Range: -20 degrees F to 250 degrees F (-28 degrees C to 99 degrees C).
 4. Thermal Resistance: 8.0 square feet-hour-degree F per BTU.
 5. Furnish each flexible duct section with integral stainless steel clamping devices for connection to round or oval fittings.
 6. Join each flexible duct section to main trunk duct through sheet metal fittings. Construct fittings of galvanized steel and equip with factory installed volume damper having positive locking regulator. Provide fittings installed in lined ductwork with insulation guard.
 7. Flexible metal duct connections shall, unless noted otherwise, be equal in size to the unit inlet connections, or shall be provided with adapters to match flexible hose to the unit inlet.
 8. At points of connection between the flexible duct and unit, permacel EZ-4719 or Minnesota Mining sealing compound shall be placed on the metallic surface and the flexible ductwork clipped over. A stainless steel clamp shall be placed over the connections, similar to Ideal Type 52 worm gear drive to secure flexible joint to air outlet and to duct. Seal joint air tight.
 9. Flexible ducts shall not be used for supporting diffusers from overhead supply ducts. Also, do not use hose ducts at VAV box inlets.
 10. Provide minimum 4' long (maximum 6' long) flexible ducts to each supply air outlet and general exhaust ceiling-mounted grille.

2.03 SINGLE WALL SPIRAL ROUND DUCTS

- A. Manufacturers: Subject to requirements of the specification, provide the following manufacturer's products by one of the following or approved equal:
1. McGill AirFlow Corporation.

2. Semco Incorporated.
 3. Spiral Mfg. Co., Inc.
 4. Substitutions: Division 01 - Product Requirements.
- B. Product Description: UL 181, Class 1, round spiral lockseam duct constructed of galvanized steel.
- C. Follow requirement in Section 23 05 48 "Noise and Vibration Controls for HVAC Piping and Equipment" for internal duct insulation (liner).
- D. Construct duct with the following minimum gages and in accordance with IBC-NJ and SMACNA:

Diameter	Gauge
3 inches to 14 inches	26
15 inches to 26 inches	24
28 inches to 36 inches	22
38 inches to 50 inches	20
52 inches to 84 inches	18

- E. Construct fittings with the following minimum gages and in accordance with IBC-NJ and SMACNA:

Diameter	Gauge
3 inches to 14 inches	24
15 inches to 26 inches	22
28 inches to 36 inches	20
38 inches to 50 inches	20
52 inches to 60 inches	18
62 inches to 84 inches	16

2.04 SINGLE WALL SPIRAL FLAT OVAL DUCTS

- A. Subject to requirements of the specification, provide the following manufacturer's products by one of the following or approved equal:
1. McGill AirFlow Corporation.
 2. Semco Incorporated
 3. Tangent Air Corp.
 4. Spiral Mfg. Co., Inc.
 5. Substitutions: Division 01 - Product Requirements.
- B. Product Description: Machine made from round spiral lockseam duct constructed of galvanized steel; rated for 10 inches wg (2.5 kPa) pressure.
- C. Follow requirement in Section 23 05 48 "Noise and Vibration Controls for HVAC Piping and Equipment" for internal duct insulation (liner).
- D. Joints: Either fully welded or bolted flange with gasket material in accordance with manufacturer's recommendations.

- E. Construct duct with the following minimum gauges and in accordance with IBC-NJ and SMACNA:

Major Axis Dimension	Gauge
7 inches to 24 inches	24
25 inches to 48 inches	22
50 inches to 70 inches	20
72 inches to 82 inches	18
84 inches and larger	16

- F. Construct fittings with the following minimum gauges:

Major Axis Fitting Dimension	Gauge
7 inches to 36 inches	20
37 inches to 60 inches	18
62 inches and larger	16

2.05 SINGLE WALL LONGITUDINALLY WELDED ROUND AND FLAT OVAL DUCTWORK FOR FUME HOOD EXHAUST

- A. Minimum 18 gauge 304 stainless steel ductwork with fully welded longitudinal seam.
- B. Transverse joints shall be fully welded.
- C. Construct duct in accordance with IBC-NJ and SMACNA.
- D. Where fume hood and general laboratory exhaust ducts are combined, all ductwork shall be stainless steel.

2.06 DOUBLE WALL SPIRAL INSULATED ROUND DUCTS

- A. Subject to requirements of the specification, provide the following manufacturer's products by one of the following or approved equal:
 - 1. McGill AirFlow Corporation
 - 2. Semco Incorporated
 - 3. Spiral Mfg. Co., Inc.
 - 4. Substitutions: Division 01 - Product Requirements.
- B. Product Description: Machine made from round spiral lockseam duct with light reinforcing corrugations, galvanized steel outer wall, 1 inch (25 mm) thick glass fiber insulation, solid galvanized steel inner wall; fittings manufactured with solid inner wall. Ductwork shall be fabricated with paintable galvanized steel.
- C. Construct round duct with the following minimum gages and in accordance with IBC-NJ and SMACNA:

Diameter	Gauge
3 inches to 14 inches	26
15 inches to 26 inches	24
28 inches to 36 inches	22
38 inches to 50 inches	20
52 inches to 84 inches	18

- D. Construct round fittings with the following minimum gauges and in accordance with IBC-NJ and SMACNA:

Diameter	Gauge
3 inches to 14 inches	24
15 inches to 26 inches	22
28 inches to 36 inches	20
38 inches to 50 inches	20
52 inches to 60 inches	18
62 inches to 84 inches	16

- E. The inner wall thickness shall be a minimum of 26 gauge.

2.07 DOUBLE WALL SPIRAL INSULATED FLAT OVAL DUCTS

- A. Manufacturers:

1. McGill AirFlow Corporation.
2. Semco Incorporated.
3. Spiral Mfg. Co., Inc.
4. Substitutions: Division 01 - Product Requirements.

- B. Product Description: Machine made from round spiral lockseam duct with light reinforcing corrugations, galvanized steel outer wall, 1 inch (25 mm) thick glass fiber insulation, solid galvanized steel inner wall; fittings manufactured with solid inner wall. Ductwork shall be fabricated with paintable galvanized steel.

- C. Construct flat oval duct with the following minimum gauges and in accordance with IBC-NJ and SMACNA:

Major Axis Dimension	Gauge
7 inches to 24 inches	24
25 inches to 48 inches	22
50 inches to 70 inches	20
72 inches to 82 inches	18
84 inches and larger	16

- D. Construct flat oval fittings with the following minimum gauges and in accordance with IBC-NJ and SMACNA:

Major Axis Fitting Dimension	Gauge
7 inches to 36 inches	20
37 inches to 60 inches	18
62 inches and larger	16

- E. The inner wall thickness shall be a minimum of 24 gauge.

2.08 PERFORATED ROUND DUCT

- A. Minimum 22 gauge galvanized paintable steel, spiral wound perforated duct with 3/16 inch diameter staggered holes on 1/4 inch center. Minimum free area 55%. Provide in all rooms with air tables and at all other locations indicated on drawings.

Ductwork shall be fabricated with paintable galvanized steel. Paint duct of a color, finish selected by the architect.

2.09 WELDED FUME HOOD, CAGE WASH, GLASS WASH EXHAUST, HUMIDIFIER DUCTWORK.

- A. Minimum 18 gauge 304 stainless steel ductwork with fully welded longitudinal seam.
- B. Transverse joints shall be fully welded.
- C. Construct duct in accordance with IBC-NJ and SMACNA.
- D. Where fume hood and general laboratory exhaust ducts are combined, all ductwork shall be stainless steel.
- E. Pitch cage wash exhaust, glass wash exhaust ductwork down to equipment.

2.10 DUCTWORK SERVING DUST COLLECTION SYSTEM

- A. All ducts serving dust collection system shall be constructed to SMACNA 10" W.G. standards.
- B. Provide duct access cleanout doors every 10 feet and at every change of direction.
- C. Provide slide dampers (blast gates) at each branch take-off to pieces of equipment for balancing purposes.
- D. Provide blast gates at each piece of equipment for shutoff purposes.
- E. All elbows shall be long radius with a radius equal to 2.5 times duct diameter.
- F. All branch takeoffs shall be 15° with respect to main duct run.
- G. All ductwork shall be leak tested in accordance with SMACNA recommendations for 10" W.G. construction.
- H. Longitudinal joints or seams shall be welded.
- I. Removable caps should be installed at all terminal ends for each piece of equipment.
- J. Flexible duct connections to each piece of equipment shall be no longer than 24" long. Flex ducts shall be tear-proof plastic, 30 mil. thickness, rated for -20" W.G. service.

2.11 TRANSVERSE DUCT CONNECTION SYSTEM

- A. Product Description: SMACNA "E" rated and SMACNA "J" rated rigidity class connection, interlocking angle and duct edge connection system with sealant, gasket, cleats, and corner clips.

2.12 LONGITUDINAL SEAMS

- A. Rectangular ducts shall be Pittsburgh lock with sealed pocket.
- B. Welded ducts shall have butt-welded seams or lap (socket) welded seams to suite the sheet thickness.

- C. All seams, joints in all supply, return, exhaust, relief and outside air ducts shall be sealed air tight throughout regardless of duct pressure and construction classification using approved duct sealant.

2.13 CASINGS/PLENUMS

- A. Fabricate casings in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible and construct for operating pressures indicated.
- B. Reinforce access door frames with steel angles tied to horizontal and vertical plenum supporting angles. Furnish hinged access doors where indicated or required for access to equipment for cleaning and inspection.
- C. Provide all metal housing, casings or plenums. Metal casings or plenums shall be constructed and jointed by external 1-1/2" standing seams of No. 16 USS gauge galvanized steel sheets, reinforced with 1-1/2" x 1-1/2" x 1/4" angles spaced not more than 3'-0" apart. Additional angles shall be provided wherever necessary to prevent vibration.
- D. Bottom panels shall be constructed to form watertight pans not less than 6" deep, with brass drains with strainers and threaded outlets located in each compartment where required. The bottom of each compartment shall be pitched to the drain. Provide water seal in drain lines to carry lines to nearest indirect drain.
- E. Casing or plenums shall be provided with steel supports, of type approved by Architect to properly support the equipment and to maintain pitch to the drains. Where insulated, they shall be arranged with adequate means of attaching the insulation, including the bottom, if any.
- F. The Contractor shall provide heavy rigid plates with all required drilling and cutouts, heavy braced to reduce vibration, for the installation of thermometers, thermostats and other instruments.
- G. Longitudinal reinforcing angles shall be installed on the inside in accordance with the following schedule:

<u>Height of Side</u>				<u>Diagonal Bracing</u>
<u>Walls or Width of Roof</u>	<u>No. Angles</u>	<u>Angle Spanning</u>	<u>Length of Casing</u>	<u>Pairs of Braces</u>
Up to 6'	0	-	Any	None
Up to 8'	1	Middle	Any	None
8' to 12'	2	1/3 points	Any	None
Over 12'	Variable	4' Centers	3&4 Panels	1
			5&6 Panels	2
			7&8 Panels	3

Angle size shall be 1-1/2" x 1-1/2" x 1/8" to 12' casing length, and 1-1/2" x 1/2" x 3/16" over 12' casing length.

NOTE: Provide knee-bracing for top of casing wherever required.

- H. All joints shall be caulked with Minnesota Mining Formula EC 1057 or Alumastic to make them airtight.

- I. Casing or plenums shall be supported on galvanized steel legs. The bottom at the floor and at any other connection to masonry shall be riveted to 1-1/2" x 1-1/2" x 1/8" galvanized steel angles which shall be secured to masonry with expansion shields and caulked tight with cement.
- J. Provide angles above and below access doors and frames for access doors.

2.14 DOUBLE WALL PLENUMS

A. General:

- 1. Double-wall (insulated) pressurized plenum equipment enclosures shall be provided for all mixed air, outside air, return air and supply air discharge plenums. All panels and components shall be prefabricated and supplied by a nationally recognized manufacturer with published standards of construction, assembly and technical performance. The manufacturer shall have produced a standardized prefabricated panel system for at least 10 years. Construction and performance of the installed system and components shall conform to all specifications listed in this document. The system and components shall not be susceptible to damage from extended exposure to airflow, pressure differentials, vibration, air temperature or humidity.

B. Joint Construction:

- 1. Panels shall be of "snap-lock" construction, such that adjacent panels are held together rigidly with an integral, continuous self-locking joint on both inside and outside panel surfaces. These joints shall not require screws, H-connectors, tape or any other type of additional fasteners or connectors.
- 2. For plenums in contact with air having temperature less than 60°F. during the summer, thermal break joints shall be provided.

C. Panel Construction:

- 1. All panels shall be 4 inches thick, with a solid galvanized steel exterior shell, and a perforated interior galvanized steel shell.
- 2. The outer and inner shells shall be tack or spot welded to perimeter and internal longitudinal steel channels and box-end internal closures, in such a manner and spacing that the panel assembly will not fail at the maximum operating loads specified in the Structural Performance specifications given in this document.
- 3. The outer shell shall be constructed of galvanized steel with a minimum 20-gauge thickness.
- 4. The inner shall be constructed of galvanized steel with a minimum 22-gauge thickness.
- 5. Perforated materials shall be 3/32-inch-diameter round holes with staggered spacing, 3/16 inch on center. The perforated material shall have a 23 percent open area.
- 6. All perimeter and internal longitudinal steel channel members shall be constructed of ASTM Type A-446 structural quality galvanized steel with a

minimum 18-gauge thickness of ASTM Type A-526 commercial-quality galvanized steel with a minimum 16-gauge thickness.

7. All steel panel surfaces, internal channels, and trim items shall be fabricated from zinc-coated steel with a hot-dipped galvanized coating (minimum G-90 coating class as determined by ASTM A-525) and shall meet all requirements of ASTM A-526 for commercial-quality galvanized carbon steel.
8. Each panel assembly shall be completely filled with acoustical/thermal insulating material that is non-combustible, inert, mildew-resistant and vermin-proof. Insulation shall not settle within the panel assembly. No insulating materials shall be used that have a flame spread greater than 25 or a smoke developed greater than 50.

D. Components and Installation:

1. All plenum base channels shall be installed on a level concrete curb, the dimensions of which shall be determined from plan-view shop drawings of the system provided by the system manufacturer. Spacing of base channel attachments shall be as outlined in the manufacturer's standard details of assembly.
2. All assembly trim items shall be constructed of hot-dipped galvanized steel (minimum 18-gauge thickness) and furnished in standard lengths to be field cut to the required dimensions. Spacing of sheet metal screws, application of duct sealant and positioning of trim shall be in accordance with the plenum manufacturer's published erection and installation details.
3. All mechanical joints and external trim items shall be sealed with a UL-Classified duct sealant in accordance with manufacturer's recommendations. In order to show that joints have been sealed properly, enough sealant shall be used so that excess sealant is extruded from all completed external joints.
4. For enclosures to be installed indoors, joints and trim shall be sealed with a solvent-based duct sealant that is a polymeric rubber formulated to withstand temperatures from -20 to +150°F. Sealant shall be formulated such that surface preparation or solvent cleaning is not necessary. Sealant shall have a UL Classification marking with a flame spread of 15 and smoke developed of 20 when applied to 18-gauge galvanized steel and a flame spread of 10 and smoke developed of 0 when applied to organic reinforced cement board, both at a coverage of 31 square feet per gallon. Sealant shall exceed 750 hours without becoming brittle under ASTM-D572 test conditions (oxygen bomb).
5. For enclosures to be installed indoors and outdoors, joints and trim shall be sealed with a solvent-based duct sealant that is a neoprene-phenolic mastic formulated to withstand temperatures from 02- to +300°F. Sealant shall be formulated such that surface preparation or solvent cleaning is not necessary. Sealant shall have a UL Classification marking with a flame spread of 5 and smoke developed of 0 when applied to 18-gauge galvanized steel and a flame spread of 5 and smoke developed of 5 when applied to inorganic reinforced cement board, both at a coverage of 53 square feet per gallon. Sealant shall exceed 1,000 hours under ASTM-D572 test conditions (oxygen bomb) without becoming brittle under 500 hours in QUV accelerated-exterior-aging apparatus without degradation (under ASTM-C732 test conditions).

6. Personnel access doors shall be provided where specified on drawings and shall be 24 inches wide by 60 inches high unless otherwise indicated. All doors shall be the same nominal thickness as the prefabricated standard door panel in which they are mounted. All access door panels and doors shall be constructed with a solid inner and outer shell (minimum 20-gauge thickness). Each door shall be installed in the door panel at the factory and shall have a minimum of two ball-bearing hinges and two wedge-lever door latches. All levers shall be operable from the interior and exterior sides of the door panels. All doors shall be installed to open against the air pressure differential. Doors shall seat against neoprene gasket materials, installed around the entire perimeter of the door frame in such a manner that door operation will provide direct compression with no sliding action between the door and gasket.
7. Doors shall be furnished with windows, which are composed of double-glazed layers of wire-reinforced safety-glass, separated by an air space, and sealed against acoustical and air leakage by interior and exterior rubber seals.
8. Openings for pipe and conduits shall be field cut to ensure proper positioning. All framing members, collars and bellmouth fittings shall be insulated, welded and sealed according to the plenum manufacturer's published installation details.
9. Plenums shall be framed all around with heavy angles and supported.
10. Outside air plenums and ducts shall be provided with drain outlet. Plenum shall be pitched down to drain outlet.

E. Structural Performance:

1. The entire plenum installation shall be designed by the plenum manufacturer to be self-supporting. Where roof spans and wall loadings require additional structural strength, it shall be provided by heavier panel skins, additional internal longitudinal reinforcing members or additional structural members and necessary supporting pipe columns. The installer shall furnish and install all structural members and pipe columns according to the drawings and published installation details provided by the plenum manufacturer.
2. The finished plenum installation shall be able to withstand a positive internal static pressure of 6 inches wg and a negative internal static pressure of 6 inches wg. Installations subjected to the effects of weather shall be able to withstand a wind loading of 100 pounds per square foot.
3. Under the conditions specified in the previous section, the assembled structure shall not exhibit any panel joint deflections in excess of $L/200$, where L is the unsupported span length of any panel section within the completed plenum.

F. Acoustical Performance:

1. The plenum manufacturer shall provide certified testing data obtained from an acoustical laboratory, listing sound absorption and transmission loss characteristics of the panel assembly. When requested by the engineer, the plenum manufacturer shall arrange to have a copy of all pertinent acoustical laboratory reports forwarded directly from the laboratory to the engineer.

2. When tested according to ANSI/ASTM C423-66 or a subsequent version of this standard, the panel assembly shall have minimum sound absorption coefficients, as shown in the following table, in the 1/3 octave band center frequencies. The coefficients used shall be those reported by the acoustical laboratory.

Sound Absorption Coefficients
1/3 Octave Band

Center Frequency (Hz)	125	250	500	1000	2000	4000	NEC
	0.63	1.09	1.17	1.08	1.03	0.97	1.00

3. When tested according to ANSI/ASTM E90-70 or a subsequent version of this standard, the panel assembly shall have minimum airborne sound transmission losses, as shown in the following table, in the combined full octave band center frequencies.

Sound Transmission Losses
Octave Band

Center Frequency (Hz)	125	250	500	1000	2000	4000	8000
	16	24	35	45	53	58	37

G. Thermal Performance:

1. Insulating materials used in all prefabricated panel assemblies shall have the following maximum thermal conductance at a mean temperature of 75°F: 0.06 Btu per hour per square foot per degree Fahrenheit.

2.15 ACCESS DOORS FOR CASING AND PLENUMS

- A. Access doors not less than 20" x 48" shall be provided in equipment casings and plenums. They shall consist of No. 16 USS gauge galvanized steel sheets mounted on angle frames with crossbracing to prevent sagging or warping, and shall have sponge rubber gaskets.

Door shall be installed on angle or channel frames, extended where required to finish flush with insulation. In insulated casings, the doors shall be of double construction, filled with insulation 1" thick. Door openings in casings shall have angle frames to provide a true and uniform seating surface for the gasketed doors.

- B. Each door shall be equipped with three (3) six screw "T" shaped extra heavy zinc plated hinges with brass pins as manufactured by Ferrum Co. No. 245 or approved equal. Provide three (3) cast zinc lever type fasteners. Ventlock No. 310 or approved equal. Inside release levers shall be provided for each door.

2.16 INSULATED PANELS

- A. Provide insulated panels for all spaces to be blanked off inside fan housings and for unused portions of louvers and where noted on the drawings.
- B. Inside and outside sheets of panels shall be constructed of alloy 25 hard aluminum sheet 20 B & S gauge. Insulation shall be 1-1/2" thick polyurethane.
- C. Sections over 24" long shall be internally braced with inside Z-bars.

- D. Panels shall be assembled and installed in such a manner as to be completely airtight and rigid.
- E. Blank-off all unused portions of louvers with double wall panel with minimum 1-1/2" thick insulation. Provide angles, supports for blank-offs.

2.17 DUCTWORK FABRICATION

- A. Fabricate and support rectangular ducts in accordance with IBC-NJ, NFPA 96 and SMACNA HVAC Duct Construction Standards - Metal and Flexible. Provide duct material, gages, reinforcing, and sealing for operating pressures indicated.
- B. Ductwork shall be continuous, shall be built with joints and seams presenting a smooth surface on the inside and neatly finished on the outside. All joints and seams for supply, exhaust, make-up and return air ductwork shall be sealed airtight with approved non-hardening resilient caulking compound. Fume hood exhaust ducts shall be fully welded. "Airtight" shall mean duct leakage not exceeding 5% of design air quantity. Should duct leakage exceed this limit, Contractor shall reseal as required and rebalance systems at no cost to Owner. ALL ductwork shall be sealed with high pressure duct sealant. Seal Class A, as defined by SMACNA, shall be provided for all ductwork.
- C. Where ductwork is exposed to view, it shall be considered an architectural component of the project. External tapes and stickers, and internal stickers, are not allowed and sealants/welds shall be finished in a workmanlike manner. All welding burns shall be filed and scraped clean. Excess sealants and filler material shall be removed. Duct supports shall have a finished appearance.
- D. See Section 23 05 48 for Noise and Vibration Controls for HVAC Piping and Equipment.
- E. Fabricate ducts having pressure class equal to or greater than the static pressure of the fans or equipment to which the duct is connected.
- F. Construct T's, bends, and elbows with minimum radius 1-1/2 times centerline duct width. Where not possible and where rectangular elbows are used, provide turning vanes. Where acoustical lining is indicated, furnish turning vanes of perforated metal with glass fiber insulation.
- G. Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible; maximum 30 degrees divergence upstream of equipment and 45 degrees convergence downstream unless noted otherwise.
- H. Fabricate continuously welded round and oval duct fittings two gages heavier than duct gages indicated in SMACNA Standard. Minimum 4 inch (100 mm) cemented slip joint, brazed or electric welded. Prime coat welded joints.
- I. Provide standard 45-degree lateral wye takeoffs. When space does not allow 45-degree lateral wye takeoff, use 90-degree conical tee connections.

2.18 HANGERS AND SUPPORTS

- A. Where hanger straps are used they shall be 1" x 18 ga. minimum, galvanized steel.
- B. Rectangular duct risers shall be supported at each floor by angles or channels secured to the sides of the duct with welds, bolts, sheet metal screws or blind rivets.

- C. Ducts over 60 inches wide shall be suspended on a trapeze type hanger. The duct shall not be secured to the hanger.
- D. Hanger spacing shall vary between 4 ft. and 8 ft. depending on duct size and distance between construction joints, such that, 4 ft. sections shall be supported every 4 ft.
- E. Provide inserts, fishplates and other methods recommended by SMACNA, and as approved, for supporting hanger straps and trapeze hangers. Do not use or submit power actuated fasteners, expansion nails or pins for supporting duct hangers.

2.19 DUCT SEALANTS

- A. Use the following sealants for joints and seams and for acoustic lining and vapor barrier application to all ductwork unless called for otherwise:

 B-F #30-02 for sealing high and low pressure ductwork
 3M-425 for taping joints in vapor-proof barriers
 B-F #85-20 for attaching acoustic lining
 B-F #30-36 for binding edges on acoustic lining
 B-F #30-35 as a vapor barrier cement on insulation
- B. Use equivalent sealants if any of the above cannot provide flame spread rating of 25 and smoke developed rating 50 or less.
- C. Duct sealants shall meet the latest VOC requirements of the South Coast Air Quality Management District (Rule #1168) and the content of VOC shall not exceed 250 grams per liter.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Division 01 - Administrative Requirements: Coordination and project conditions.
- B. Verify sizes of equipment connections before fabricating transitions.

3.02 INSTALLATION

- A. Install ducts in accordance with IBC-NJ, NFPA 96 and SMACNA HVAC Duct Construction Standards - Metal and Flexible. All seams and joints shall be sealed throughout with approved duct sealant.
- B. During shipping, storage on-site and throughout construction, install temporary closures of metal or taped polyethylene on open ductwork to prevent construction dust from entering ductwork system throughout the entire fabrication and installation process. Protect duct from dust and debris at entrance at all times. Clean ducts throughout demolition and construction and prior to start-up and operation of system.
- C. Provide internally insulated (lined) ductwork in accordance with Section 23 05 48, Noise and Vibration Controls for HVAC Piping and Equipment.
- D. Use crimp joints with beaded sleeve couplings for joining round duct sizes 8 inch (200 mm) and smaller. Use flanged joints for ducts larger than 8 inches.

- E. Install duct hangers and supports in accordance with Section 23 05 29.
- F. Use double nuts and lock washers on threaded rod supports.
- G. Set plenum doors 6 to 12 inches (150 to 300 mm) above floor. Arrange door swing so fan static pressure holds door in closed position.
- H. Casings: Install floor-mounted casings on 4 inch (100 mm) high concrete curbs. Refer to Division 03. At floor, rivet panels on 8 inch (200 mm) centers to angles. Where floors are acoustically insulated, furnish liner of 18 gage (1.20 mm) galvanized expanded metal mesh supported at 12 inch (300 mm) centers, turned up 12 inches (300 mm) at sides with sheet metal shields.
- I. Coordinate with all affected trades to insure that no ceilings, equipment or other materials other than as specifically provided herein are supported from ductwork or the ductwork hanger system.
- J. Coordinate with others as necessary to insure that access doors have been provided in hung ceilings, shaft wall, or other construction, of ample size for proper operation and maintenance of the installation.
- K. While the drawings shall be adhered to as closely as possible, the right is reserved to vary the run and size of ducts during the progress of the work if required to meet structural conditions.
- L. Sheet metal sub-contractor shall install all ductwork in strict adherence to the ceiling height schedules indicated on the Architect's drawings. Sheet metal sub-contractor shall consult with the Heating, Fire Protection, Electric and Plumbing sub-contractors and shall, in conjunction with the above contractors, establish the necessary space requirements for each trade. The sheet metal ductwork shall, whether indicated or not, rise and/or drop and/or change in shape to clear any and all conduits, lighting fixtures, sprinklers, plumbing and heating piping to maintain the desired ceiling heights.
- M. Transition pieces from rectangular to round at fan discharge shall be 16 gauge all-welded construction. Provide suitable angle reinforcement. Branches off medium and high pressure duct mains shall have conical taps.
- N. Provide watertight stainless steel or copper counter flashings around all ducts passing through openings in exterior wall or through roof.
- O. Provide a fire damper and sheetmetal sleeve for each duct penetration through fire rated walls. Wherever ducts penetrate Mechanical Equipment Room walls, floor and ceiling slabs, and no fire smoke or fire damper is required, the entire space between duct and wall sleeve or slab opening shall be tightly packed with approved sound-proof material. Each face of opening shall further be caulked airtight with approved non-hardening resilient caulking.
- P. All duct accessories, including but not limited to, access doors, dampers, etc. in stainless steel ducts shall be stainless steel.

3.03 INTERFACE WITH OTHER PRODUCTS

- A. Install openings in ductwork where required to accommodate thermometers and controllers. Install pitot tube openings for testing of systems. Install pitot tube complete with metal can with spring device or screw to prevent air leakage. Where

openings are provided in insulated ductwork, install insulation material inside metal ring.

- B. Connect diffusers to low pressure ducts with 18 inches maximum length of flexible duct held in place with strap or clamp.
- C. Connect air outlets and inlets to supply ducts with 18 inches maximum length of flexible duct. Do not use flexible duct to change direction.

3.04 DUCT PRESSURE TEST

A. Pressure Testing of Ductwork

1. Air pressure testing during erection shall include separate air leakage tests of plenum, the horizontal distribution system ductwork and, after all ductwork is installed and the central station apparatus is erected, leakage testing of the entire System. The testing shall apply to all ductwork in systems constructed to 4" w.g. or higher pressure classes.
2. Test all ductwork at corresponding pressure class to which it is constructed. Duct leakage shall be limited to the following:

<u>Average Size of Run Diameter or Equivalent</u>	<u>100 ft. Run</u>	
	<u>(A)</u>	<u>(B)</u>
12 inches or less	10	1"
20 inches or less	15	2"
30 inches or less	25	6"
40 inches or less	30	9"
50 inches or less	30	9"

(A) Permissible loss in cfm.

(B) Corresponding differential gauge reading (0.875 inch diameter orifice plate).

3. Tests shall be made prior to insulation of system being tested using suitable test equipment including test blower, "U" tube, orifice, tubing and cocks, arranged to indicate the amount of air leakage.
4. The leakage tests of the ductwork shall be made with pressure in the system, obtained by operation of the test blower.
5. All joints shall be inspected and checked for audible leakage, repaired if necessary and retested.
6. Contractor shall test ductwork using SMACNA leakage test methods to limit amount of leakage per sq. ft. of ductwork prescribed for Leakage Class 6 or 6" WG Duct Design.
7. Contractor shall provide flanges, blank-off plates and accessories required for tests. Test ducts in sections as required by Owner and Construction Manager.

3.05 CLEANING

- A. Division 01 - Execution and Closeout Requirements: Final cleaning.

B. Scope of Work:

1. **The Bidder is not to include the cost of duct cleaning in its bid proposal. The Bidder is responsible to take all necessary precautions to prevent dust and debris from entering the duct system throughout the construction period until Substantial Completion. If the system is inspected and found to be unacceptable prior to Substantial Completion, the Bidder will be responsible to clean the duct system at no additional cost to the College.**
- 4.2. Mechanical Contractor shall provide all labor, materials, facilities, equipment and services to thoroughly clean HVAC system including all supply air and exhaust ductwork, associated air devices, turning vanes, dampers, reheat coils, etc. Mechanical Contractor shall remove, store and re-install ceiling tiles as required for access to systems. Mechanical Contractor shall provide and install duct access doors as required for proper access. Mechanical Contractor shall repair or replace all damaged ceiling tiles, wall penetrations, ceiling penetrations, floor penetrations, insulation, control components or other damaged items to match existing.
- 2.3. Determine cleaning method to prevent damage to existing systems. Notify Engineer of proposed method and impact on system prior to start. Also notify Engineer of any system defects discovered during cleaning process..
- C. Clean duct systems with high power vacuum machines. Protect equipment with potential to be harmed by excessive dirt with filters, or bypass during cleaning. Install access openings into ductwork for cleaning purposes.
- D. The duct system shall be inspected and certified by an air system cleaning specialist, member of NADCA, to confirm that it meets all NADCA standards.
- E. Ducts shall be cleaned in accordance with Advanced Level of Duct Cleanliness as required by SMACNA's Duct Cleanliness for New Construction Guidelines. All labels, internal and external, shall be removed.

3.06 CONSTRUCTION INDOOR AIR QUALITY MANAGEMENT PLAN

- A. The Contractor shall incorporate all protective measures as required to prevent the contamination of the duct system and air distribution system. Air pollutants as described in the "SMACNA-IAQ Guidelines for Occupied Buildings Under Construction" Tables 2-2 and 2-3 shall be prevented from entering the duct system and air distribution system. Preventative measures including, but not limited to the following, shall be incorporated:
 1. All stored ductwork and air distribution equipment shall be kept dry and clean.
 2. Sealing of all ductwork and louvers prior to finish cleaning of building.
 3. Utilization of temporary filters.
 4. Sealing of fans, fan coil units, etc.
 5. Duct and equipment cleaning.
 6. Provisions for temporary construction exhaust fans to remove dust, odors, etc.

7. HVAC protection as defined in Chapter 3 of the above noted SMACNA manual.
 8. Source control as defined in the above noted SMACNA manual.
 9. Pathway interruption as defined in the above noted SMACNA manual.
 10. Housekeeping as defined in the above noted SMACNA
 11. Scheduling as defined in the above noted SMACNA manual.
- B. Contractor shall coordinate systems installation with General Contractor and develop construction Indoor Air Quality plan. Plan shall be submitted to Professional for review. Plan shall identify methods to prevent contamination of the duct system along with schedule/phasing issues.
- C. It is the intent that the permanent HVAC systems will not be used for temporary heating and cooling. Contractors shall provide temporary heating and cooling as required to meet construction requirements.
- D. After final cleaning of HVAC system and building, the system shall be flushed with 100% outdoor air for a two-week time period in accordance with ASHRAE Standard 62. After flush-out procedure, permanent final filters shall be installed in their respective systems.
- E. After completion of the job, Contractor shall submit a letter indicating that the IAQ measures noted in this project have been met. The letter shall include specific dates for all cleaning, flushing and filter replacements.

3.07 SCHEDULES

A. Ductwork Material Schedule:

AIR SYSTEM	MATERIAL
Supply	Galvanized Steel
Return and Spill	Galvanized Steel
General Laboratory Exhaust**	Galvanized Steel
Humidifier section*	Stainless Steel
Perforated Duct	Galvanized Steel
Fume Hood Exhaust**	Stainless Steel
Outside Air Intake	Galvanized Steel
Combustion Air	Galvanized Steel
Emergency Generation Ventilation	Galvanized Steel
Toilet Exhaust, Non-Laboratory General Exhaust	Galvanized Steel
All Rooftop Exhaust Ductwork	Stainless Steel
Cage Wash and Glass Wash Exhaust	Stainless Steel
Laundry Dryer Exhaust	Aluminum

* Including humidifier section and a minimum of 10 feet of ductwork downstream of humidifier.

** Where general laboratory exhaust and fume exhaust ducts are combined, all ductwork shall be stainless steel.

B. Ductwork Pressure Class Schedule:

AIR SYSTEM	PRESSURE CLASS
Constant Volume Supply	3 inch wg regardless of velocity.
Variable Air Volume Supply (downstream of VAV boxes)	2 inch wg regardless of velocity.
Variable Air Volume Supply (upstream of VAV boxes)	6 inch wg
Return and Relief, Spill	3 inch wg
General Laboratory Exhaust	6 inch wg
Fume Hood Exhaust	6 inch wg
Emergency Generation Ventilation	2 inch wg
Dust Collection System	12 inch wg
Toilet Exhaust, Non-Laboratory General Exhaust	3 inch wg

Note: Minimum pressure class for systems other than those listed above shall be 2" w.g.

END OF SECTION