

SPECIAL SPECIFICATION

SECTION 15891S

DUCTWORK

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

- A. Section Includes: This specification, in conjunction with the contract documents and design drawings, provides the minimum requirements for materials and operations used in the fabrication and installation of ductwork. Systems covered by this document include heating, ventilating, air conditioning and exhaust for pressure classes from minus 2 inches to plus 10 inches water gauge (0 Pa to +2490.8 Pa.) Operations include the specification of ductwork materials, gauges, pressure classifications, construction, filters, dampers, connectors, supports, testing and certifications. **It is intended that all ductwork shall be galvanized steel unless identified otherwise by these specifications or the construction documents.** This specification does not include ductwork requirements for **corrosive, abrasive, etc. type** materials handling exhaust systems. All work performed under this specification shall conform to Division 15, "General Materials and Work Requirements - Mechanical."
- B. Related Sections: Refer to the following sections for related work:
1. Division 1: Section 01300S "Descriptive Submittals"
 2. Division 7: Section 07900S "Sealants"
 3. **Division 13: Section 13085S Seismic Protection**
 4. Division 15: Section 15050S "Basic Mechanical Materials and Methods"
 5. **Division 15: Section 15070S – Vibration Limits and Control.**
 6. Division 15: Section 15250S "Pipe and Equipment Insulation for MicroFab"
 7. Division 15: Section 15950S "Testing Adjusting and Balancing"
 8. **Division 15: Section 15994 – Mechanical Systems Demonstration**

1.02 REFERENCES

- A. Sheet Metal And Air Conditioning Contractors' National Association (SMACNA)
HVAC Duct Construction Standards - Metal and Flexible
HVAC Duct Systems Applications
HVAC Duct Systems Design

Fire, Smoke and Radiation Damper Installation Guide for HVAC Systems

Accepted Industry Practice for Industrial Duct Design

HVAC Systems - Testing, Adjusting and Balancing

Round Industrial Duct Construction Standards

Rectangular Industrial Duct Construction Standards

B. National Fire Protection Association (NFPA)

80 Standard for Fire Doors and Windows

90A Standard for Installation of AC and Ventilation Systems

90B Standard for Installation of Warm Air Heating and AC Systems

255 Building Materials, Test of Burning Characteristics (same as ASTM E84)

C. American Society for Testing and Materials (ASTM)

A240 Standard Specification for Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet and Strip for Pressure Vessels

A480 Standard Specification for General Requirements for Flat Rolled Stainless Heat-Resisting Steel Plate, Sheet and Strip

A527 Standard Specification for Steel Sheet, Zinc Coated (Galvanized) by the Hot Dip Process, Lock Forming Quality

E477 Standard Test Method for Measuring Acoustical and Airflow Performance of Duct Liner Material and Prefabricated Silencers

E814 Standard Test Method for Fire Tests of Through Penetration Fire Stops

D. American Welding Society (AWS)

B2.2 Brazing Procedures and Performance Qualifications

B2.1 Welding Procedures and Performance Qualifications

E. Underwriter's Laboratories (UL)

181 Factory Made Air Ducts and Air Connectors

723 Test for Surface Burning Characteristics of Burning Materials (ASTM E84)

1.03 SUBMITTALS

General: Manufacturers, products and/or model numbers cited in this specification are meant to serve as a guide to minimum standards set forth by this specification. Proposed substitutions that can meet these minimum standards are allowed for submittal, and shall be included in the submittal package furnished to the Sandia Delegated Representative (SDR) for consideration and approval, prior to commencement of work. Submittals shall conform to Standard Specification Division 1, Section "Descriptive Submittals."

- A. Shop Drawings: Submit shop drawings for the following items:
1. Plenums and plenum related items showing physical dimensions, joints, sealants, door construction and hardware.
 2. Factory fabricated ducts, fittings and joining systems.
 3. Fire wall duct penetrations; fire and smoke dampers; louvers and access doors.
 4. **All ductwork on ¼ scale plans showing dimensions, pressure classes, duct sizes, connection, fitting details, equipment connected to and equipment connections show structure and walls, reflected ceilings where relevant and all adjacent piping, lights, sprinkler heads and piping, conduit, racks and equipment to prove coordination. Provide sections at all equipment and congested areas.**
- B. Submit Material Safety Data Sheets on sealants and adhesives.
- C. Submit changes or alterations in ductwork layout, with supporting calculations showing that the modified design will not increase total pressure, before work commences.
- D. Submit factory specifications for fire stopping materials.
- E. Submit control wiring diagrams for automatic dampers and other automated ductwork accessories.

1.04 DUCTWORK PRESSURE CLASSIFICATION

Unless otherwise indicated on the construction drawings, ductwork shall be constructed to meet the appropriate pressure class defined below.

- A. Ductwork from the supply air fan to the terminal velocity reduction device (VAV box) or zone tempering coil **and outside air intakes** shall be fabricated to meet minimum 4" w.g. (996.3 Pa) internal pressure.
- B. Ductwork from downstream of terminal velocity reduction device (VAV box) or zone tempering coil shall be fabricated to meet minimum 2" w.g. (498.2 Pa) internal pressure.
- C. Return air ductwork shall be fabricated to meet minimum 1" w.g. (249.1 Pa) internal pressure.
- D. Exhaust ductwork shall be fabricated to meet either a minimum 2" w.g. (498.2 Pa) negative pressure, or the exhaust fan pressure at shut-off.

1.05 QUALITY ASSURANCE

- A. Employ qualified sheet metal workers in accordance with SMACNA Duct Construction Standards.
- B. Asbestos Free: Insulating and sealing materials must be certified to be free of asbestos.
- C. Brazing: Certify brazing procedures, brazers, and operators in accordance with AWS B2.2 Brazing Procedures and Performance Qualifications.
- D. Welding: Certify welding procedures, welding equipment and welders in accordance with AWS B2.1 Welding Procedures and Performance Qualifications.
- E. Attachments, such as conduit and pipe, to ductwork are not permitted.

1.06 WARRANTY

Ductwork system components furnished under this contract shall be guaranteed against defective design, materials, and workmanship for the full warranty period, which is standard with the manufacturer or supplier, but in no case less than one year from the date of system acceptance.

PART 2 - PRODUCTS

2.01 MATERIALS, GENERAL

- A. Rigid Ducts, Casings and Fittings: Shall be made from galvanized steel sheets, unless otherwise shown on the contract documents. Sheets shall be free of pits, blisters, slivers, and ungalvanized spots. Sheets shall be of lock forming quality, having a galvanized zinc coating of 1.25 ounces per square foot (0.38 gm/m²) for each side per ASTM A527, unless otherwise noted on the contract documents.
- B. Stainless Ductwork: Stainless steel ductwork shall be ASTM A480 Type 316 with finish coating per ASTM A480 No. 4 for exposed surfaces, and ASTM A240, Type 304 with ASTM A480 No. 2B finish for concealed surfaces. Stainless steel ductwork shall be of the spiral lockseam type with factory fabricated fittings.
- C. Supports: Angle iron, channels, rods and related supporting materials shall be galvanized or prime coated.
- D. Fasteners: Use galvanized rivets, screws and bolts throughout, except on stainless steel ductwork, use SS fasteners. Liner fasteners should be suitable for adhesive, mechanical or welding attachment; able to withstand a 50 pound (222 N-m/m) tensile dead load; prevent air leakage; and extend 1/8 inch (3.2 mm) from insulation into airstream.
- E. Reinforcement: Provide galvanized steel or stainless steel reinforcement shapes and plates where required.

- F. Tie Rods:** Use galvanized steel, 1/4 inch (6.35 mm) minimum diameter fasteners for ductwork 36 inch (914.4 mm) or less in length; use 3/8 inch (9.53 mm) minimum diameter for lengths longer than 36 in. (914.4 mm.)
- H. Mechanical Liner Fasteners:** Shall be of galvanized steel, suitable for adhesive, mechanical or welding attachment. Provide fasteners that will not damage the liner when applied as recommended by the manufacturer, that do not cause leakage within the duct and that will sustain a 50 pound (222 N-m/m) tensile dead load perpendicular to duct wall.

2.02 DESIGN AND CONSTRUCTION

A. General:

1. Ductwork, joints, seams, reinforcement, liners, insulation, fittings, controls, and accessories shall be designed and constructed following guidelines in SMACNA HVAC Duct Systems Applications, Duct Systems Design and Duct Construction Standards - Metal and Flexible, and NFPA 90A and 90B.
2. Construct all ducts, casings and fittings of rigid, galvanized steel, unless otherwise shown in the contract documents.
3. Contractor is responsible for coordination between the ductwork trade and the other mechanical, electrical and architectural trades.
4. Insulation and duct liner shall be as specified in Division 15, Section "Insulation."

B. Plenums:

1. **MicroFab air handlers, see specifications 15721-S, 15722-S, 15723-S, and 15724-S.**
2. Main air handling (equipment) plenum walls, doors, and roof shall be factory built as follows: 18 gauge (1.31 mm) galvanized steel, minimum, double-wall construction (perforated inner walls) 4 inch (101.6 mm) acoustical insulated casing (top and sides) to provide a "U"-value of 0.06 Btu/hr-ft²-°F (0.341 W/m²K), hinged access doors with 90° latching handles to all compartments (double-wall insulated doors with air-tight sealing gaskets). Panels shall be provided with (end, bottom or top) supply and return duct openings, as shown on the drawings; return air and outside air dampers shall be furnished where indicated. Interior partition walls shall be perforated 20 gauge (1.01 mm) steel acoustic panels sandwiching 2" (50.8 mm) minimum thickness insulation, reinforced to be rigid under all operating conditions.
3. All other plenums shall be factory or site built of 16 gauge (1.61 mm) galvanized metal panels. Maximum width of panel shall be 21" (533.4 mm). One end of panel shall be flanged 1" (25.4 mm) and opposite end formed with 1" (25.4 mm) double standing seam.

C. Rectangular Ductwork: Shall conform to SMACNA HVAC Duct Construction Standards, Metal and Flexible or SMACNA Rectangular Industrial Duct Construction Standards, except:

1. Construct ducts using Pittsburgh lock corner seams.

2. Cross-Breaking:
 - a. Sheet metal ducts and fittings over 18 inches (457.2 mm) shall be **beaded**, cross-broken; or otherwise stiffened to eliminate oil canning or vibration.
 - b. Vertical and horizontal sheet metal barriers, duct offsets, and elbows shall be **beaded reinforced or cross-broken to prevent oil canning.**
 - c. Cross-breaking shall be applied to the sheet metal between the standing seams or reinforcing angles; the center of cross-break shall be of the required height to assure surfaces being rigid.
3. Radius Elbows: Radius elbows with a rectangular cross section shall have an inside radius of not less than **1 1/2 times** the width of the duct **unless shown otherwise.** Vane spacing shall be 1/3 of the duct width for widths up to 35 inches (889.0 mm). For ducts 36 inches (914.4 mm) and over, vane spacing shall be 1/4 the duct width.
4. Square Elbows: Square elbows shall be equipped with **double** thickness turning vanes with a 3/4" (19.1 mm) trailing edge preassembled on runners constructed per SMACNA Accepted Industry Practice for Industrial Duct Design.

D. Round Ductwork:

1. Spiral lockseam or longitudinal seam as manufactured by United McGill Sheet Metal Company. Models Uniseal, Unicoat, Unirib or Longitudinal Seam.
2. Minimum galvanized steel gauges (mm). The following is based upon SMACNA HVAC Duct Construction Standards - Metal and Flexible.

Positive Static Pressures from 0 to 2" w.g. (0 to +498.2Pa)

Diameter in. (mm)	Spiral Seam	Longitudinal Seam
3 to 8 (76.2-203.2)	28 (0.40)	28 (0.40)
9 to 14 (228.6-355.6)	28 (0.40)	26 (0.45)
15 to 26 (381-660.4)	26 (0.45)	24 (0.63)
27 to 36 (685.8-914.4)	24 (0.63)	22 (0.80)
37 to 50 (939.8-1270)	22 (0.80)	20 (1.00)
51 to 60 (1295.4-1524)	20 (1.00)	18 (1.25)
61 to 84 (1549.4-2133.6)	18 (1.25)	16 (1.60)

Positive Static Pressures from 2" to 10" w.g. (+ 498.2 to +2,498.2 Pa)

Diameter in. (mm)	Spiral Seam	Longitudinal Seam
3 to 14 (76.2-355.6)	26 (0.45)	24 (0.63)
15 to 26 (381-660.4)	24 (0.63)	22 (0.80)
27 to 36 (685.8-914.4)	22 (0.80)	20 (1.00)
37 to 50 (939.8-1270)	20 (1.00)	20 (1.00)
51 to 60 (1295.4-1524)	18 (1.25)	18 (1.25)
61 to 84 (1549.4-2133.6)	18 (1.25)	16 (1.60)

Negative Static Pressures from 0 to 2" w.g. (0 to -498.2 Pa)

Diameter in. (mm)	Spiral Seam	Longitudinal Seam
3 to 8 (76.2-203.2)	28 (0.40)	24 (0.63)
9 to 14 (228.6-355.6)	26 (0.45)	24 (0.63)
15 to 26 (381-660.4)	24 (0.63)	22 (0.80)
27 to 36 (685.8-914.4)	22 (0.80)	20 (1.00)
37 to 50 (939.8-1270)	20 (1.00)	18 (1.25)
51 to 60 (1271-1549)	18 (1.25)	16 (1.60)
61 to 84 (1549.4-2133.6)	16 (1.60)	14 (1.90)

When pressures listed on the drawings are greater than 10" (+2490.8 Pa) or less than 2" (498.2 Pa) negative static, conform to requirements in SMACNA HVAC Duct Construction Standards, Round Industrial Duct Construction Standards.

3. Elbows:

- a. Elbows for round ducts shall have a minimum center-line radius of 1-1/2 times the diameter of the duct **unless shown otherwise** and shall be constructed without splitters.
- b. Smooth or stamped elbows shall be used whenever possible.
- c. When gored elbows are used they shall be constructed as follows: Elbows up to 36° shall have 2 gores, 37° through 72° shall have 3 gores, and 73° through 90° shall have 5 gores.
- d. At the discretion of the SDR, adjustable elbows are permitted for systems rated at less than +4 in. w.g. (996.3 Pa). The gores shall be tack welded.

- E. Flat Oval Ductwork: Ductwork and fittings shall conform to the table shown below: Positive pressure applications only, up to 10" w.g. (2490.8 Pa). For negative pressure applications, submit special design and reinforcements required.

Major Dimension in. (mm)	Spiral Seam Duct	Longitudinal Seam Duct	Fittings
3 to 24 (76.2-609.6)	24 (0.63)	20 (1.00)	20 (1.00)
25 to 36 (635-914.4)	22 (0.80)	20 (1.00)	20 (1.00)
37 to 48 (939.8-1219.2)	22 (0.80)	18 (1.25)	18 (1.25)
49 to 60 (1244.6-1524)	20 (1.00)	18 (1.25)	18 (1.25)
61 to 70 (1549.4-1778)	20 (1.00)	16 (1.60)	16 (1.60)
71 & up (1803.4 & up)	18 (1.25)	16 (1.60)	16 (1.60)

2.03 DAMPERS

A. Labeling: Dampers shall bear identification labels. The labels shall be metal, plastic or mylar, and permanently marked with the following information:

1. Manufacturer's name.
2. Model number.
3. Date of manufacture.
4. Airflow direction.
5. Leakage classification and qualifying agency.
6. Maximum rated airflow and static pressure differential (cfm, in. w.g. and m³/s, Pa.)
7. Fire rating.
8. Electrical rating, if applicable.

B. Fire Dampers:

1. Dampers shall be stamped with an Underwriter's Laboratory (UL) label per UL 181 or UL 723, consistent with the fire rating of the partition in which they are installed. The dampers shall be curtain type and shall be equipped for vertical or horizontal installation as required by the installation location.
2. The fire damper's blades shall be retained in a recess such that the free area of connecting ductwork is not reduced.
3. Fire dampers shall be rated for a minimum of 1 1/2 hours and have a fusible link rated 50 °F (10 °C) above the maximum temperature of the system, but not less than 160 °F (74 °C).
4. Damper blades and casings shall be manufactured from 24 gage (0.70 mm) galvanized steel, have hinges with non-ferrous pins and spring catches to hold damper in the closed position.
5. Provide a hook on the fusible link, so that link can be easily removed to check damper for operation.
6. Rectangular ducts shall use Ruskin IBD2 style B, and round ducts shall use Ruskin IBD2 style CR, or Ruskin IBD2, style CO for oval duct.

C. Smoke Dampers:

1. Dampers shall be stamped with a UL label (181 or 723) consistent with Class II or Class I leakage.
2. Dampers shall withstand a minimum of 450 °F (232 °C) elevated temperature, for 30 minutes.
3. The damper blades shall be retained in a recess such that the free area of connecting ductwork is not reduced.
4. Dampers shall be manufactured from minimum 16 gage (1.61 mm) galvanized or stainless steel and have non-ferrous hinges.
5. Dampers shall be equipped with a side plate mounted electric or pneumatic operator.
6. Manufactured by Ruskin, model SD36.

D. Combination Fire/Smoke Dampers:

1. **Combination Fire/Smoke Dampers shall be installed at locations shown on the drawings and shall meet the requirements of NFPA 90A. Dampers shall be constructed, tested and stamped in accordance with UL555 and UL555S consistent with the fire rating of the partition in which they are installed.**
2. **Dampers shall be classified for “Dynamic Closure” to shutoff against airflow for a minimum of 2375 FPM and 4” w.g. for horizontal or vertical flow. Each damper shall bear a UL stamp be marked with the UL hour classification, flow direction, and maximum pressure and velocity and “for use in dynamic systems”.**
3. **Dampers shall be supplied with a factory-mounted actuator. Single piece airfoil damper blades for rectangular dampers. Leakage Class I and temperature rated to withstand temperature to 450^oF.**
4. **Fire dampers shall be rated for a minimum of 1 ½ hours and have a fusible link rated 50^oF above the maximum temperature of the system, but not less than 160^oF.**
5. **Provide a hook on the fusible link, so the link can be easily removed to check damper for operation.**
6. **Each damper shall be shipped with the manufactures UL installation instructions and the dampers shall be installed in accordance with these instructions.**

E. Outside Air Dampers:

Dampers shall be low-leakage type; 6063 T5 heavy gage aluminum blades and frame; extruded vinyl seals. Manufactured by Ruskin; model CD-50.

F. Balancing Dampers:

1. Dampers may be vendor purchased or contractor fabricated.

2. Rectangular dampers with either width or height dimension less than 24" (609.6 mm):
 - a. Dampers shall be opposed blade type.
 - b. Duct frame shall be reinforced casing angle.
 - c. Blade, single thickness 16 gauge (1.61 mm) minimum, galvanized steel or 316 stainless steel, welded or bolted to shaft.
 - d. Continuous through shaft, 3/8" (9.53 mm) diameter minimum.
 - e. Brass or steel bearings, pressed into frame and designed for dynamic requirements.
 - f. End of shaft shall be permanently marked to indicate blade position.
 - g. Locking quadrant mounted on outside of frame.
3. Rectangular dampers with both width and height dimensions greater than 24" (609.6 mm):
 - a. Frame, 5" x 1" x 16 gauge (127 x 25.4 x 1.61 mm) galvanized or stainless steel channel.
 - b. Blades, 8" (203.2 mm) maximum width, 16 gauge (1.61 mm) galvanized or stainless steel, opposed blade.
 - c. Shafts/bearings, designed to meet dynamic requirements. Blades positively locked to shafts.
 - d. Control shaft 1/2" (12.7) square, galvanized or stainless steel, permanently marked to indicate blade position.
 - e. Locking quadrant mounted on outside of frame.
4. Round dampers up to 24" (609.6 mm) diameter:
 - a. Shall be butterfly type.
 - b. Frame, 18 gauge (1.31 mm) galvanized or stainless steel, or duct casing reinforced as required.
 - c. Blade, single thickness 16 gauge (1.61 mm) galvanized or stainless steel, welded or permanently bolted to shaft.
 - d. Continuous through shaft 3/8" (9.53 mm) diameter minimum.
 - e. Brass or steel bearings pressed into frame and designed for dynamic requirements.
 - f. End of shaft permanently marked to indicate blade position.
 - g. Locking quadrant mounted on outside of frame.

2.04 HANGERS AND SUPPORTS

A. General:

1. Straps and angles shall be manufactured from galvanized steel; rods shall be manufactured from uncoated or galvanized steel.
2. Perforated iron band for duct support is prohibited.
3. Stainless steel ductwork shall be provided with stainless steel support materials.

B. Horizontal Ducts:

1. Refer to SMACNA Duct Construction Standards - Metal and Flexible Table 4-1 and 4-2 respectively for rectangular and round ductwork minimum hanger size and spacing.
2. Trapeze Supports: Maximum spacing is 6 ft. (1.83 m) on center. Refer to SMACNA Duct Construction Standards - Metal and Flexible for size and load requirements.

C. Vertical Ducts: Support and reinforcements for vertical duct riser supports from floor or wall shall comply with SMACNA's HVAC Duct Construction Standards - Metal and Flexible Figure 4-6 and 4-7.

D. Building Attachments: Shall be concrete inserts, powder actuated fasteners or structural steel fasteners compatible with building materials. Do not use powder actuated fasteners for concrete slabs less than 4 inches (101.6 mm) thick. **Attachment in MicroFab to concrete waffle slab not permitted. Attach to overhead column to column steel instead.**

E. **For the MicroLab and WIF, all duct hangers supported from a waffle slab shall have spring isolations that isolate it from the waffle slab.**

2.05 SEALANTS

General: All sealants shall conform to Standard Specification "Sealants". See Section 3.03.D. "Sealing Ductwork".

A. Self-adhering vinyl coated fabric duct tape is not permitted, except to temporarily seal the duct openings for contamination prevention.

B. Outdoor Ducts:

1. Ductwork Exterior:

- a. Neoprene based, phenolic mastic: 24 hour cure time, UV resistant, operational temperature range of -20 to +300 °F (-29 to 149 °C.), manufactured by United McGill, type Uni-Weather.
- b. Two step tape sealing: Tape is of a woven fiber impregnated with a gypsum mineral compound. Coating is a modified acrylic/silicone activator that reacts exothermically with tape, to form a hard, durable, airtight, UL (723) classified,

UV resistant seal, with a 24 to 48 hour cure time. Manufactured by United-McGill, MDTx-300 Tapes with MTC-50 Coating.

2. **Liner Adhesive:** Non-oxidizing, vinyl acrylic, water-based adhesive used to bond insulation to sheet metal surfaces. Operational temperature range -20 to +160°F (-29 to 71 °C); curing time 24 hours. Manufactured by United McGill, type Uni-Tack.

C. Indoor Ducts:

1. **Ductwork:** Water based, vinyl acrylic polymeric sealant; nonflammable; fire retardant; operational temperature range of -25 to 110 °F (-32 to 43 °C); 48 hour cure time. Manufactured by United McGill, type Uni-Grip.
2. **Ductwork:** Two step tape sealing. Tape is of a woven fiber impregnated with a gypsum mineral compound. Coating is a modified acrylic/silicone activator that reacts exothermically with tape to form a hard, durable, airtight seal, UL classified, with a 24 to 48 hour cure time. Manufactured by United-McGill, MDTx-300 Tapes with MTA-20 Adhesive.
3. **Liner Adhesive:** Non-oxidizing, vinyl acrylic, water-based adhesive used to bond insulation to sheet metal surfaces. Operational temperature range -20 to +160°F (-29 to +71 °C); curing time 24 hours. Manufactured by United McGill, type Uni-Tack.

D. Fire Stopping: Seal ductwork penetrations to halt the spread of fire, water and smoke through fire walls and floors and as indicated on contract drawings with fire resistant sealant. Maximum allowable flame spread, as tested by ASTM E814, is 25 with a smoke-developed rating no higher than 50. Fire stopping materials shall be of the following types:

1. Two-part, foamed in place fire stop sealant shall be of fire resistant silicone. Manufactured by Dow Corning, type "Fire Stop Foam" or General Electric, type "Pensil 851."
2. One-part, elastomeric fire resistant sealant. Manufactured by Dow Corning, "Fire Stop Sealant," or "Fire Barrier Caulk G-25," manufactured by the 3M Company.

2.06 ACCESS DOORS

- A. Access doors shall comply with NFPA 80.
- B. Duct Access Door shall be factory fabricated 22 gage (0.85 mm), galvanized steel, double skin, insulated and a minimum 18" x 14" (457.2 mm x 355.6 mm), unless directed otherwise by the SDR. Door shall conform to SMACNA HVAC Duct Construction Standards. Manufactured by Ruskin, Model No. AHWCW or ADHW; or Ductmate, Model "Sandwich".
- C. Plenum Access Door shall be 20 gage (1.01 mm) outer skin, galvanized steel, 22 gage (0.85 mm) perforated inner liner, hinged insulated (2 inch or 50.8 mm minimum.) Plenums larger than 24" x 24" (609.6 x 609.6 mm) shall be equipped with a door containing an observation window. Manufactured by United McGill, model SL.

- D. Labeling: Access doors shall bear identification labels. The labels shall be metal, mylar or plastic and permanently marked with the following information:
1. PCC designation and air handler.
 2. Leakage classification and qualifying agency.
 3. Signs should be marked: "Caution: Negative Pressure" or "Caution: Positive Pressure."

2.07 LOUVERS

A. Construction:

Louvers shall have the maximum free area (minimum 50% of nominal size) and minimum pressure drop for each type as listed on the drawing louver schedule and shall be manufactured from 6063-T6 aluminum, or 18 gage (1.31 mm) galvanized steel and finished with Kynar. Slats shall be inclined at least 45 degrees from the horizontal and overlap a minimum of 1 inch (25.4 mm.) Slats over 48 inches (1.2 m) shall have intermediate supports. An integral rain channel shall be formed with the slats. Louvers shall be compatible with the adjacent substrate.

- B. Manufacturer: Louvers shall be of standard manufacture by one of the following companies:

Ruskin Mfg. Co.
Airline Products Co.
Industrial Louvers, Inc.
Louvers and Dampers, Inc.

2.08 FILTERS

- A. Replaceable Panel Filters: Provide factory fabricated, flat panel type replaceable air filters with holding frames, at ratings and in sizes indicated. Media material to be 1, 2 or 4 inch (25.4, 50.8 or 101.6 mm) thick and be UL class 2 rated. Construct filters of lofted, reinforced cotton/synthetic blend media, spray with non-flammable adhesive, frame in throwaway fiberboard casings, and sandwich between perforated metal grilles. Construct ductwork holding frames of 20 ga. (1.01 mm) galvanized steel, capable of holding media and media frame in place, and gasketed to prevent unfiltered air by-passing between media frames and holding members. Provide filters with rated face velocity of 498.2 fpm (2540 mm/s), initial resistance no greater than 0.30" w.g. (74.7 Pa), final rated resistance of 0.50" w.g. (124.5 Pa.). Manufactured by EcoAir, model E35S or E35SH.
- B. High Efficiency Particulate Air (HEPA) Filters: Provide factory fabricated HEPA filters with holding casing; where shown, in sizes indicated on drawings. Provide glass fiber media, rated UL class 1, with dustpot efficiency of not less than 99.97%, when tested with 0.3 micron particles. Static pressure drop not to exceed 1.0" w.g. (249.1 Pa), when clean and operating at rated capacity. Equip filters with neoprene gaskets and construct media of continuous sheets with closely spaced pleats separated by corrugated aluminum inserts. Construct holding casing of 18 ga. (1.31 mm) galvanized steel, complete with gaskets and holding latches, and capable of being bolted together or held together with retainers to form filter bank with airtight joints. Construct downstream corners of holding device with cushion pads to protect media. Provide filters 11 1/2" (292.1 mm) deep with

rated face velocity of 250 fpm (1270 cm/s), initial operating resistance of 1.0" w.g. (249.1 Pa.) Manufactured by Cambridge. (**MicroFab see specification 15869-S for ceiling mounted filters and 15766-S for fan filter units**).

- C. Activated Carbon Filters: Provide factory fabricated activated carbon filters with housings; where shown, in sizes and ratings indicated on the drawings. Construct housing of 16 ga. (1.61 mm) galvanized steel designed for servicing through gasketed access doors on both sides. Equip housings with lightweight trays containing activated carbon on metal slide channel tracks. Construct separately removable carbon cell trays of 26 ga. (0.55 mm) epoxy coated perforated steel and steel framing. Construct carbon cell holding frames of 14 ga. (1.99 mm) epoxy coated steel; seal each unit to prevent unfiltered air by-pass. Construct units with capacity of not less than 45 pounds (20.4 kg) of activated carbon per 1000 cfm (0.47 m³/s) of airflow. Provide filters with rated face velocity of 500 fpm (2540 mm/s), and resistance of 0.35" w.g. (87.2 Pa.)
- D. Extended Surface Self-supporting Filters: Provide factory fabricated, dry, extended surface self-supporting filters with holding frames, in sizes and at locations indicated. Equip with UL Class 1 fibrous media material constructed so that individual pleats are maintained in tapered form by flexible internal supports under rated air flow conditions. Construct holding frames of 18 ga. (1.31 mm) galvanized steel and provide suitable fasteners and gasketing to hold filter units and to prevent unfiltered air passing between media frames and holding devices. Design holding frames which are suitable for bolting together into built-up filter banks. Provide filters with rated face velocity of 500 fpm (2540 mm/s), initial resistance of 0.25" w.g. (62.3 Pa), with a dustpot efficiency of 60-65%; 0.40" w.g. (99.6 Pa) at 80-85% efficiency; or 0.70" w.g. (174.4 Pa) at 90-95% efficiency.
- E. Pre-Filters: Provide factory fabricated pleated prefilters on HEPA installation. Nominal size of 20 x 20 x 2 inch (508.0 x 508.0 x 508.0 mm), unless otherwise indicated on the drawings. Initial resistance of 0.15" w.g. (37.4 Pa) at 1000 cfm (0.47 m³/s.) Efficiency of 36.5%, as manufactured by Farr.

2.09 FILTER GAUGES

Filter gauge: Inclined tube differential type; range 0-4 inches (0-101.6 mm); accuracy +/- 1% of full scale; complete with 1/4" (6.35 mm) tubing, static pressure tips, red gage oil, and mounting hardware; as manufactured by Dwyer Co.; model no. 350.AF.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Ductwork installation shall not proceed, until representatives from the other contracting trades have been consulted to ensure that there are no layout or installation conflicts, unless otherwise directed by the SDR.
- B. Structural conditions of the building may indicate that modifications to the ductwork are necessary. Dimensions on drawings indicate free inside area. Actual duct dimensions may need to be altered for insulation allowance when required. Ducts shall be transitioned or divided as may be required; whenever this is necessary, the equivalent area shall be maintained. Such corrections shall be approved and directed by the SDR, before modifications are started.
- C. Exit passageways, stairs, ramps and other exits shall not be used as a part of the air return, supply or exhaust.
- D. Installation and workmanship shall be such that the system is free from buckling, warping, breathing (oil canning), and vibration. Installation must conform to the requirements set forth in NFPA 90A and 90B.

3.02 PREPARATION

Open ends of ducts shall be covered and sealed with duct tape during installation to prevent debris from contaminating system.

3.03 INSTALLATION

A. Flexible Ducts:

1. Provide flexible duct in fully extended condition, free from sags and kinks.
2. Use only the minimum length required to make the connection.
3. Do not exceed 5'-0" (1.52 m) in length, fully extended. (**MicroFab 8'-0"**).
4. Where horizontal support is required, provide at least 3/4" (19.0 mm) wide banding material hangers at not more than 18" (457.2 mm) centers.
5. Make joints and connections with 1/2" (12.7 mm) wide positive locking steel, nylon or plenum rated straps.
6. Use insulated flex where insulated duct is required.

B. Metal Ductwork:

1. Install with a minimum of 4" (101.6 mm) separation from earth.

2. Duct in concrete slabs shall be round and encased in at least 2" (50.8 mm) of concrete.
 3. Securely fasten at each change in direction **and seismically restrain per Specification 13085-S.**
- C. Insulation: Shall be installed as detailed in Standard Specification Division 15, Section "Insulation." The insulation, facings, tapes and adhesives applied to the exterior surfaces of ducts located within the buildings shall have a composite flame spread of 25 or less and a smoke developed rating of 50 or less.
- D. Sealing Ductwork:
1. 0"-2" w.g. (0-498.2 Pa) classification: Transverse joints shall be sealed as per SMACNA guidelines for Seal Class C. Joints shall be taped or caulked after installation to prevent air leakage. Contractor shall also reference Section 2.05-Sealants.
 2. Greater than 2" w.g. (498.2 Pa) classification: Joints, seams and penetrations shall be sealed as per SMACNA guidelines for Seal Class A. The shop procedure for sealing ducts shall be equivalent to the following: before fittings and joints are assembled, duct adhesive shall be applied, using a pump-type oil can, to rivets, grooved seams, and tap-off collars on the internal side of the metal. Pittsburgh lock pocket shall be flooded with adhesive, using pump-type oil can, and the duct assembled. Duct adhesive shall be brushed around reinforcing corners, rivets, notches and tap-off collars after duct is assembled then taped and sealer brushed completely over tape. Where joints are not accessible for proper sealing, hand holes should be cut in the duct and joints sealed from the inside. Fabricate hand hole covers and cover the holes with insulation. Special care shall be taken to seal all duct corners.
 3. Exterior Ductwork: Ductwork exposed to weather shall have all seams soldered. Where it is determined to be impractical by both the Contractor and the Sandia Delegated Representative (SDR), use the **two step taping system** specified in **Section 2.05-Sealants.**
 4. Stainless steel exhaust ductwork: Joints to be continuously welded.

3.04 HANGERS AND SUPPORTS

- A. Do not attach hangers to roof decking. No cutting or drilling of structural steel will be allowed.
- B. Hangers shall be installed plumb and shall present a neat appearance.
- C. Strap hangers shall extend the full depth of the duct, bend and extend 2 inches (50.8 mm) under and against the bottom of the duct.
- D. Attach hangers to the ducts using rivets or screws of appropriate sizes 6 inches (152.4 mm) on center (minimum of 2 each side) and on the bottom return.
- E. All ducts shall be rigidly supported.

1. Where vertical ducts pass through floors or roofs, supporting angles shall be attached to ducts and to the structure.
 2. Place supporting angles on at least two sides of the duct.
- F. Reference Section 2.04 for Hangers and Supports construction and spacing data.

3.05 CONNECTORS

Provide flexible connections, not less than 4 inches (101.6 mm) wide, constructed of approved fireproof, waterproof, non-asbestos, woven fabric or glass fabric, at the inlet and outlet connection of each fan unit, securely fastened to the unit and to the ductwork by a galvanized iron band provided with tightening screws. This connection shall be UL listed, minimum 30 oz. (850 gm) size. There shall be no metal to metal contact at flexible connections. There shall be no stretching of the flexible material at flexible connections.

3.06 DAMPERS

A. Fire and Smoke Dampers:

1. Dampers shall be installed in a sheet-metal collar which shall be reinforced with angle-iron frames. Dampers shall be installed according to SMACNA Fire, Smoke and Radiation Damper Installation for HVAC Systems.
2. Duct weight and the construction of these dampers shall be made to comply with the standards of the NFPA.
3. Provide access doors at all fire damper locations. Access doors shall be located so that the spring catch is accessible when the damper is closed.
4. Fire dampers shall be supported independent of ductwork in the ceiling, wall or floor, as conditions at the site dictate.
5. Fire dampers shall not be installed in exhaust systems.

B. Balancing Dampers: Shall be installed where shown on drawings and as may be required to balance system.

C. Duct Connectors: Ducts shall be connected to fire and smoke dampers with slip joints so that the damper will remain within the fire barrier, even if the duct should collapse.

3.07 ACCESS DOORS

A. Duct Access Doors: Provide in locations indicated on drawings and as required to properly and easily service, maintain, and inspect duct coils, fire dampers and other equipment.

B. Plenum Access Doors:

1. Doors shall be provided with a flat iron or angle iron stiffening frame and so constructed that they can be operated without twisting or distorting.

2. The opening at each door shall be provided with a continuous reinforcing galvanized bar or angle against which the door will close, and be provided with a sponge rubber gasket to make the door opening airtight.
3. Walk through type doors at plenum chambers shall be provided with piano hinges.

3.08 PLENUMS

- A. Panels shall be assembled by interlocking the flanged end with the double standing seam and bolting on 18" (457.2 mm) centers. Seams shall project into the air side of the apparatus casings. Sealer shall be poured into, or plenum tape wrapped around the double seam prior to assembly. Joint shall be assembled immediately after sealer

is applied. Paint outside of seam with sealer and allow 24 hours to dry before applying air pressure.

- B. Panels shall be braced rigidly in place by 1-1/2" x 1-1/2" x 1/8" (38.1 x 38.1 x 3.2 mm) angles spaced on 4'-0" (1.2m) centers maximum and run continuous for the full length or width of the casings.
- C. Casings shall be secured to concrete curbs on floors, or walls by a 2" x 2" x 3/16" (50.8 x 50.8 x 4.8 mm) toe angle, gasketed between the casing and the toe angle and gasketed or grouted between the toe angle and the floor. The toe angles shall be secured to the floor or wall by 1/4" (6.35 mm) bolts 1' -0" (304.8 mm) o.c., shot into the floor or the wall or 1/4" (6.35 mm) "J" bolts set in concrete 1'-0" (304.8 mm) o.c., through the flange angles of the panels. The toe angles shall run continuously for the full length of the casing in contact with the floor or wall. Seal joints airtight with sealer.
- D. Rivets and bolts through the casing shall be gasketed.
- E. Casings shall be constructed according to SMACNA HVAC Duct Construction Standards - Metal and Flexible.

3.09 DUCT PENETRATIONS

- A. Ducts through masonry openings and along edges of all plenums at floors and walls, shall be provided with a continuous 2" x 2" x 1/8" (50.8 x 50.8 x 3.2 mm) galvanized angle iron which shall be bolted to the construction and made airtight to the same by applying silicone caulking compound. Sheet metal at these locations shall be bolted to the angle irons.
- B. Ducts through drywall or plaster walls and ceilings shall be finished with a 22 gage (0.85 mm) galvanized steel flange neatly installed.

3.10 LOUVERS

Install storm louvers at air openings in the outside walls where indicated on the drawings. The exterior face of the louver shall have a flange all around, neatly fitted to the building wall, flashed

at top and all sides caulked. On the outside face of each louver, install a removable screen, consisting of 1/2" (12.7 mm) mesh, galvanized wire screen in a galvanized channel frame.

3.11 FILTERS AND GAUGES

- A. Filters: Furnish and install filters as scheduled on the drawings. Follow manufacturer's directions for installing each type of filter. The filters shall be installed such that there will be no leakage around the filter banks. Filters in frame holders shall be provided with lift handles. Hinged access panels or doors shall be installed for convenient access to each filter section. Filter retainer frames shall be arranged to provide proper support to facilitate each filter fitting tightly in place with provision to seal properly. Provide reinforcement as required such that there is no more than two inches (50.8 mm) of deflection across the filter rack during operation. The filters shall be clean when the job is complete. Furnish new clean filters for the first stage filters in each bank (one extra set per system). Filters banks shall be located in a convenient and accessible place, so that it can be serviced without the use of a stepladder. If this is impractical, install a permanent ladder or scaffolding for ease of service.
- B. Filter gauges: Furnish and install gauges for the measurement of air flow resistance through the filters at each bank of filters. Furnish each gauge with two 3-way ball valves for venting and gauge adjustment.

3.12 INSPECTION AND TESTING

- A. The Contractor shall be responsible for providing a joint and cooperative effort to coordinate the test and balance as specified in Standard Specification "System Component Checkout and Balance."
- B. Pre-Inspection: The SDR shall examine areas and conditions under which ductwork will be installed. Work shall not proceed until conditions are acceptable to the SDR.
- C. Inspection: SDR shall ensure that filters, dampers, louvers, gauges, electrical components and other accessories referenced in this document are installed correctly and system is operating in compliance with requirements.
- D. Testing: Ductwork rated 4" w.g. (996.3 Pa) and higher, laboratory exhaust ducts and ductwork indicated on the contract documents shall be tested for leaks. Testing is not required for other ductwork rated 0 to 3 " w.g. (0-747.3 Pa.)
 - 1. Test Holes: Drill test holes in ductwork at locations indicated on the drawings or as indicated by the SDR. Low velocity systems shall be provided with rubber stoppers. High velocity systems with shall be provided with a screwed plug, with plug hole filled with the surrounding insulation. **Do not drill holes in coated stainless steel ductwork.**
 - 2. Testing shall be done following guidelines in SMACNA-HVAC Systems - Testing, Adjusting and Balancing or ASTM E477, as directed by the SDR.
 - 3. SNL fire protection engineering shall perform a test to ensure that ductwork meets fire and smoke spread requirements.

3.13 CLEANING

Ductwork shall be cleaned as it is being installed, to remove oil film and dust allowing sealants, such as silicone caulk, to cure before duct is cleaned and sealed.

END OF SECTION