FMOC

Specification Section 15810 Ductwork

January 14, 2013

Revision 0

SAND

This document has undergone formal review and approval and been reviewed by a Derivative Classifier, and its contents have been deemed unclassified/unlimited release.

Sandia National Laboratories

U.S. DEPARTMENT OF ENERGY

National Nuclear Security Administration

Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

Change Log

Rev	By	Date	Type	Change Description	Pages Changed
0	JG/LEO	01/14/13	Subst	Edited and applied FMOC standard spec brand.	All

CONSTRUCTIONSTANDARD SPECIFICATION

SECTION 15810

DUCTWORK

Page

CONSTRUCTION STANDARD SPECIFICATION
SECTION 15810
DUCTWORK

PART 1 - GENERAL

1.01 SUMMARY

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 (HVAC) and exhaust for pressure classes from minus 10" to plus 10" water gauge (w.g.). Operations include the specification of ductwork materials, gauges, pressure classifications, construction, duct liners, filters, dampers, connectors, supports, testing, and certifications. This specification does not include ductwork requirements for materials handling systems. The materials, products, accessories, and methods listed in this specification shall be followed unless noted otherwise on the drawings. All work performed under this specification shall conform to section 15050, *Basic Mechanical Materials and Methods*.

1.02 REFERENCES

A. The latest edition of the following codes and standards shall be used. Where differences between standards and this specification exist, this specification shall take precedence. Where standards allow for the use of alternate materials and methods, the contractor shall submit for approval, a request to use alternate materials and methods before beginning work.

B. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA)

HVAC Duct Construction Standards–Metal and Flexible
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
HVAC Air Duct Leakage Test Manual

C. National Fire Protection Association® (NFPA)

80	Standard for Fire Doors and Windows
90A	Standard for Installation of Air-Conditioning and Ventilation Systems
90B	Standard for Installation of Warm Air Heating and Air-Conditioning Systems
255	Building Materials, Test of Burning Characteristics Standard Method of Test of Surface Burning Characteristics of Building Materials (same as ASTM E84)

D. 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
A653	Standard Specification for Steel Sheet, Zinc Coated (Galvanized) or Zinc-Iron Alloy-Coated by the Hot Dip Process
C916	Standard Specification for Adhesives for Duct Thermal Insulation
C1071	Standard Specification for Fibrous Glass Duct Lining Insulation
E84	Standard Test Method for Surface Burning Characteristics of Building Materials
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

E. American Welding Society (AWS)

B2.2	Brazing Procedures and Performance Qualifications
D9.1	Sheet Metal Welding Code

F. Underwriter's Laboratories (UL)

181	Factory Made Air Ducts and Air Connectors
555	Standard for Safety Fire Dampers
555S	Leakage Rated Dampers for Use in Smoke Control Systems
723	Test for Surface Burning Characteristics of Burning Materials (ASTM E84)
94VO	Flammability of Plastic Materials

G. North American Insulation Manufacturers Association (NAIMA)

AH124	Fibrous Glass Duct Liner Standard

1.03 SUBMITTALS

General: Manufacturers, products, and 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 section 01330, *Submittal Procedures*.

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. Firewall duct penetrations, fire and smoke dampers, louvers, and access doors.

B. Submit Material Safety Data Sheets on sealants and adhesives.

C. Submit changes or alterations in ductwork layout, with supporting calculations showing the modified design will not increase total pressure before work commences. Submittals for proposed changes shall be stamped for approval prior to commencement of work.

D. Submit control-wiring diagrams for automatic dampers and other automated ductwork accessories.

E. Duct Coordination Drawings (Duct Shop Drawings): When required on the Descriptive Submittal List, the contractor shall submit ¼" or ⅛" scale plan drawings of duct work layout with overlays of other major systems, structures, and equipment that could interfere with the routing of the ductwork. Include reflected ceiling layout, ceiling and wall mounted access doors and panels required to provide access to dampers and other operating devices, and ceiling mounted items including light fixtures, diffusers, grills, speakers, and sprinklers. Include elevation sections through congested areas. Base input on information from installers of items involved and when possible, field verify obstacles to the duct layout.

F. Ductwork Reinforcement Information: When required by the Descriptive Submittal List or requested by the Sandia Construction Observer, submit information on the duct reinforcement to be used for each section of duct. Information shall include copies of tables from SMACNA construction standards highlighting the actual duct sizes, pressure class, material, gauge, reinforcement type and spacing, joint type and spacing, applied loads, and hanger type and spacing. When alternated methods of sizing are used as provided by SMACNA, provide calculations to support the reinforcement selection.

G. Alternative Materials and Methods: Proposed deviations of materials and methods from these specifications require approved submittal information prior to any construction. Submittals should clearly note the submittals are for a change to the specifications and identify the applicable paragraph from this specification. Submittals shall include physical descriptions and results of testing and analysis to

support the equal performance of the substituted items. Testing and analysis shall follow the guidelines for *Functional Criteria* from the SMACNA standards.

1.04 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 D9.1, *Sheet Metal Welding Code*.

E. Attachments such as conduit and pipe to ductwork are not permitted.

1.05 WARRANTY

A. 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 of lock form quality per ASTM A653 with a G90 zinc coating (0.90 ounce [oz.]/feet [ft.]^2 both sides), unless otherwise shown on the contract documents. Sheets shall be free of pits, blisters, slivers, and ungalvanized spots.

B. Polyvinyl Chloride (PVC) Coated Rigid Ducts, Casings and Fittings: Shall be made from galvanized steel sheets of lock form quality per ASTM A653 with a G60 zinc coating (0.60 oz./ft.^{2} both sides), unless otherwise shown on the contract documents. Provide with factory applied 4-mil PVC coating on exposed surfaces (exterior of duct for underground applications and interior of ducts and fittings for fume handling) and 2-mil coating on opposing sides of ductwork. Ductwork shall be UL-181, Class 1 listed.

C. Stainless Ductwork: Unless noted otherwise on the drawings, stainless steel ductwork shall be Type 316L steel sheet per ASTM A480 and ASTM A240 with a finished surfaced No. 4 for exposed locations, and No. 2B for concealed locations.

Stainless steel ductwork shall be of the spiral lockseam type with factory fabricated fittings.

D. Stainless Steel (Teflon®) Coated Ductwork: Base metal shall be AISI 300 series stainless steel, constructed to a duct gauge and reinforcing system in accordance with *SMACNA Round Industrial Duct Construction Standards* with a Class 1, -6" w.g. schedule. Longitudinal seams shall be fusion welded. Transverse seams shall be butt welded; no dissimilar filler materials allowed. The coating shall be a Teflon fluoropolymer barrier thermoplastic resin with an average thickness not to exceed 12 mils. Acceptable manufacturer is PermaShield Pipe® or equivalent.

E. Supports: Angle iron, channels, saddles, band straps, rods, and related supporting materials shall be galvanized or red oxide coated.

F. Fasteners: Use galvanized rivets, screws and bolts throughout, except on stainless steel ductwork. Use stainless steel fasteners.

G. Reinforcement: Provide galvanized steel or stainless steel reinforcement shapes and plates where required.

H. Tie Rods: Use galvanized steel, ¼" minimum diameter fasteners for ductwork 36" or less in length. Use ⅜" minimum diameter for lengths longer than 36".

I. Flexible Duct–Supply and Return Air (Insulated, Low Pressure): Duct to be a factory fabricated assembly with a laminated inner liner of aluminum foil, fiberglass and polyester, a galvanized steel helix coil formed to the inner liner, a fiberglass insulation blanket, and a polyethylene outer jacket. Flexible duct shall be rated for 10.0" w.g. positive pressure, 5.0" w.g. negative pressure through 16" diameter, 5500 feet per minute (FPM) velocity, -20° to 250°F operating temperature, 0.1 perm rating, and have a maximum thermal conductance of 0.16 British thermal unit (BTU)/Hour (Hr.) $ft.^2$ °F (R-6.0). Flexible duct shall have a flame resistant rating of 25 or less and a smoke developed rating of 50 or less. Flexible duct shall be tested in accordance with UL 181 and listed and labeled as Class 0 or Class 1. Flexmaster Type 5 or equal.

J. Flexible Duct–Supply and Return Air (Insulated, High Pressure): Duct to be a factory fabricated assembly with a laminated inner liner of aluminum foil, fiberglass and polyester, a galvanized steel helix coil formed to the inner liner, a fiberglass insulation blanket, and a polyethylene outer jacket. Flexible duct shall be rated for 20.0" w.g. positive pressure, 5.0" w.g. negative pressure through 16" diameter, 5500 FPM velocity, -20° to 250°F operating temperature, 0.1 perm rating, and have a maximum thermal conductance of 0.16 BTU/Hr. ft^2 °F (R-6.0). Flexible duct shall have a flame resistant rating of 25 or less and a smoke developed rating of 50 or less. Flexible duct shall be tested in accordance with UL 181 and listed and labeled as Class 0 or Class 1. Flexmaster Type 3 or equal.

K. Flexible Duct–Lab Exhaust Systems: Ductwork to be a factory fabricated assembly of neoprene-coated polyester with galvanized steel helix reinforcement. Flexible

duct shall be rated for a minimum of 48.0" w.g. positive pressure, 16.0" w.g. negative pressure, 5500 FPM velocity, -65° to 250°F. Flexible duct shall be a UL94V0 approved material. Novaflex Model U-LOK 200 or equal.

L. Mechanical Liner and Fasteners:

1. Liners: Internal duct liners shall be 1" thick fiberglass, Type I or II per ASTM C1071, and have a thermal conductivity (k-value) of 0.26 at 75°F. Liners shall comply with NFPA 90A and 90B and with NAIMA AH124 and have a maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E84. Liners shall be treated with an U.S. Environmental Protection Agency approved biocide to resist bacterial and fungal growth. All surfaces exposed to the air stream shall be coated to prevent erosion of glass fibers.

2. Mechanical Fasteners: Galvanized steel, suitable for adhesive, mechanical or welding attachment (self-stick, adhesive fasteners are not permitted). 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 tensile dead load perpendicular to duct wall.

3. Liner Adhesive: Non-oxidizing, vinyl acrylic, water-based adhesive used to bond insulation to sheet metal surfaces. Operational temperature ranges from -20° to +160°F; curing time 24 hours. Manufactured by United McGill, type Uni-Tack. Comply with NFPA 90A and 90B and with ASTM C916.

2.02 DESIGN AND CONSTRUCTION

A. General:

1. Construct all ducts, casings and fittings of rigid, galvanized steel, unless otherwise shown in the contract documents.

2. Contractor is responsible for coordination between the ductwork trade and the other mechanical, electrical, and architectural trades.

3. Insulation shall be as specified in section 15081, *Duct Insulation*.

4. Install internal duct liners on ducts indicated to have liners on the construction drawings. Install liners per NAIMA duct liner guidelines.

B. Ductwork Pressure Classification

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

1. Ductwork from the supply air fan to the terminal velocity reduction device ([Variable Air Volume]VAV box) or zone-tempering coil shall be fabricated to

the higher pressure of either 4" w.g. internal pressure, or pressure classification called out by the designer on the contract documents.

2. Ductwork from downstream of terminal velocity reduction device (VAV box) or zone tempering coil shall be fabricated to meet minimum 1" w.g. internal pressure.
3. Return air ductwork shall be fabricated to meet minimum 1" w.g. internal pressure.
4. Lab exhaust ductwork shall be fabricated to meet the lower of either 4" w.g. negative pressure, or the exhaust fan pressure at shutoff.
5. Restroom exhaust and general exhaust ductwork shall be fabricated to meet the lower of either 2" w.g. negative pressure, or the exhaust fan pressure at shutoff.
6. Acid resistant ductwork (Teflon coated) shall be fabricated to meet the higher pressure of either 4" w.g. "negative 6" w.g or pressure classification called out by the designer on the contract documents.

C. Plenums:

1. Main air handling (equipment) plenum walls, doors, and roof shall be factory built as follows: 18 gauge galvanized steel minimum, double-wall construction (perforated inner walls), 4" acoustical insulated casing (top and sides) to provide a "U"-value of 0.06 BTU/Hr. ft.^{2} $^\circ$F, hinged access doors with 90° latching handles to all compartments (double-wall insulated doors with air-tight sealing gaskets). All access compartments shall have service lights. Doors shall be provided with 12"x12" double pane, hermetically sealed observation windows of tempered or tempered wire glass. 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 steel acoustic panels sandwiching 4" minimum thickness, 1.5 pound (lb.)/ cubic feet (cu. ft.) rigid fiberglass insulation, reinforced to be rigid under all operating conditions.
2. All other plenums shall be factory or site built of 16 gauge galvanized metal panels. Maximum width of panel shall be 21". One end of panel shall be flanged 1" and opposite end formed with 1" double standing seam.

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

1. Addendum No. 1 (November 1997) covering Midpanel Tie Rod use shall not be used.
2. Construct ducts using Pittsburgh Lock or Double Corner seams, except Snap Lock seams may be used for pressure classes of 2" or less.
3. Cross-Breaking:

a. Sheet metal ducts and fittings over 19" wide be beaded, cross-broken, or otherwise stiffened, to eliminate oil canning or vibration.
b. Vertical and horizontal sheet metal barriers, duct offsets, and elbows 19" wide or larger shall be cross-broken.
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.

4. Radius Elbows: Radius elbows with a rectangular cross section shall have a centerline radius of not less than the width of the duct or shall be furnished with single thickness splitter vanes. A single splitter vane shall be used for elbows with a ratio of inside radius to duct width of 0.5 to 0.2. Two splitter vanes shall be used for ratios less than 0.20.

5. Square Elbows: Square elbows shall be equipped with either single or double thickness turning vanes, with a radius of 4.5", and a separation of 3.25", pre-assembled on runners constructed per SMACNA Accepted Industry Practice for Industrial Duct Design. Vanes shall be securely attached to the runners. Vanes shall be welded to the runners in systems with pressures greater than 6" w.g. or velocities greater than 3000 FPM. The maximum unsupported length of vanes shall be 36".

E. Round Ductwork:

1. Spiral lockseam or longitudinal welded seam as manufactured by United McGill Sheet Metal Company. Models Uniseal, Unicoat, Longitudinal Seam or equivalent.

2. Minimum galvanized steel or stainless steel gauges, hanger spacing, and reinforcement shall be per SMACNA HVAC Duct Construction Standards–Metal and Flexible for pressures from negative 4" w.g. up to positive 10" w.g. For pressures less than negative 4" w.g., or greater than positive 10" w.g., minimum galvanized steel or stainless steel gauges, hanger spacing, and reinforcement shall be per SMACNA Round Industrial Duct Construction Standards.

3. Fittings: Fittings shall have a wall thickness not less than that required for longitudinal-seam straight duct.

4. Elbows:

a. Elbows for round ducts shall have a minimum centerline radius of 1-½ times the diameter of the duct 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 two gores, 37° through 72° shall have three gores, and 73° through 90° shall have five gores.
d. Four gore adjustable elbows are permitted for systems rated at 1" w.g. or less. The gores shall be tack welded and coated with sealer.

F. Flat Oval Ductwork: Ductwork and fitting spiral lockseam or welded with gauges, reinforcement, and supports conforming to SMACNA Duct Construction Standards Metal and Flexible: Positive pressure applications only, up to 10" w.g. For negative pressure applications, submit special design and reinforcements required.

2.03 DAMPERS

A. Fire Dampers:

1. Fire 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 consistent with the fire rating of the partition in which they are installed.
2. Dampers shall be classified for “Dynamic Closure” to shutoff against the higher of either 2375 FPM and 4" w.g., or velocity and pressure as indicated by the designer on the contract documents 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. The dampers shall be curtain type and the fire damper's blades shall be retained in a recess such that the free area of connecting ductwork is not reduced.
4. Fire dampers shall be rated for a minimum of 1½ hours and have a fusible link rated 50°F above the maximum temperature of the system, but not less than 160°F.
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 manufacturer's UL installation instructions and the dampers shall be installed in accordance with these instructions.
7. Perform an acceptance drop test per NFPA 90A after construction of walls, ceiling, and duct is complete. The drop test shall be witnessed by a Sandia National Laboratories (SNL) Fire Protection representative, and the damper shall be reset.
8. Each fire damper shall be safely accessible when construction is complete.
9. Each fire damper shall be accessible without having to reach through security bars.

B. 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 the higher of either 2375 FPM and 4" w.g., or velocity and pressure as indicated on the contract documents by the designer 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 temperatures to 450°F.
4. Fire dampers shall be rated for a minimum of 1½ hours and have a fusible link rated 50°F above the maximum temperature of the system, but not less than 160°F.
5. Provide a hook on the fusible link, so link can be easily removed to check damper for operation.
6. Each damper shall be shipped with the manufacturer's UL installation instructions and the dampers shall be installed in accordance with these instructions.

C. Outside Air Dampers: Dampers shall be low-leakage, airfoil, type 6063 T5 heavy gage aluminum blades and frame, extruded vinyl seals. Manufactured by Ruskin model CD-50 or equivalent.

D. Manual Balancing Dampers (Supply Air and General Exhaust Systems):

Dampers may be factory or contractor fabricated per SMACNA Duct Construction Standards Metal and Flexible section for Volume Dampers with the following exceptions:

1. Dampers shall be prefabricated in a frame to attach to the duct. The frame for rectangular dampers shall be minimum 16 gauge galvanized steel, structural hat channel with reinforced corners.
2. Bearings shall be sleeve type synthetic or oil impregnated bronze, pressed into the frame.
3. Dampers shall have an external locking manual quadrant. On duct systems with external insulation, the quadrant shall be installed with a standoff bracket to clear the insulation. The quadrant shall have a wing nut for locking the damper in place and a scale for indicating the position of the damper. (A handle attached directly to the damper shaft is not acceptable.)
4. The end of the shaft shall be permanently marked to indicate blade position.
5. Dampers shall be of the same material as the duct material.
6. Blades shall be positively locked to the shafts.
7. Round dampers up to 24" shall be single blade butterfly type. Frames shall include rolled stiffener beads to allow easy sealing of spiral ductwork joints.

E. Manual Balancing Dampers (Lab Exhaust Systems):

Dampers shall be factory fabricated either butterfly or blast gate type and rated for up to 3000 FPM velocity and 4" w.g. For pressures greater than negative 4" w.g., dampers shall be constructed per SMACNA Round Industrial Duct Construction Standards.

1. Bearings shall be sleeve type synthetic or oil impregnated bronze, pressed into the frame.
2. All butterfly dampers shall have an external locking manual quadrant. On duct systems with external insulation, the quadrant shall be installed with a standoff bracket to clear the insulation. The quadrant shall have a wing nut for locking the damper in place and a scale for indicating the position of the damper. (A handle attached directly to the damper shaft is not acceptable.)
3. Blast gate dampers shall have a bolt to lock the blade in position.
4. The end of the shaft shall be permanently marked to indicate blade position.
5. Dampers shall be of the same material as the duct material.
6. Continuous through shafts of ½" diameter and welded or bolted to the blades.

F. Control Dampers: Control dampers shall be furnished under section 13943, *Facilities Control System,* and as listed on the drawings.

2.04 HANGERS AND SUPPORTS

A. General: Refer to SMACNA Duct Construction Standards–Metal and Flexible, Rectangular Industrial Duct Construction Standards, and Round Industrial Duct Construction Standards respectively for rectangular and round ductwork for installation of hangers and spacing.

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. Wire for duct support is prohibited.
4. Round duct hangers shall use strap bands that conform to the duct in a manner that does not cause deformation to the duct. Trapeze hangers are not acceptable for round ducts.
5. Round duct shall be supported with duct saddles in order to cradle the duct and prevent deformation to the duct.

B. 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" thick. Screwed fasteners shall be load rated.

C. Exterior Ducts: Unless detailed otherwise on the drawings, exterior ducts supported on roofs shall be supported with structural steel angle or channel sized per SMACNA standards for trapeze hangers and supported with pipe or angle columns.

1. Hangers shall be spaced a minimum of 5' on center.
2. The minimum size of the trapeze hanger shall be supported with 1-½" x 1-½" x $^{3}/_{16}$" angle or C3 X 4.1 lb. channel sized.
3. Minimum column supports shall be 2" diameter standard weight pipe and coordinated with roofing penetration requirements.
4. Round duct shall be supported with duct saddles in order to cradle the duct and prevent deformation to the duct.

2.05 SEALANTS

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

B. Outdoor Ducts (without exterior insulation):

1. Polymeric rubber, resins, and reinforcing materials dispersed in solvent: 24-hour cure time, UV resistant, operational temperature range of -20 to +150˚F, manufactured by United McGill, type Uni-Weather or approved equal.

C. Indoor Ducts and Outdoor Ducts with Exterior Insulation:

1. Ductwork: Water based, vinyl acrylic polymeric sealant, nonflammable, fire retardant, operational temperature range of -25 to 200˚F, 48 hour cure time. Manufactured by Ductmate®, type Pro-Seal® or approved equal.
2. Pressurized Ductwork: Ductwork that is to be sealed while under pressure shall be sealed with water based mastics with fiberglass reinforcing and with short curing times. Manufactured by Versa Grip, type 102 (Hard Cast) or approved equal.

D. Fire Stopping: Seal ductwork penetrations to halt the spread of fire, water, and smoke through firewalls 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 in accordance with section 07270, *Firestop and Smokestop Systems*:

2.06 ACCESS DOORS

A. Duct access door shall be factory fabricated, galvanized steel, double skin, and insulated. Door shall conform to SMACNA HVAC Duct Construction Standards and shall be hinged with sash locks and gaskets. Access doors shall be provided adjacent to each fire damper, smoke damper, smoke detector, and control device and

for any additional locations shown on the drawings. The opening size shall be large enough to permit maintenance and resetting of the device in a safe manner.

B. Plenum access door shall be double wall constructed per SMACNA Duct Construction Standards Metal and Flexible for casing Access Doors – 3-10" w.g. Doors shall be 20" wide unless shown otherwise on the drawings and doors shall open against the air 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 galvanized steel and finished with Kynar®. Slats shall be inclined at least 45° from the horizontal and overlap a minimum of 1" Slats over 48" and shall have intermediate supports. An integral rain channel shall be formed with the slats. Louvers shall include a ½-¾" mesh galvanized steel or aluminum bird screen. Louvers shall be compatible with the adjacent substrate.

PART 3 – EXECUTION

3.01 EXAMINATION

A. Construct and install ducts to SMACNA HVAC Duct Construction Standards Metal and Flexible, SMACNA Round Industrial Duct Construction Standards, or SMACNA Rectangular Industrial Duct Construction Standards (as per Part 2, *Products*) and this specification.

B. Ductwork installation shall not proceed until representatives from the other contracting trades have been consulted to ensure there are no layout or installation conflicts, unless otherwise directed by the SDR.

C. 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.

D. Exit passageways, stairs, ramps, and other exits shall not be used as a part of the air return, supply, or exhaust.

E. 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.

F. Duct and fittings must be located a sufficient distance from other work to permit the installation of the finished covering not less than ½" from such other work, and not less than ½" between the finished covering on the different services.

3.02 PREPARATION

A. Open ends of ducts shall be covered and sealed with duct tape during installation to prevent debris from contaminating system. If the duct is not clean prior to sealing, then clean and seal to prevent debris from contaminating the system.

3.03 INSTALLATION

A. Flexible Ducts:

1. Provide flexible duct in fully extended condition, free from kinks, and free from compression.
2. Use only the minimum length required to make the connection.
3. Do not exceed 5'-0" in length, fully extended.
4. Where horizontal support is required, hanger or saddle material shall be wide enough so it does not reduce the internal diameter of the duct and shall be a minimum 1" wide banding material hangers at not more than 2'-6" centers. Maximum allowable sag ½" per foot of support spacing. Flexible duct shall extend straight for several inches from a connection before bending.
5. Make joints and connections with ½" wide positive locking steel, nylon, or plenum rated straps. Connections shall be per SMACNA Duct Construction Standards.
6. Use insulated flex where insulated duct is required.

B. Metal Ductwork:

1. Install with a minimum of 4" separation from earth to the duct or insulation finish.
2. Securely fasten at each change in direction.
3. Install branch connections and couplings tight to the duct wall surface to minimize projection into the duct. Secure with sheet metal screws at intervals of 12" with a minimum of three screws in each connection.

C. Underground Ducts: Use PVC coated galvanized steel for underground ducts and install in accordance with the manufacturer’s requirements. Repair damage to PVC coatings with manufacturer’s recommended materials.

1. Duct in concrete slabs shall be round and encased in at least 2" of concrete.
2. Use a vibrator to fill voids in concrete.

D. Insulation: Shall be installed as detailed in section 15081, *Duct 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.

E. Sealing Ductwork:

1. 0"–2" w.g. classification: Transverse joints shall be sealed as per SMACNA guidelines for Seal Class C using products listed in section 2.0.

2. Greater than 2" w.g. positive or greater than ½" w.g. negative 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, 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 sealer shall be brushed around reinforcing corners, rivets, notches, and tap-off collars after duct is assembled. 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. Stainless steel exhaust ductwork: Joints to be continuously welded.

3.04 GAS FIRED EQUIPMENT

A. Combustion air and venting of gas-fired equipment shall conform to the requirements of the International Mechanical Code® and the International Fuel Gas Code®.

3.05 DUCT LINERS

A. Install duct liners at locations as shown on the drawings and in accordance with NAIMA Fibrous Glass Duct Liner Standard. Apply with a single layer of indicated thickness.

B. Do not install liners within 24" of evaporative cooling equipment, across fire dampers, or within 3' downstream of duct humidifiers.

C. Apply adhesive coating to all exposed edges of liner that do not receive nosing treatment.

D. Metal nosing shall be installed over exposed liner edges that face upstream of the airflow.

3.06 HANGERS AND SUPPORTS FOR VAV AND FAN COIL UNITS

A. Metal strapping for supporting and hanging ductwork and VAV boxes may be attached to metal roof decks with the following conditions:

1. The metal roof deck is 22 gauge or heavier.
2. For round ductwork 18" diameter or less and rectangular ductwork having a perimeter of 96" or less and duct thickness of 20 gauge or lighter.
3. Metal strapping must be attached to the side flute of the metal deck with one each No. 10 Buildex screw (or other equal load rated fastener) at each end for U-shaped straps and two each No. 10 screws for single point attachments.
4. VAV boxes weighing 110 lbs. or less. VAV boxes shall be supported separately from ductwork and piping.

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 1" under and against the bottom of the duct.

D. Attach hangers to the ducts using rivets or screws of appropriate sizes 6" on center (minimum of two 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 two for Hangers and Supports construction and spacing data.

G. Fan coil units shall be supported and mounted in accordance with the manufacturer’s instructions.

3.07 CONNECTORS

A. Provide flexible connections, not less than 4" wide, constructed of approved fireproof, waterproof, non-asbestos, 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. There shall be no metal-to-metal contact at flexible connections. There shall be no stretching of the flexible material at flexible connections. This connection shall be UL listed, to meet NFPA 90 requirements and the following applications:

1. Indoor Supply/Return Air: Neoprene coated glass fabric, minimum 30 oz./square (sq.) yard (yd.), Ventfabrics - Ventglas® or DuroDyne - Neoprene
2. Outdoor Supply/Return Air: UV-resistant Hypalon® coated glass fabric, minimum 24 oz./sq. yd. Ventfabrics – Ventlon®” or DuroDyne – Durolon®

3. Laboratory/Chemical Exhaust: Teflon coated glass fabric, minimum 16 oz./sq. yd., Ventfabrics – Ventel®
4. Sunshields shall be mounted to only one side of the flexible connection.

3.08 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 and the manufacturer's requirements.
2. Provide access doors at all fire damper locations. Access doors shall be located so the spring catch is accessible when the damper is closed.
3. Fire dampers shall be supported independent of ductwork in the ceiling, wall, or floor, as conditions at the site dictate.
4. Fire dampers shall not be installed in exhaust systems.
5. Duct Connectors: Ducts shall be connected to fire and smoke dampers with slip joints so the damper will remain within the fire barrier, even if the duct should collapse.

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

C. Control Dampers: Control dampers shall be furnished under section 13943, *Facilities Control System* and as listed on the drawings.

3.09 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 constructed so 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 meet the requirements of SMACNA HVAC Duct Construction Standards–Metal and Flexible.
4. Doors with observation windows shall be constructed with tempered or tempered wire glass.

3.10 PLENUMS

A. Panels shall be assembled by interlocking the flanged end with the double standing seam and bolting on 18" centers. Seams shall project into the airside 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 1-½" x 1-½" x ⅛" angles spaced on 4'-0" 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 $^{3}/_{16}$" 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 ¼" bolts 1' -0" on center (o.c.), shot into the floor or the wall or ¼" "J" bolts set in concrete 1'-0" 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.

3.11 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 ⅛" 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 gauge galvanized steel flange neatly installed.

3.12 LOUVERS

A. 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 ½" mesh, galvanized wire screen in a galvanized channel frame.

3.13 FILTERS AND GAUGES FOR AIR HANDLING UNITS

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 so 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 so there is no more than 2" of deflection across the filter rack during operation. Clean filters shall be installed before Test and Balance can begin. 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 Magnehelic® gauges for the measurement of airflow resistance through the filters at each bank of filters. Furnish each gauge with two 3-way ball valves for venting and gauge adjustment.

3.14 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 section 15901, *System Component Checkout and Balance*.

B. Inspection: The contractor shall ensure filters, dampers, louvers, gauges, electrical components, and other accessories referenced in this document are installed correctly and system is operating in compliance with requirements prior to startup and request for final inspection. After all deficiencies are corrected, then Test and Balance can be performed.

C. Leak Testing: Ductwork rated in excess of 3" w.g. , laboratory exhaust ducts and ductwork specified for leak testing on the contract documents shall be tested for leaks. Ductwork systems less than 500 sq. ft. shall not be leak tested, unless indicated on the contract documents. Testing is not required for other ductwork rated 0 to 3" w.g.

1. Testing shall be done following guidelines in SMACNA-HVAC Duct Leakage Test Manual.
2. The leakage test shall meet the leakage classification (C_L) of 6 or less using the following equation. $C_L = F/P^{0.65}$.

D. Perform an acceptance drop test per NFPA 90 after construction of walls, ceiling, and duct is complete. The dropt test shall be witnessed by a SNL Fire Protection representative, and the damper shall be reset.

3.15 CLEANING

A. 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