SECTION 233113 - AIR DISTRIBUTION

PART 1 - GENERAL

1.1 APPLICABLE REQUIREMENTS

A. All work to be furnished and installed under this Section shall comply with all the requirements of General Conditions, Supplemental Conditions, Division 01 - General Requirements, Section 230500 - Basic Materials and Methods, and other Sections in Division 23 specified herein.

1.2 SCOPE

A. All work to be furnished and installed under this Section shall comply with all the requirements of Division 01, and shall include, but not necessarily be limited to, the following:

1. Ductwork - Rigid, Flexible and Fabric.
2. Diffusers, Grilles, and Registers.
3. Ductwork Specialties.
4. Flexible Connections.
5. Sealants, Adhesives and Tapes.
6. Duct Access Panels and Doors.
7. Variable Air Volume (VAV) Terminal Units.
8. Combination Fire and Smoke Dampers.
9. Fire Dampers.
10. Smoke Dampers.
11. Flashings.

1.3 RELATED WORK SPECIFIED ELSEWHERE

A. Section 230500: Basic Materials and Methods.

B. Section 230593: Testing, Adjusting and Balancing.

C. Section 230713: Duct Insulation.

D. Section 230900: Building Automation System (BAS) Control.

E. Division 26: Electrical.

1.4 QUALITY ASSURANCE

A. Codes and Standards: Provide products conforming to the requirements of the following:

1. ARI 885-98: Procedure for Estimating Occupied Space Sound Levels in the Application of Air Terminal and Air Outlets.
2. AMCA-210: Laboratory Methods of Testing Fans for Rating Purposes.
3. ANSI S12.23: Designation of Sound Power Emitted by Machinery and Equipment.
4. ASC-A7001: Standard for Duct Sealants.
5. ASHRAE Standard 130: Methods of Testing Air Terminal Units.

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6. AHRI Standard 885: Procedures for Estimating Occupied Space Sound Levels in the Application of Air Terminals and Air Outlets.
7. NFPA 90A: Standards for the Installation of Air Conditioning and Ventilating Systems.
8. NFPA 90B: Standard for the Installation of Warm Air Heating and Air-Conditioning Systems.
9. NFPA 96: Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations
10. American Society for Testing and Materials (ASTM): Manufacture and test in accordance with the ASTM Standards, including:
    a. ASTM A167: Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip. Type 304 or 304 stainless steel.
    b. ASTM A525: Standard Specification for General Requirements for Steel Sheet, Zinc-Coated (Galvanized) Hot-Dip Process. G60 and G90 zinc-coated.
    c. ASTM A527/A527M: Standard Specification for Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Lock-Forming Quality.
    d. ASTM C920: Standard Specification for Elastomeric Joint Sealants.
11. Underwriters Laboratory (UL): Manufacture and test in accordance with the UL Standards, including:
    a. 181:Standard for Factory-Made Air Ducts and Air Connectors.
    b. 181A: Standard for Closure Systems for Use With Rigid Air Ducts.
    c. 181B: Standard for Closure Systems for Use With Flexible Air Ducts and Air Connectors.
    d. 268A: Standard for Smoke Detectors for Duct Application.
    e. 555: Standard for Fire Dampers.
    f. 555C: Standard for Ceiling Dampers.
    g. 555S: Standard for Smoke Dampers.
    h. 723: Standard for Test for Surface Burning Characteristics of Building Materials.
    i. 1978: Standard for Safety – Grease Ducts.
    j. 2043: Standard for Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces.
    k. 2221: Standard for Tests of Fire Resistive Grease Duct Enclosure Assemblies.

B. Provide and construct ductwork systems in conformance with the latest editions of the following documents:
1. SMACNA HVAC Duct Construction Standards-Metal and Flexible.
2. SMACNA HVAC Air Duct Leakage Test Manual.
3. SMACNA HVAC Phenolic Duct Construction Standards.
4. SMACNA - Accepted Industry Practice for Industrial Duct Construction" for duct pressures above +5" w.g. positive pressure or below -5" w.g. negative pressure. Where differences exist between SMACNA and the prevailing building code, the

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gauge or construction method of the submitted ductwork shall be the more stringent of the two standards.

5. ASHRAE Systems and Equipment Handbook "Duct Construction" chapter.
6. ASHRAE Fundamentals Handbook "Duct Design" chapter.

C. Alternatives: The SMACNA standards and publications referenced in this Section of the specifications establish ductwork construction requirements.

1. Alternatives to these standards and publications may be submitted. Approval will be based on demonstration that such alternatives are equivalent and satisfy the functional requirements described in the referenced standards.
2. Such demonstration shall include evidence that the alternatives proposed were tested in accordance with SMACNA procedures and with test results certified by an independent testing laboratory.

D. All ductwork and equipment shall be seismically supported and braced to meet or exceed the minimum requirements of “SMACNA Seismic Restraint Manual-Guidelines for Mechanical Systems” and local building code requirements.

E. Flame/Smoke Rating: All materials, including sealants and adhesives, exposed within plenum shall be noncombustible or have a flame-spread index of 25 or less, and smoke developed index of 50 or less, as tested by ASTM E84 (NFPA 255) Method or UL 723. All materials installed within a plenum shall meet these requirements or have a safety data sheet available to indicate that materials are non-combustible. In addition, the products, when tested, shall not drip flame particles, and flame shall not be progressive. Provide Underwriters Laboratories, Inc., label or listing; or satisfactory certified test report from an approved testing laboratory to prove the fire hazard ratings for materials proposed for use do not exceed those specified. Discrete plumbing, mechanical, and electrical products that are located in a plenum and have exposed combustible material shall be in accordance with UL 2043.

1.5 DEFINITIONS

A. Class 0: Factory-made air ducts and connectors, compliant with ANSI/UL 181, having a surface burning characteristic of zero. Typically constructed of semi-rigid corrugated aluminum. This does not include sheet metal ductwork constructed per SMACNA Standards.

B. Class 1: Factory-made air ducts and connectors, compliant with ANSI/UL 181, having a flame spread index of not over 25 and a smoke developed index of not more than 50. Typically constructed of flexible ductwork, rigid fiberglass ductwork and plastic ductwork. This does not include sheet metal ductwork constructed per SMACNA Standards.

C. Flexible Air Duct (Factory-Made): Class 0 or Class 1 air ducts tested in accordance with 15 tests per ANSI/UL 181 and installed in conformance with the conditions of the listing and NFPA 90A/90B. Flexible ducts shall not be installed to serve more than two stories and shall not penetrate a fire-resistance rated assembly or construction. Maximum lengths of flexible ductwork shall not exceed lengths identified in this section or as limited by the AHJ, whichever is shorter.

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D. Flexible Duct Connector (Factory-Made): Class 0 or Class 1 connectors tested in accordance with 12 of 15 tests per ANSI/UL 181 and installed in conformance with the conditions of the listing and NFPA 90A/90B. Connectors include, but are not limited to, short flexible connections between air handlers and ductwork systems, uninsulated transition fittings, specialty shapes for diffuser connections, etc. Connectors shall not penetrate a wall, floor, or ceiling. Maximum lengths of flexible ductwork shall not exceed five foot (5') lengths or as limited by the AHJ, whichever is shorter.

1.6 SUBMITTALS

A. Prior to construction, submit for approval on all materials and equipment:

1. Ductwork - Rigid, Flexible and Fabric.
2. Ductwork Specialties.
3. Flexible Connections.
4. Sealants, Adhesives and Tapes.
5. Flashings.
6. Duct Access Panels and Doors.
7. Diffusers, Grilles, and Registers.
8. Fire/Smoke Dampers - Schedule of selected dampers must include the location, nominal size, free area velocity, and static pressure drop at free area velocity for each damper.
9. VAV Boxes.
10. SMACNA "HVAC Duct Construction Standards - Metal and Flexible".

B. Shop Drawings: Provide shop drawings of sheet metal ductwork and plenums as follows:

1. Draw to a scale not less than 1/8" to one foot, with sheet sizes equal to Contract Drawings.
2. Show duct sizes, where possible use even duct sizes.
3. Show fitting details.
4. Show coordination with lighting fixtures, fire dampers, fire/smoke dampers, piping, diffusers, grilles, registers, fans, major electrical runs, cable trays and bus ducts.
5. Factory-fabricated grease duct – show full isometric assembly diagram with dimensions and fittings identified. Provide full list of component model numbers and images.

C. Shop Drawings: Provide shop drawings for field erected mechanical equipment:

1. Draw to a scale of 1/2" to one foot, with sheet sizes equal to Contract Drawings.
2. Show plan, sections, elevations and details of all joints and enclosures.
3. Detail access doors and hardware.
4. Detail coil, damper, humidifier, filter and fan installations.
5. Show access space for electrical components that are part of the equipment provided and/or installed such as power and control panels on humidifiers. This shall be coordinated with Division 26 and NEC.

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D. Certifications: Provide a duct schedule, certified by an officer of the sheet metal fabrication subcontractor, that the ductwork conforms to SMACNA standards, and for each sheet metal system furnished on the project include:

1. System name.
2. Duct material.
3. Duct gauge.
4. SMACNA rectangular reinforcement number.
5. SMACNA intermediate reinforcement number.
6. SMACNA transverse reinforcement number.
7. Rod diameter and type.
8. Sealant type.
9. Attachment method.
10. Duct system design pressure.

E. Construction IAQ Management Plan: Collaborate with the general contractor to submit and implement an IAQ Management Plan for the construction process meeting the requirements of the SMACNA IAQ Guidelines. This plan should address the protection of the ventilation system components during construction and cleanup of contaminated components after construction is complete. SMACNA IAQ Guideline recommends control measures in five areas. The IAQ Management Plan should address how compliance has been achieved in these required five areas as follows:

1. HVAC Protection
    a. Shutdown of return side of existing HVAC system in areas affected by heavy construction.
    b. Provision of temporary filters if existing or new systems must remain operational during construction.
    c. Close the supply, return and exhaust dampers and seal duct openings in areas subject to construction dust.
2. Source Control
    a. How will reduction of contaminants be reduced at the source?
    b. What steps will be taken to employ low emitting products and sealants.
    c. How will air handling equipment be cycled off when not needed?
3. Pathway Interruption
    a. Describe how the construction space will be ventilated as required to dilute contaminants.
    b. Describe how occupied spaces adjacent to construction areas will be kept at positive pressure relative to spaces under construction.
4. Housekeeping: Describe how the following housekeeping objectives will be implemented:
    a. Reduction of dust generated by work will be suppressed.
    b. Maintaining a frequent cleaning frequency for dust and particulates.
    c. Remove spills or excess applications of solvent-containing products as soon as possible.
    d. Remove accumulated water and keep work areas as dry as possible.

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e. Protect insulation materials from exposure to moisture.

5. Scheduling: Describe how overlap of construction activity and ongoing building occupancy activities will be minimized.

F. Field Manual: Submit one copy of the SMACNA "HVAC Duct Construction Standards - Metal and Flexible". Maintain a second copy on the project site.

G. Any ductwork installed without prior approval by the specifier, shall be replaced at the expense of the contractor.

H. The contractor must comply with the enclosed specification in its entirety. If on inspections, the specifier finds changes have been made without prior approval, the contractor will make the applicable changes to comply with this specification, at the contractor’s expense.

I. At the discretion of the specifier, sheet metal gauges and reinforcing may be checked at various times to verify all duct construction is compliant.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to the site in containers with manufacturer's stamp or label affixed.

B. Store and protect products against dirt, water, chemical, and mechanical damage. Do not install damaged components. Remove damaged products from project site.

1.8 WARRANTY

A. Provide minimum one-year warranty from date of Substantial Completion, including all parts, material, labor and travel.

B. Refer to Section 230500 for additional warranty and Substantial Completion requirements.

C. Factory-built grease duct – minimum 20 year material warranty; Contractor shall follow all manufacturer’s requirements to maintain the warranty during procurement, storage, and installation.

PART 2 - PRODUCTS

2.1 DUCTWORK

A. Construct all ducts and plenum of gauges, and with joints, bracing, reinforcing, and other construction details in accordance with the latest construction standards previously listed. Metals shall be manufactured by United States Steel, Nucor.

B. Duct dimensions indicated on drawings are net, inside, clear dimensions. For internally lined ducts, add lining thickness to determine metal duct dimensions.

C. Ducts shall be constructed of material gauges and reinforcement Class per SMACNA pressurization classifications to meet 150% of the pressure requirements for external static pressure scheduled on drawings for the fans serving each system. Where differences exist between SMACNA and the prevailing building code, the gauge or construction method of the submitted ductwork shall be the more stringent of the code

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or standard. Refer to Part III - Execution for matrix of pressure and leakage requirements.

D. Ductwork gauge shall not be thinner than 26-gauge for all work.

2.2 SHEET METAL MATERIALS

A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A653/A653M.

1. Galvanized Coating Designation: G60 (Z180) for ductwork inside the building envelope in non-corrosive environments. G90 (Z275) for ductwork installed external to the building and may be installed inside the building as an alternate to G60.

C. Reinforcement Shapes and Plates: ASTM A36/A36M, steel plates, shapes, and bars; black and galvanized. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.

D. Tie Rods: Galvanized steel, 1/4-inch (6-mm) minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch (10-mm) minimum diameter for lengths longer than 36 inches (900 mm).

2.3 DUCTWORK FABRICATION

A. Rectangular Ducts

1. Longitudinal Seams:

a. Pittsburgh Lockor butt/corner weld for +/- 10 in. w.g. service.

2. Lateral Joints:

a. Slip drive joints, standard seams, flanges or welding as required by SMACNA HVAC Duct Construction Standards for system static pressure and sealed airtight. Flanged and gasketed joint fittings, such as Ductmate 25/35/45, Carlisle, MEZ Industries, are acceptable joint methods, but must be sealed as described previously. Transverse duct joints shall be constructed per Figure 1-4 for types T-8 through T-25. T-1 and T-5 slip joints are NOT allowed for transverse duct joints. T-5 slip joints may be used at connections to fire and smoke dampers as breakaway connections. Joint T-2, T-3, T-6 and T-7 reinforced slip joints are allowed below 2” static pressures.
b. Exposed Ductwork: All sealant or gaskets applied internally within joint.
c. Concealed Ductwork: Same as exposed ductwork, or sealant may be applied to the exterior side of joints.
d. Welded where required for leakproof and airtight operation and per code.

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B. Round Ducts

1. Longitudinal Seams:

a. Spiral seam (RL-1), butt weld (RL-4), or grooved seam flat/pipe lock (RL-5) for +/- 10 in. w.g. service.

2. Lateral Joints:

a. Exposed Ductwork: Beaded sleeve joint (RT-1), crimp joint bead (RT-5), or flange type joint. All joints secured with sheet metal screws. All sealant applied internally within joint.
b. Concealed Ductwork: Same as exposed ductwork, or sealant may be applied to the exterior side of joints.
c. Welded where required for leakproof and airtight operation.

C. Elbows

1. Construct long radius elbows with centerline not less than 1.5 times the duct width. Shorter radius elbows may be used where required to fit in restricted spaces, or as shown. For rectangular ductwork provide single thickness turning vanes on all short rectangular elbows less than 25" wide or provide double thickness turning vanes for short rectangular elbows 25" wide and greater. Number of vanes per SMACNA. Elbows with square throat and radius heel are NOT allowed.

D. Transitions

1. Construct transitions to not exceed the slopes identified per SMACNA HVAC Duct Construction Standards-Metal and Flexible. Slopes shall generally be no greater than 15%, and no greater than 30% where shown on the drawings.

E. Branch Connections

1. Provide 45°entry boots or radius taps for rectangular duct take-offs. Provide conical, bellmouth or 45° lo-loss boot taps for round duct take-offs. Straight 90° taps and spin-in taps are not allowed, except where round take-off duct size equals height of branch duct size. Provide volume dampers at each duct take-off for balancing. Provide insulation guards at transitions to lined ductwork.

F. Manufactured Joints

1. 316 stainless steel adjustable clamps with gaskets for connecting welded laterals, branches, and Y fittings. Manufacturer: CECO Environmental #KB Duct.

2.4 RECTANGULAR DUCTWORK

A. Construct rectangular ductwork to meet all functional criteria defined in of the SMACNA HVAC Duct Construction Standards-Metal and Flexible. All ductwork must comply with all local, code requirements. Ductwork shall be constructed of galvanized steel. Diagonally cross break all panels on ducts 30 inches wide and larger, or bead using automatic bead machine with beads at 12 inches on center or less. All connections shall utilize 45° boot take-offs. Bullhead tees and straight taps are not permitted.

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1. Listed manufactured ductwork system are allowed where they are installed per the manufacturer’s installation instructions and meet or exceed the requirements of the design requirements.

2.5 ROUND AND OVAL DUCTWORK

A. Round and oval ductwork shall be constructed to SMACNA round ductwork requirements of galvanized sheet steel. Comply with SMACNA HVAC Duct Construction Standards-Metal and Flexible, based on indicated static-pressure class unless otherwise indicated. Longitudinal seams shall be spiral lock seams or continuous welded. Flat oval may be utilized in space-restricted areas. All elbows shall be long radius type with centerline radius to duct diameter of 1.5, exceptions will only be allowed at restricted space locations.

B. Round or oval duct and fitting manufacturers:

1. McGill Airflow Corporation.
2. Lindab.
3. Semco.
4. Sheet Metal Connectors.
5. Spiral Manufacturing.
6. Nordfab.
7. Spiral Fittings.

C. Flat-Oval Ducts:

1. Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension).

D. Transverse Joints:

1. Fabricate according to SMACNA HVAC Duct Construction Standards-Metal and Flexible, for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions. All transverse joints, including mechanical flange type fittings, to be externally sealed at all joints.
2. Exception: internal manufactured single or dual EPDM rubber gasket fittings do not require external sealant.
3. Transverse joints in ducts larger than 50” diameter require flanged joints.
4. Lap or snap lock seams are not permitted for round ductwork of any size.

E. Longitudinal Seams:

1. Select seam types and fabricate according to SMACNA HVAC Duct Construction Standards-Metal and Flexible, Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA HVAC Duct Construction Standards-Metal and Flexible. All longitudinal joints shall be sealed airtight with sealant or continuous welding.
2. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
3. Fabricate flat-oval ducts larger than 72 inches in width (major dimension) with butt-welded longitudinal seams.

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F. Tees and Laterals:

1. Select types and fabricate compliant with SMACNA HVAC Duct Construction Standards-Metal and Flexible, Figure 3-5, "90 Degree Tees and Laterals" (45 degree lateral portions only), and Figure 3-6, "Conical Tees" for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions.
2. Spin-in type or other types of butt tees, bullhead tees or straight taps are not permitted.

G. Elbows:

1. Any deviation from a straight run shall be made using a gored or welded elbows or stamped elbows. Normal 90-degree elbows may include 5-gore fittings and the radius of the elbow is 1.5 times the diameter of the duct. All gores shall be continuous metal or use fully welded joints/seams. Die stamped sheet metal elbows shall be fully welded on the heel and throat by an automated welder. Flexible duct elbows or adjustable gore type elbows are not allowed.
2. Construct long radius elbows with centerline not less than 1.5 times the duct width. Shorter radius elbows may be used where required to fit in restricted spaces with prior approval or where shown on the drawings.

2.6 DIFFUSERS, GRILLES AND REGISTERS

A. All diffusers, grilles, and registers shall be selected to provide proper air distribution for the intended occupant application. All supply air devices shall be selected to provide a maximum air velocity of 50 fpm at three feet above the floor, unless otherwise noted. Manufacturer's representative shall carefully review Architectural and Mechanical drawings and ensure diffuser/grille/register selections will provide proper air distribution at NC values 7 points less than what is acoustically required for the served space. Manufacturer at no additional expense to the Owner shall replace diffusers, grilles, and registers not providing proper distribution or excessive noise at scheduled airflow.

B. All frames shall be selected to fit the ceiling type. Verify with Architectural Drawings. Each diffuser, grille and register shall be individually capable of balancing via duct mounted balancing dampers or attached opposed blade dampers. Provide unit opposed blade damper where individual duct mounted balancing dampers are not provided.

C. Refer to schedule on drawings for sizes, capacities and patterns.

D. Manufacturers: Titus, Krueger, Price, Greenheck, MetalAire, Nailor, Anemostat, Carnes, Tuttle&Bailey.

2.7 FLEXIBLE DUCTWORK

A. Pre-insulated flexible round ductwork, minimum one-inch thick, Class 0 or Class 1, may be utilized for final connections to each air outlet and inlet, unless shown otherwise on the plans. Uninsulated flexible ductwork, flexible PVC or flexible aluminum duct products are not allowed. Duct shall have a minimum R-4.2 (one-inch thick) for ductwork enclosed in conditioned spaces and R-8.0 (two-inch thick) for ductwork installed in unconditioned spaces. Maximum length of flexible ductwork in each low-

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pressure branch shall not exceed five feet (5’) and maximum flexible connector lengths shall not exceed five feet (5’).

B. All connections shall utilize welded conical tees, aluminum conical fitting, or manufacturer high efficiency branch take-offs. Spin-in type or other types of butt tees, bullhead tees or straight taps ARE NOT permitted. Manufacturers: Flexmaster #CBD, or 45° boot take-offs by Flexmaster #STO.

C. Damper regulators shall include end bearings as manufactured by DuraDyne, Ventlok.

D. Flexible ductwork for low pressure systems with positive static pressure up to 2” w.g. positive pressure and negative pressured up to 1/2" w.g. suitable for both terminal unit connection and diffuser/grilles. Flexible ductwork fittings may be used at seismic expansion joints and to accommodate vertical drift between building levels. Fabrication shall include a multiple laminate of aluminized polyester/mylar, fiberglass insulation, and polyester, mechanically locked to galvanized steel helix without adhesives, exterior fiberglass insulation and fire-retardant polyester/mylar outer jacket. Manufacturers: Casco #L-181M, Flexmaster #Type 5B, Thermaflex #M-KC or EverClean.

E. Flexible Duct Clamps/Draw Bands: Stainless steel band with cadmium-plated hex screw to tighten band with a worm-gear action in sizes up to 18 inches to match duct size. Use permanent screwed attachment systems for ducts sizes larger than 18”.

2.8 DUCTWORK SPECIALTIES

A. General: Where specifically called for, materials for use in fabricating ductwork specialties shall be identical to that used to fabricate ductwork. See drawings and Part 3, Execution for schedule.

B. Flexible Connections (Indoor Applications):

1. Provide flexible connectors at the discharge and inlet of fans, air handlers, rotating mechanical equipment, and where shown on the Drawings for proper vibration isolation.
2. Neoprene (polychloroprene) impregnated glass cloth with 24-gauge (minimum) galvanized metal frame. Hypalon, teflon or silicone coated fabrics may be acceptable.
3. Shall be airtight, watertight and fire retardant.
4. Minimum density of 30 oz. per sq. yard.
5. Temperature range: -40°F to 200°F
6. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723/ASTM E84.
7. Neoprene-only connectors are not allowed due to non-compliant surface-burning characteristics.
8. Minimum dimensions shall be 3" metal, 3" fabric, 3" metal up to maximum dimensions of 4” metal, 6” fabric, 4” metal as required by application.
9. Manufacturers: Ventfabrics #Ventglas, Duro Dyne, Q Industries, Kinetics, Ductmate Proflex or Elgen.

C. Volume and Splitter Dampers: Minimum 18-gauge galvanized sheet metal blade and frame with Ventfabrics Inc., Ventlok operating hardware. Damper to be reinforced to

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prevent vibration. For accessible dampers, provide #641 self -locking dial regulators and #644 self-locking dial regulators for insulated ductwork, #637 square end bearing, and #635 spring end bearing, as applicable. For inaccessible dampers, provide #666 or #677 concealed locking damper regulator with bearings as above. For static pressures above 3"wg, provide #640 HiVel dial regulator and #609 HiVel end bearing for accessible dampers. Regulators shall extend to and through ceiling with neatly installed hardware at the finished ceiling. For inaccessible dampers requiring adjustment through diffusers use Young Regulator, Bowden cable control system.

D. Multi-louver Volume Dampers: 16-gauge galvanized steel frame. Opposed, 6" wide, 16-gauge galvanized steel blades. Concealed linkage in frame. Ruskin #CD35/OBD.

E. Seismic Duct Connector (Indoors): Provide flexible connector at penetrations between two structural elements where the structural design has designated allowable seismic or settlement movement. Flexible EPDM elastomeric fabric bonded to a 1/4" steel perimeter flange on each end. EPDM shall be rated for maximum temperature of 250°F and 3 psi maximum. Connector shall be rated to meet or exceed structural design requirements with a minimum of 3” for axial compression, 3” axial extension, and 3” lateral deflection. Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723/ASTM E84. Manufacturers: Mercer Rubber Co #ME-3/MI-9-3, Mason Industries #MD-4/MI-9, Flexicraft, Garlock, Hyspan.

F. Hanging Cables with Adjustable Fastener: Wire rope hangers for maximum point loads not exceeding 100 lbs. (45 Kg) for supporting rigid galvanized ductwork not exceeding 18” (450 mm) diameter, and suspended diffusers/grilles/terminal units. Alternate to metal strap options per SMACNA's "HVAC Duct Construction Standards - Metal and Flexible".

1. Wire Rope: High tensile steel wire rope, to ASTM 1023/1023M, class A zinc coating; 7 by 7 or 7 by 19 cross-sectional construction; having a tensile strength of 256,000 psi (1,770 N per sq. mm); lengths, diameters, and wire construction to accommodate design loads and as indicated on Construction Shop Drawings.
2. Adjustable Fastener: Mild steel (type EN1A), bright zinc plated, one-channel body; encasing a series of Type 302 stainless-steel springs with serrated self-locking grade 40 chrome steel balls, adjustable by means of an integrated mechanism, capable of accommodating load of 100 lbs. (45 kg) (maximum per hanger).
3. Manufacturers: Gripple #Standard No. 2/3/4/5, Ductmate #Clutcher.

2.9 ACCESS DOORS

A. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 7-2 (7-2M), "Duct Access Doors and Panels," and 7-3, "Access Doors - Round Duct." Access doors shall be insulated hollow core double construction. Access doors in exhaust ducts shall be of same, or heavier, gauge material as duct in which installed.

B. Casing Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 9-16, "Casing Access Doors."

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Access doors shall be insulated hollow core double construction of same, or heavier, gauge material as duct in which installed.

C. Minimum door size shall be 12" by 12" for simple manual access and up to 24" by 24" where personnel must pass through infrequently. Provide 20" x 54" (minimum) door for access to filters and more frequent maintenance.

D. Maximum door leakage shall not exceed 10 cfm/sq.ft. at maximum operating pressure. Doors larger than four sq.ft. in area shall open against pressure.

E. Doors:

1. Double wall, rectangular.
2. Galvanized sheet metal with insulation fill and gauge thickness as indicated for duct pressure class. Minimum 1” insulation thickness for doors up to 24” tall and 2” thick insulation for larger door assemblies as required per energy code. Insulation not required in exhaust duct access doors as allowed by local code.
3. Latches: Steel cam or lever type. Access doors shall openable by hand with no tools.
4. Vision panel shall be provided on doors 24” x 60” and larger.
5. Fabricate doors airtight and suitable for duct pressure and air leakage class.
6. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets for doors up to 24” tall. For larger doors provide 1-1/2" by 1/8" flat stock or 14-gauge angle frame.
7. Gaskets: Closed cell neoprene rubber, 1” x 1/4" (minimum).
8. Access Door Manufacturers (Small Dimensions, Low Pressure Rating): CESCO, Pottorff, Ruskin, Vent Products, Air Balance Inc., Ductmate Sandwich, United Enertech, as required by size and pressure application.

F. Hinges and Latches:

1. Access doors up to 14 by 14 inches (300 x 300 mm) square: Two hinges or continuous piano hinge and one sash lock. Doors shall not be removable.
2. Access doors up to 16 by 24 inches (400 by 600 mm) square: Two hinges or continuous piano hinge and two sash locks (minimum). Doors shall not be removable.
3. Access doors up to 24 by 48 inches (600 by 1200 mm): Three hinges or continuous piano hinge and two compression latches (minimum) with outside and inside handles.
4. Access doors larger than 24 by 48 inches (600 by 1200 mm): Four hinges or continuous piano hinge and two compression latches (minimum) with outside and inside handles.
5. Latch Manufacturer: Ventlok #100 Series hinges and latches on low pressure system doors up to 18 " maximum dimension, #200 Series on larger low pressure system doors, #333 Series on high pressure systems with stops.

2.10 DUCTWORK SEALANT

A. Duct tape is not allowed.

B. Solvent-based and oil-based sealants are not allowed indoors.

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C. Seal outside of all transverse joints, including mechanical joint flanges and corners, similar to Ductmate, on all supply, return, exhaust, and outside air intake ducts.

D. All sealant systems for outdoor application to be suitable for use in exposure to water, sunlight, temperatures extremes associated with project location.

E. All sealant systems for indoor application to be meet VOC limits as specified in South Coast Air Quality Management District (SCAQMD) Rule #1168 limiting VOC's to 80 grams/liter for duct liner adhesives and 250 grams/liter for duct sealants.

F. Indoor Application Water-Based Sealant for Lateral Duct Joints:

1. Flexible, adhesive sealant, suitable for high velocity and high pressure applications, UL 181B-M listed, UL 723 classified, and complying with NFPA requirements for Class 1 ducts.

    a. Sealant shall be water based latex UL 181 B-M non-reinforced sealant.
    b. Sealant shall meet flame spread rating of 0 and smoke developed rating of 0.
    c. Flexibility on 1/4" mandrel.
    d. Freeze/thaw stability - 5 cycles.
    e. Service temperature: -20°F to +200°F (-29°F to +93°C).
    f. ASTM 5590; Resistance to mold, mildew and water.
    g. Meet all SMACNA seal classes.
    h. Meet all SMACNA pressure classes (+/-): 1/2, 1, 2, 3, 4, 6, and 10" water gauge.

2. Manufacturer: Carlisle (Hardcast) #Iron Grip 601, Design Polymerics #DP1010, Ductmate #FIBERseal.

G. Indoor Application Water-Based Sealant for Longitudinal Duct Seams:

1. Spiral and oval lockseams are not longitudinal seams and do not require additional duct sealant, however, lateral joints must be sealed.
2. Joints that are not fully welded shall be sealed.
3. Flexible, adhesive sealant, suitable for high velocity and high pressure applications, UL 181B-M listed, UL 723 classified, and complying with NFPA requirements for Class 1 ducts.

    a. Sealant shall be water based latex UL 181 B-M non-reinforced sealant.
    b. Sealant shall meet flame spread rating of 0 and smoke developed rating of 0.
    c. Flexibility on 1/4" mandrel.
    d. Freeze/thaw stability - 5 cycles.
    e. Service temperature: -20°F to +200°F (-29°F to +93°C).
    f. ASTM 5590; Resistance to mold, mildew and water.
    g. Meet all SMACNA seal classes.
    h. Meet all SMACNA pressure classes (+/-): 1/2, 1, 2, 3, 4, 6, and 10" water gauge.

4. Manufacturer: Carlisle (Hardcast) #Flex-Grip 550 or #Iron Grip 601 or #Spray-Seal, Ductmate #PROseal or #FIBERseal, Design Polymerics #DP1010 or #DP1020 or #DP 1010 Spray.

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H. Indoor Application Water-Based Joint and Seam Sealant with Extended 10-Year Material Warranty:

1. Flexible, adhesive sealant, suitable for high velocity and high pressure applications, UL 181B-M listed, UL 723 classified, and complying with NFPA requirements for Class 1 ducts.

a. Sealant shall be water based latex UL 181 B-M non-reinforced sealant.
b. Sealant shall meet flame spread rating of 0 and smoke developed rating of 0.
c. Flexibility on 1/4” mandrel.
d. Freeze/thaw stability - 5 cycles.
e. Service temperature: -20°F to +200°F (-29°F to +93°C).
f. ASTM 5590; Resistance to mold, mildew and water.
g. Meet all SMACNA seal classes.
h. Meet all SMACNA pressure classes (+/-): 1/2, 1, 2, 3, 4, 6, and 10” water gauge.
i. Manufacturer: Carlisle (Hardcast) #Iron Grip 601 or #Flex-Grip 550 or #Spray-Seal and #Aluma-Grip AFT-701 rolled sealant.

2. And, all transverse joints, longitudinal seams, and duct wall penetrations shall be sealed by a 30-mil rolled sealant. Rolled sealant shall be comprised of a 2-mil foil faced with 28 mils of butyl adhesive/sealant conforming to the product specifications. Rolled sealant shall have the following physical properties:

a. Peel Strength: 16 lbs. per linear inch.
b. Tensile strength: 955 psi
c. Elongation: 560%
d. Bonding time: Instant with full bond in 24 hours.
e. Resistance to mold, mildew and water.
f. Weather Resistance per ASTM G-53 @ 2000 hours QUV.
g. Service temperature: -20°F to +200°F (-29°F to +93°C).
h. Surface burning characteristics: Flame spread/smoke developed rating of 20/40, tested in accordance with UL 723.
i. VOC: 0 g/l
j. Meet all SMACNA seal classes.
k. Meet all SMACNA pressure classes (+/-): 1/2, 1, 2, 3, 4, and 6” water gauge.
l. Manufacturer: Carlisle (Hardcast) #Aluma-Grip AFT-701 rolled sealant.

I. Outdoor Application Two-Part Tape Sealing System:

1. Woven-fiber tape impregnated with gypsum mineral compound and modified acrylic/silicone activator to react exothermally with tape to form hard, durable airtight seal.
2. Manufacturer: Carlisle (Hardcast) #Two Part II, McGill Uni-Cast.

J. Outdoor Application Low VOC Solvent Based Joint and Seam Sealant:

1. Flexible, adhesive sealant, suitable for outdoor application on joints and seams.

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a. Sealant shall be solvent based synthetic elastomeric. Water and UV resistant. Crack and peel resistant.
b. Compliant with ASMT E84 and UL 723. Sealant shall meet flame spread rating of 0 and smoke developed rating of 0 after cured.
c. Freeze/thaw stability - 5 cycles.
d. Service temperature: -20°F to +190°F (-29°C to +88°C).
e. VOC: 44 g/l.
f. ASTM 5590 compliant for resistance to mold, mildew and water.
g. Meet all SMACNA seal classes.
h. Meet all SMACNA pressure classes (+/-): 1/2, 1, 2, 3, 4, 6, and 10” water gauge.

2. Manufacturer: Design Polymerics #DP1090.

K. Rolled (Tape) Mastic Sealant for indoor and outdoor application on flat sheet metal duct joints. Aluminum substrate with modified butyl sealant. Compliant with UL 181B-FX. Rolled sealant shall have the following physical properties:

a. Peel Strength: >10 lbs. per linear inch.
b. Bonding time: Instant tack with full bond in 24 hours.
c. Resistance to mold, mildew and water.
d. Weather Resistance per ASTM G-53 @ 2000 hours QUV.
e. Service temperature: -20°F to +180°F (-29°C to +82°C).
f. Surface burning characteristics: Flame spread/smoke developed rating of 5/25, tested in accordance with UL 723.
g. VOC: 0 g/l.
h. Meet all SMACNA seal classes.
i. Meet all SMACNA pressure classes (+/-): 1/2, 1, 2, 3, 4, 6” and 10” water gauge.
j. Roll width as required to maintain minimum 3/4” adhesion width on each side of joint.
k. City of Los Angeles RR#8069 approved.
l. Manufacturer: Carlisle (Hardcast) #Foil-Grip 1404-181BFX rolled sealant.

L. Manufacturers of duct sealant systems for various ductwork applications: Design Polymerics, Tremco, Dure Dyne, Carlisle Hardcast, Ductmate, Mon-Eco Industries, Sikaflex, and McGill AirSeal LLC.

2.11 PLENUMS AND EQUIPMENT CASINGS

A. Construct casings and plenums in conformance with SMACNA. Minimum Pressure Class: Unless otherwise indicated construct plenums and casings to withstand either a negative or positive static pressure of 4" w.g.

B. Single-Wall Casings and Plenums

1. Construct in accordance with SMACNA Standards.
2. Use steel-angle-reinforced standing-seam construction.
3. Locate intermediate bracing angles bolted to the casing 24 inches on centers.
4. Construct for static pressure indicated or for the maximum fan static pressure whichever is less.

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5. Bolt to 3" high concrete pads using 1-1/2" x 1-1/2" x 1/4" thick galvanized steel structural sections.

C. Double-Wall Insulated Ductwork

1. Construct in accordance with SMACNA Standards. Provide insulation thicknesses to meet or exceed the minimum required by local energy codes.
2. Provide 2" (minimum) thick prefabricated double wall insulated metal panel assemblies, with 16-gauge aluminum or 18-gauge minimum galvanized steel outer sheets.
3. Provide 22-gauge galvanized steel inner sheets to encapsulate the insulation.
4. Casings shall be fully metal enclosed, insulated with 2" thick (minimum) rigid fiberglass insulation and conforming to NFPA 90A, with maximum flame spread of 25 and maximum smoke developed of 50.
5. Field or factory fabricate to size and configuration indicated on the drawings, using field verified dimensions.
6. Provide coordinated shop drawings.
7. Reinforce spans 10' or greater with structural steel sections to yield maximum deflection 1/4" at minus 10" w.g. or plus 10" w.g. static pressure.
8. Provide openings and doors, all factory framed, and reinforced with 304 stainless steel structural sections.
9. Construct doors of same material as casings, of sizes and locations indicated on the drawings but not smaller than 18" by 54", and conforming to SMACNA.
10. Provide doors, hinges and hardware factory fabricated and mounted.
11. Door swings shall open against air pressure, with door latches operable from either side.
12. Provide door seals with neoprene gaskets, which have an airtight seal.
13. Provide each door with a 10" by 10" wire reinforced double pane window.
14. Bolt base channel to 3" high concrete pads.

2.12 FIRE, SMOKE AND COMBINATION FIRE/SMOKE DAMPERS

A. General:

1. Provide UL labeled 3 hour rated fire dampers at 3-hour and greater penetrations.
2. Provide UL labeled 1-1/2 hour rated fire dampers at less than 3-hour penetrations.
3. All dampers to be certified under the latest UL Standard. Certification based on former non-current standards is unacceptable.
4. All damper installations to conform with NFPA 90A and manufacturer's installation instructions. Details on drawings are shown for reference only.
5. Install in ducts passing through walls, floors, and ceilings as required by code. Refer to Architectural and Mechanical plans for damper locations.
6. Provide fire, smoke and fire/smoke dampers in locations as required by local code and NFPA-90A and 92A.
7. Provide sleeves, slip joints, retaining angles, duct access doors, ceiling access panels, etc., as required to check and service the fire dampers. Slip or break away joints are not allowed to be taped or sealed.

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8. Access doors shall be tight fitting hinged with hand operable cam or lever type latches. Access shall not require the use of keys, tools or special knowledge. Removable doors are not allowed. Access doors shall be not less than 12” x 12” or provided with removable duct section. The access point shall permanently labeled with 1” (25 mm) high letters: "FIRE DAMPER”, “SMOKE DAMPER”, or “FIRE/SMOKE DAMPER”.
9. All dampers to be designed for use in dynamic systems.
10. Dampers shall be rated for Leakage Class I. Leakage Class II may be used if damper size is smaller than available Leakage Class I dampers.
11. Dampers shall be certified for use by State and local authorities.
12. Dampers shall be installed straight and true, level in all planes, and square in all dimensions. Dampers shall move freely without undue stress doe to twisting, racking, bowing, or other installation error. Do not install actuators in area where moisture can penetrate actuator or where temperature exceeds 120°F.
13. All fire dampers shall be sized to provide equivalent free area through the damper equal to, or greater than, the free area of the connecting ductwork. Upsize fire dampers as required to minimize pressure drops. In no case is the damper pressure drop to exceed 0.20” w.g., but ideally less than 0.10” w.g .for low velocity dampers, as designed for total system static pressure allowance. Refer to submittal requirements in Part One of this section and requirements on the drawings.

B. Radiation Ceiling Fire Dampers:

1. Bladed ceiling fire damper constructed and tested in conformance with UL-555C (dynamic rating).
2. Fire damper shall have a fusible link that opens at 165°F (74°C) or 212°F (100°C) for high temperature duct applications. Installation shall be in accordance with damper manufacturer's instructions.
3. Provide fire blanket where required to obtain listed fire rating.
4. Manufacturers: Ruskin #CFD Series, Greenheck #CRD Series, or equal by Pottorff, Cesco, Nailor, or Air Balance.

C. Dynamic Fire Dampers (FD) for use in Dynamic and Static Systems:

1. Curtain fire damper constructed and tested in conformance with UL-555C.
2. Fire damper shall have a fusible link that opens at 165°F (74°C) or 212°F (100°C) for high temperature duct applications. Fire damper shall be equipped for vertical penetrations with manufacturer supplied sleeve. Installation shall be in accordance with damper manufacturer's instructions.
3. Curtain damper shall not be located in air stream during system operation, Style B or C. Clear inside opening through fire damper is to match clear inside opening of duct. Fire dampers in lined ducts are to match size of sheet metal duct.
4. Dynamic Closure Rating Velocity: 2000 fpm (minimum).
5. Allowable Pressure Drop: size damper as shown on drawings and as required to not exceed maximum allowable pressure drop of 0.10” w.g. at full air flow.
6. Pressure rating: 4” w.g.

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7. Manufacturers: Ruskin #DIBD Series, Greenheck #DFD Series, or equal by Pottorff, Air Balance, Nailor or CESCO.

D. Combination Fire and Smoke Dampers (FSD):

1. Required Locations:

a. Install at ducted penetrations through rated fire barriers, fire walls, rated ceilings, rated corridor ceilings, shaft enclosures, and smoke barriers and partitions as defined on Architectural drawings and Chapter 7 of the Building Code.
b. Per NFPA-90A install smoke dampers or combination fire/smoke dampers in systems with a capacity greater than 15,000 cfm to isolate the air handling equipment from the remainder of the system on the building supply and return side. Air handling units located on the floor they serve and only serving that floor are exempt. Air handling units located on the roof and serving only the floor immediately below the roof shall be exempt.

2. General Requirements:

a. Dampers shall be Low Leakage Class 1 in accordance with UL 555S.
b. Dampers shall be provided as a manufactured UL listed device with electric actuator. Actuator shall be attached to sleeve outside of air stream.
c. Temperature Rating: 165°F (74°C) or 212°F (100°C) for high temperature duct applications.
d. Mounting: Vertical or horizontal
e. Frame: 5” wide by 16-gauge roll formed, galvanized steel hat-channel, minimum.
f. Sleeve: Minimum 20-gauge thickness and minimum 16” long.
g. Bearings: Stainless steel, permanently lubricated sleeve type.
h. Each damper shall be equipped with a controlled 15 second electric heat-actuated release device. This device is to be equipped with a push-button reset. No manual fusible links are permitted. Installation shall be in accordance with damper manufacturer's instructions. Coordinate power and smoke detector connections with electrical installer. Integral smoke detection and actuating devices may be used if listed and approved for such service. Comply with building code requirements. All combination fire and smoke dampers shall automatically reset from closed to open position upon the reapplication of power to actuators, if temperature switch is not tripped.
i. Dampers shall be installed straight and true, level in all planes, and square in all dimensions. Dampers shall move freely without undue stress due to twisting, racking, bowing, or other installation error.
j. Voltage: Coordinate with Division 26 work and electrical installer for power to damper actuator. Provide 24 VAC, 120 VAC or 230 VAC power option to match power supply provided by Division 26. Prior to purchase and installation coordinate with Division 26 to align power requirements at no additional cost to Owner.
k. Electric Actuators: All gear and housing shall be steel. The actuator shall be direct coupled and employ a steel toothed cold-weld clamp for

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connecting to damper shafts. Aluminum clamps or set-screw attachments are not acceptable. Actuator shall be UL listed and manufactured under ISO 9001 quality control.

1) Actuator shall carry a manufacturer's 5-year warranty.
2) Damper position shall fail closed on loss of power.
3) Actuator shall have microprocessor based motor controller providing electronic cut off at full open so that no noise can be generated while holding open. Holding noise level shall be inaudible. Actuator shall be incapable of burning out if stalled before full rotation is reached.
4) Actuator shall have UL555S Listing by the damper manufacturer and be rated for 20,000 cycles minimum. Actuator shall draw no more than 0.23 amps at 120-volt running, or 0.11 amps holding at 120-volt (27 VA and 10 VA respectively for 24-volt power) for 70 in.lbs. torque.
5) Stall and instantaneous type actuators are not acceptable.
6) Do not install in areas where moisture can penetrate damper or actuator, nor where actuator temperature exceeds 122°F (50°C).
7) Manufacturer: Belimo #FS Series or equal by Siemens, Johnson Controls, or Honeywell.

3. Required Options:

a. Provide open or closed indicator assembly consisting of a single pole, double throw switch used to indicate damper blade position. Include switch mounting bracket, crank arm, blade bracket and linkage from blade to the switch. Or, provide optional actuator end switches to indicate damper open and damper closed positions. Coordinate with fire alarm system and FireFighter's Smoke Control Panel for remote indication and damper override control.
b. Provide a damper mounted testing module to permit test cycling of the damper actuator assembly as required for start-up testing and maintenance.
c. Provide integral duct smoke detector and coordinate with Division 26 for area smoke detection and comply with NFPA-90A and NFPA-72. All wiring to be provided by Division 26 installers. In buildings not equipped with an approved fire alarm system the smoke detection activation shall cause a visual signal and audible signal in a normally occupied area and be identified as air duct detector trouble.For exposed wall applications provide matching wall grille to maintain appearance and fire rating.
e. Temperature limited override: Provide a two-temperature electronic high temperature limit. A primary sensor at 165°F (or higher temperature as dictated by AHJ or Building Code) can be bypassed by an external electrical signal allowing the damper to reopen and remain open until the temperature reaches the setting of the secondary sensor at 350°F at which point the damper is closed and remains closed. Both sensors are to be equipped with manual resets.

4. Low Velocity Applications (1500 fpm or below):

a. Maximum Rate Velocity: 1500 fpm.

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b. Style: 3V grooved blades or airfoil-shaped, single piece, double skin with mechanically fastened silicone edge seals.
c. Allowable Pressure Drop: size damper as shown on drawings and as required to not exceed maximum allowable pressure drop of 0.10” w.g. at full air flow.
d. Pressure rating: 4” w.g.
e. Manufacturers: Ruskin #FSD37 or #FSD60 or #FSD60-3, Ruskin #FSDR25 or #FSDR60 round style, Greenheck #FSD-211 or #FSD-231 or #FSD-311 or #FSD-311M, or equal by Pottorff, Nailor, Cesco or Air Balance.

5. High Velocity Applications (Greater than 1500 fpm):

a. Maximum Rate Velocity: 4000 fpm.
b. Style: True airfoil-shaped, extruded aluminum blades with silicone edge seals.
c. Allowable Pressure Drop: size damper as shown on drawings and as required to not exceed maximum allowable pressure drop of 0.20” w.g. at full air flow.
d. Pressure rating: 4” w.g.
e. Manufacturers: Ruskin #FSD60 or #FSD60-3, Greenheck #FSD-311 or #FSD-231 or #FSD-311 or #FSD-331, or equal by Pottorff, Nailor, Cesco or Air Balance.

6. Low and Medium Velocity Round Applications (3000 fpm or below):

a. Maximum Rate Velocity: 3000 fpm.
b. Style: Two piece 14-gauge thickness galvanized steel with mechanically fastened silicone edge seals
c. Allowable Pressure Drop: size damper as shown on drawings and as required to not exceed maximum allowable pressure drop of 0.15” w.g. at full air flow.
d. Pressure rating: 4” w.g.
e. Manufacturers: Ruskin #FSDR25 or #FSDR60, Greenheck #FSDR-511, or equal by Pottorff, Nailor, Cesco or Air Balance.

7. Corridor Ceiling Application:

a. Maximum Rate Velocity: 1500 fpm.
b. Style: 3V grooved blades or airfoil-shaped, single piece, double skin with mechanically fastened silicone edge seals.
c. Allowable Pressure Drop: size damper as shown on drawings and as required to not exceed maximum allowable pressure drop of 0.10” sp w.g. at full air flow.
d. Pressure rating: 4” w.g.
e. Manufacturers: Ruskin #FSD60-C, Greenheck #CFSD-211, or equal by Pottorff, Nailor, Cesco or Air Balance.

E. Smoke Dampers (SD):

1. Required Locations:

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a. Install at rated smoke barriers and partitions as defined on Architectural drawings and Chapter 7 of the Building Code.
b. Per NFPA-90A install smoke dampers in systems with a capacity greater than 15,000 cfm to isolate the air handling equipment from the remainder of the system on the building supply and return side. Air handling units located on the floor they serve and only serving that floor are exempt. Air handling units located on the roof and serving only the floor immediately below the roof shall be exempt.

2. General Requirements:

a. Dampers shall be Low Leakage Class 1 in accordance with UL 555S.
b. Dampers shall be provided as a manufactured UL listed device with electric actuator. Actuator shall be attached to sleeve outside of air stream.
c. Temperature Rating: 165°F (74°C) or 212°F (100°C) for high temperature duct applications.
d. Mounting: Vertical or horizontal
e. Frame: 5” wide by 16-gauge roll formed, galvanized steel hat-channel, minimum.
f. Sleeve: Minimum 20-gauge thickness and minimum 12” long.
g. Bearings: Stainless steel, permanently lubricated sleeve type.
h. Smoke damper shall be equipped for vertical wall penetrations with manufacturer supplied sleeve and fail closed on loss of power. Each damper shall be equipped with a controlled 15 second electric heat-actuated release device. This device is to be equipped with a push-button reset. No manual fusible links are permitted. Installation shall be in accordance with damper manufacturer's instructions. Coordinate power and smoke detector connections with electrical installer. Integral smoke detection and actuating devices may be used if listed and approved for such service. Comply with building code requirements. All combination smoke and fire dampers shall automatically reset from closed to open position upon the reapplication of power to actuators, if temperature switch is not tripped.
i. Dampers shall be installed straight and true, level in all planes, and square in all dimensions. Dampers shall move freely without undue stress due to twisting, racking, bowing, or other installation error.
j. Voltage: Coordinate with Division 26 work and electrical installer for power to damper actuator. Provide 24 VAC, 120 VAC or 230 VAC power option to match power supply provided by Division 26. Prior to purchase and installation coordinate with Division 26 to align power requirements at no additional cost to Owner.
k. Electric Actuators: All gear and housing shall be steel. The actuator shall be direct coupled and employ a steel toothed cold-weld clamp for connecting to damper shafts. Aluminum clamps or set-screw attachments are not acceptable. Actuator shall be UL listed and manufactured under ISO 9001 quality control.

1) Actuator shall carry a manufacturer’s 5-year warranty.

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2) Actuator shall have microprocessor based motor controller providing electronic cut off at full open so that no noise can be generated while holding open. Holding noise level shall be inaudible. Actuator shall be incapable of burning out if stalled before full rotation is reached.
3) Actuator shall have UL555S Listing by the damper manufacturer and be rated for 20,000 cycles minimum. Actuator shall draw no more than 0.23 amps at 120-volt running, or 0.11 amps holding at 120-volt (27 VA and 10 VA respectively for 24-volt power) for 70 in-lb torque.
4) Stall and instantaneous type actuators are not acceptable.
5) Do not install in areas where moisture can penetrate damper or actuator nor where actuator temperature exceeds 122□F (50°C).
6) Manufacturer: Belimo #FS Series or equal by Siemens, Johnson Controls, or Honeywell.

3. Required Options:
   a. Provide open or closed indicator option assembly consisting of a single pole and a double throw switch used to indicate damper blade position. Output from switch to position indicator light (LED, provided by Division 26) is by automatic temperature control contractor. Include switch mounting bracket, crank arm, blade bracket and linkage from blade to the switch.
   b. Provide a test module to permit test cycling of the damper/actuator in the field
   c. Provide integral duct smoke detector or coordinate with Division 26 for area smoke detection. Division 26 to provide all wiring.For exposed wall applications provide matching wall grille to maintain appearance and fire rating.
4. Low Velocity Applications (1500 fpm or below):
   a. Maximum Rate Velocity: 1500 fpm.
   b. Style: 3V grooved blades or airfoil-shaped, single piece, double skin with mechanically fastened silicone edge seals.
   c. Allowable Pressure Drop: size damper as shown on drawings and as required to not exceed maximum allowable pressure drop of 0.10” sp w.g. at full air flow.
   d. Pressure rating: 4” w.g.
   e. Manufacturer: Ruskin #SD-37, Ruskin #SD-60, Greenheck #SMD-201, Pottorff #SD-141, Pottorff #SD-151, or equal by Nailor, Cesco or Air Balance.
5. High Velocity Applications (Greater than 1500 fpm):
   a. Maximum Rate Velocity: 4000 fpm.
   b. Style: True airfoil-shaped, extruded aluminum blades with silicone edge seals.
   c. Allowable Pressure Drop: size damper as shown on drawings and as required to not exceed maximum allowable pressure drop of 0.20” sp wg at full air flow.
   d. Pressure rating: 4” wg.

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e. Manufacturer: Ruskin #SD-50, Greenheck #SMD-401, or equal by Pottorff, Nailor, Cesco or Air Balance.

2.13 DIGITAL DUAL DUCT CONSTANT AIR TERMINAL UNITS

A. Furnish and install dual duct air terminal boxes of the sizes and capacities shown on the Drawings.

B. The control assemblies shall be pressure independent and shall be able to be reset to any airflow between zero and maximum scheduled CFM. The valves shall be normally open. The differential static pressure of the basic assembly shall not exceed 0.13" w.g. for all sizes with inlet velocities of 2,000 fpm or less.

C. Cooling and heating inlets shall have separate damper assemblies for complete pressure independent control of each airstream for variable or constant volume total discharge applications. Terminals with inlet dampers mechanically interconnected are not acceptable. The air valve shall be galvanized steel or die cast aluminum; damper shafts shall operate in rustproof Delrin, self-lubricating bearings. The air valve shall seat against durable gaskets and not exceed a 2% leakage rate per ARI standards.

D. The control device shall be designed to maintain consistent flow measurement regardless of inlet flow deflection. Angled duct inlets, at 90° or less to the control device, shall not alter the maximum or minimum factory setting by more than 10%. The assembly shall incorporate a multi-point averaging differential pressure sensor mounted on the inlet.

E. The cabinet assemblies shall be contained in a 22-gauge (minimum) galvanized steel box.

F. Cabinet shall be internally insulated with liner that prevents fibers from entering the air stream.

1. Insulation liner shall be 3/4" thick (minimum) or greater. Refer to schedule on drawing for additional requirements that may be more restrictive.
2. Insulation types include, but are not limited to, the following:
    a. Fiberglass or mineral wool acoustical duct liner bonded with a bio based thermosetting resin mat fiber-free facing.
    b. Fiberglass or mineral wool insulation with a foil or sheetmetal facing.
    c. Elastomeric closed cell insulation with a foil or sheetmetal facing.
    d. Natural (denim or recycled) fiber with bio based thermosetting resin with a foil or sheetmetal facing.
3. Refer to Section 230713 “Duct Insulation” for additional requirements.
4. Comply with ASTM E84, ASTM C1071, UL 723, UL 181, NFPA 90A and 90B, and UL Greenguard Low VOC certified.
5. K-value: 0.25 Btu•in./(hr•ft²•°F) at 75°F (maximum).
6. Flame spread index: ASTM E84, less than 25.
7. Smoke developed index: ASTM E84, less than 50.

G. Fabricate and install 10 foot (minimum) acoustically lined sheet metal discharge plenum on all air terminal units. Refer to detail on drawings for more information.

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Discharge plenum shall be mounted downstream of reheat coils where applicable. Inside dimension of plenum shall be 2" larger in height and 4” larger in width than the outlet of the air terminal unit, whichever is greater. Refer to detail on plans for additional information. This is required for acoustic noise dissipation.

1. Insulation liner shall be 2" thick (minimum) or greater. Refer to schedule on drawing for additional requirements that may be more restrictive.
2. Insulation types include, but are not limited to, the following:
    a. Fiberglass or mineral wool acoustical duct liner bonded with a bio based thermosetting resin mat fiber-free facing.
    b. Fiberglass or mineral wool insulation with a foil or sheetmetal facing.
    c. Elastomeric closed cell insulation with a foil or sheetmetal facing.
    d. Natural (denim or recycled) fiber with bio based thermosetting resin with a foil or sheetmetal facing.
3. Refer to Section 230713 “Duct Insulation” for additional requirements.
4. Comply with ASTM E84, ASTM C1071, UL 723, UL 181, NFPA 90A and 90B, and UL Greenguard Low VOC certified.
5. K-value: 0.25 Btu•in./(hr•ft²•°F) at 75°F (maximum).
6. Flame spread index: ASTM E84, less than 25.
7. Smoke developed index: ASTM E84, less than 50.

H. Controls to be direct digital and connected to the BAS. Provide boxes without operator. Provide factory mounted low voltage transformer of sufficient capacity to power the DDC controls. Coordinate control with temperature Control Contractor. Provide factory mounted operator and thermostat control if not provided by Control Contractor.

I. Manufacturer: Titus #DEDV, Price, Trane, Enviro-Tec, Carnes, Tuttle & Bailey, Nailor, Krueger, Anemostat.

2.14 DUCT SILENCERS

A. Sound traps shall be IAC Acoustics, Vibro-Acoustics, Aerosonics, United McGill, Pottorff, Ruskin, Nailor. Sound traps shall be sized for a maximum air pressure drop and maximum air velocity as noted on schedule.

B. Materials

1. Outer casings of rectangular silencers shall be made of 22-gauge type #G-90 lock-former-quality galvanized steel.
2. Interior partitions for rectangular silencers shall be not less than 26-gauge type #G-90 galvanized lock-former-quality perforated steel.
3. Filler material shall be as indicated on the Schedules and as appropriate for the application:
    a. Standard fill: Filler material shall be inorganic glass fiber of a proper density to obtain the specified acoustic performance and be packed under not less than 5% compression to eliminate voids due to vibration and settling. Material shall be inert, vermin- and moisture-proof.

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b. Encapsulated fill for hospital or clean room applications: Filler material shall be inorganic glass fiber of a proper density to obtain the specified acoustic performance and be packed under not less than 5% compression to eliminate voids due to vibration and settling. Material shall be inert, vermin- and moisture-proof. Filler material shall be totally encapsulated and sealed with polymeric film of an appropriate thickness. The encapsulated fill material shall be separated from the interior perforated baffles by means of a noncombustible, erosion resistant, factory-installed, acoustic stand-off. It shall not be acceptable to omit the acoustic stand-off and try to compensate for its absence by means of corrugated baffles.
c. Packless sound traps: No sound absorptive material of any kind is to be used in the silencers. The silencers shall attenuate air/gas transmitted noise solely by virtue of controlled impedance membranes and broadly tuned resonators.
d. “Green” fill alternate: Acoustic fill material shall be 100% environmentally friendly, and constructed of recycled natural fibers. Each fiber shall be treated with an EPA registered fungal inhibitor in order to prevent mold, mildew, fungi, and pest protection. The fill material must not contain any harmful chemicals, irritants, and/or volatile organic compounds (VOCs) in order to prevent off-gassing.

4. Combustion ratings for the silencer acoustic fill shall be not greater than the following when tested to ASTM E 84, NFPA Standard 255, or UL No. 723:

a. Flame Spread Classification: 25
b. Smoke Development Rating: 50

C. Construction

1. Units shall be constructed in accordance with the ASHRAE Guide recommendations for high pressure duct work. Seams shall be lock formed and mastic filled. Rectangular casing seams shall be in the corners of the silencer shell to provide maximum unit strength and rigidity. Interior partitions shall be fabricated from single-piece, margin-perforated sheets and shall have die-formed entrance and exit shapes so as to provide the maximum aerodynamic efficiency and minimum self-noise characteristics in the sound attenuator. Blunt noses or squared off partitions will not be accepted.
2. Attachment of the interior partitions to the casing shall be by means of an interlocking track assembly. Tracks shall be solid galvanized steel and shall be welded to the outer casing. Attachment of the interior partitions to the tracks shall be such that a minimum of 4 thicknesses of metal exist at this location. The track assembly shall stiffen the exterior casing, provide a reinforced attachment detail for the interior partitions, and shall maintain a uniform airspace width along the length of the silencer for consistent aerodynamic and acoustic performance. Interior partitions shall be additionally secured to the outer casing with welded nose clips at both ends of the sound attenuator.
3. Sound attenuating units shall not fail structurally when subjected to a differential air pressure of 8-inches water gauge from inside to outside the casing. Airtight

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construction shall be provided by use of a duct sealing compound on the jobsite material and labor furnished by the contractor.

D. Acoustic Performance

1. All silencer ratings shall be determined in a duct-to-reverberant room test facility which provides for airflow in both directions through the test silencer in accordance with ASTM Specification E477-99. The test facility shall be NVLAP accredited for the ASTM E477-99 test standard. Data from a non-accredited laboratory will not be acceptable. The test set-up and procedure shall be such that all effects due to end reflection, directivity, flanking transmission, standing waves, and test chamber sound absorption are eliminated. Acoustic ratings shall include Dynamic Insertion Loss (DIL) and Self-Noise (SN) Power Levels both for FORWARD FLOW (air and noise in same direction) and REVERSE FLOW (air and noise in opposite directions) with airflow of at least 2000 fpm entering face velocity. Data for rectangular and tubular type silencers shall be presented for tests conducted using silencers no smaller than the following cross-sections:

a. Rectangular, inch: 24x24, 24x30, or 24x36, and
b. Tubular, inch: 12, 24, 36, and 48

E. Aerodynamic Performance

1. Static pressure loss of silencers shall not exceed those listed in the silencer schedule as the airflow indicates. Airflow measurements shall be made in accordance with ASTM specification E477-99 and applicable portions of ASME, AMCA, and ADC airflow test codes. Tests shall be reported on the identical units for which acoustic data is presented.

2.15 PRE-INSULATED PHENOLIC FOAM DUCT SYSTEM FOR INDOOR CONDITIONED LOCATIONS

A. General

1. Ductwork System materials, including the panel, adhesive, tape, sealant, flanges and gasket to be certified by Underwriters' Laboratory standard as a Class 1 air duct (UL 181)
2. The preinsulated panels shall be manufactured of CFC-free phenolic foam thermo-bonded on both sides to a factory applied aluminum foil facing. The standard panel is to be no less than 1.15" (30mm) in thickness with minimum R-6 insulating value. Increase thickness as necessary to meet requirements of local energy code.
3. All fabricated duct segments and fittings shall be designed to meet or exceed the minimum requirements of the "SMACNA HVAC Phenolic Duct Construction Standards" latest edition.
4. Duct sizes are limited to maximum 80" x 80" operating up to 4" w.g. positive or 3" w.g. negative pressure class.

B. System

1. The panels used in the fabrication of the ductwork system shall Pal Phenolic Duct rigid phenolic insulation panels with a thermal conductivity of 0.1977 BTU-

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in/hr•ft^2 °F and a minimum compressive strength of 29 psi, as manufactured by Pal International.

2. Pal Phenolic Duct rigid phenolic insulation panels shall comprise a 3.4–3.75 pcf nominal density CFC/HCFC–free rigid Phenolic insulation core with zero Ozone Depletion Potential (ODP), autohesively bonded on both sides with 60-micron aluminum internal liner and a 200-micron aluminum external liner. Both liners are to be solid aluminum with no perforations.
3. All other components required for the fabrication of the system shall be from the Pal Phenolic Duct System guidelines including the sealant, contact adhesive, aluminum tape, self–adhesive gasket, ductwork reinforcements, closures, connectors and flanges.

C. Fire and Smoke Performance

1. The rigid phenolic insulation panels shall achieve the following fire and smoke performance requirements:
   a. ASTM E 84–low contribution to fire growth not exceeding 25 Flame Spread and 50 Smoke Developed indices.
   b. UL 723 –low contribution to fire growth not exceeding 25 Flame Spread and 50 Smoke Developed indices.
   c. UL 181 – UL/ULC classification as a Class 1 Air Duct to NFPA Standards 90A & 90B.

D. Sealant Material

1. All internal seams must be fully sealed with an unbroken layer of Pal Phenolic sealant.
2. Each ductwork section must be duly connected with an inter-locking, double sealed jointing system. Sufficient sealant should be applied to each layer in order to seal the rigid phenolic insulation panels and ensure minimum air leakage.
3. Ductwork reinforcement, if necessary, shall be applied to protect against side deformation from both positive and negative pressure.
4. All external seams where two separate panels join must be tiger clipped, taped and jacketed in watershed fashion whenever possible to achieve a permanent bond with a smooth appearance.

E. Manufacturers: AQC Industries #PalDuct, KoolDuct.

PART 3 - EXECUTION

3.1 DUCTWORK GENERAL REQUIREMENTS

A. Fabricate ducts with galvanized sheet steel, except as otherwise indicated and as follows:

1. All duct system appurtenances are to be the same material as ductwork including volume dampers and access panels.
2. Where duct joints are not connected using flanges or manufactured assemblies, provide sheet-metal screws equally spaces around the joint or equivalent fastening method as required by mechanical code and SMACNA HVAC Duct

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Construction Standards-Metal and Flexible. Where sheet-metal screws are utilized provide a minimum of three screws on round ductwork and minimum four screws on rectangular ductwork. Maximum spacing between screws shall not be greater than 12” on center.

3. Furnish and install backdraft dampers of applicable type at all ductwork systems connected to the outdoors (except where prohibited by code) at point of connection to the exterior of the building or where otherwise indicated in the Drawings. Backdraft dampers may be omitted only where motorized isolation dampers are indicated in the Drawings instead, where allowed by code.

   a. Contractor shall coordinate with test and balance company to set all counterbalance weights and springs on backdraft dampers during final system balancing for all systems to achieve airflows and pressures indicated in the Drawings.

3.2 DUCTWORK CONSTRUCTION AND SEALING CRITERIA

A. Leakage classification of ductwork shall conform to the minimum requirements of Table 3.1 and Table 3.2 (see below) based on procedures of “SMACNA HVAC Duct Construction Standards-Metal and Flexible” and “SMACNA HVAC Air Duct Leakage Test Manual” as follows:

TABLE 3.1
DUCT LEAKAGE CLASSIFICATION

DUCT WORKING PRESSURE CLASS	AIR PRESSURE LESS THAN +/- 0.5”WC	AIR PRESSURE +/-0.5” TO +/-2.99”	AIR PRESSURE +/-3” TO +/-10” WC
SMACNA Seal Class	C	A	A
Sealing Applicable	Transverse joints	Transverse joints longitudinal seams and all duct wall penetrations	Transverse joints longitudinal seams and all duct wall penetrations
LEAKAGE CLASS			
Rectangular sheet metal SMACNA Leakage Class	6	6	4
Round sheet metal SMACNA Leakage Class	6	4	2
Note: Duct sealant ranges and classification are generally more restrictive than SMACNA guidelines.			

B. Ductwork shall be constructed to SMACNA pressure class based on 150% of the maximum working pressure at connection to air handling unit, or better as specified

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herein. Unless called out otherwise on drawings the pressure classification of ductwork shall be as follows:

TABLE 3.2
DUCT CONSTRUCTION CLASSIFICATION

DUCT SYSTEM	LOCATION	WORKING PRESSURE (ESP FROM SCHEDULE)	BUILD TO SMACNA PRESSURE CLASS	BUILD TO SMACNA SEAL CLASS
Low pressure supply air	Downstream of air terminal units to grilles, registers or diffusers.	+0.5”	+1” wc	A
Low pressure supply air	From AHU to grilles, registers or diffusers.	+0.5 wc	+1” wc	A
Transfer air	From grille to grille, or acoustic boots or “z” bends	-/+0.25” wc	-/+0.5” wc	C
Med pressure supply air	From AHU to air terminal units	+6” wc	+10” wc	A
General exhaust	From grille to exhaust fan	-1” wc	-2” wc	A
Toilet/shower room exhaust	From grille to exhaust fan	-1” wc	-2” wc	A

3.3 DUCTWORK LEAKAGE TESTING

A. Refer to Section 230593 Testing, Adjusting and Balancing for air leakage testing requirements and procedures.

3.4 DUCTWORK SPECIALTIES INSTALLATION

A. Ductwork is generally diagrammatically indicated and shall be generally installed as indicated. Do not scale Drawings for exact location of ducts. Install ducts to best suit field conditions and cooperate with other trades. Do not penetrate Structural members without consent of Architect or Structural Engineer. Check with Structural drawings prior to locating any penetrations. Duct sizes are indicated as net inside dimensions on the Drawings. The indicated dimensions shall be altered at the job site for the purpose of avoiding interferences and clearance difficulties to other dimensions producing the same air handling characteristics, provided such altered dimensions are approved by the Architect. Ducts shall be constructed in accordance with the latest edition of codes and standards identified in Part 1 and as shown on the Drawings.

1. Grilles, Registers and Diffusers: Install flush, squared, tightly sealed, and entirely covering sheet metal ductwork and gaskets. Thread sheet metal mounting screws tightly into sheet metal. All frames shall be selected to fit the ceiling type. Verify with Architectural Drawing. Each diffuser, grille and register shall be individually capable of balancing via duct mounted balancing dampers or attached opposed blade dampers. Provide unit opposed blade damper only

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where individual duct mounted balancing dampers are specifically noted as not provided. Duct connections shall fit securely to necks or collars behind face area. Provide all necessary transition pieces and duct collars to make connections from ductwork to neck sizes. Where ducts connect directly to necks or collars provide a minimum straight duct section of two times the duct diameter to the last elbow. Where minimum straight duct sections are not physically possible provide sheet metal plenum sized for approximately 500 fpm air velocity with duct tapped directly to side of plenum. Where building walls, floors and ceilings form portions of duct or plenum, provide gasketed angles or channels at junction points, securely bolted and sealed to building structure.

2. Install turning vanes in all mitered elbows in all ducts, so that tips are parallel with the sides of the ducts. Tips of acoustical turning vanes on outside radius shall be flush with acoustical lining.
3. Provide flexible connections to completely isolate fans from direct contact with all sheet metal work.
4. Provide access doors, as required, for access to valves, controllers, and dampers.
5. Volume Dampers: Provide manual volume dampers in all supply, return and exhaust branch and run-out ductwork to grilles, diffusers, registers, and other inlet and outlet openings to facilitate balancing of air distribution systems. These are to be provided as part of contract whether shown on plans or not. Where ceilings are not accessible, provide access door or remote damper regulator. Volume dampers must be installed immediately downstream of each duct takeoff.
6. Splitters and splitter dampers shall not be installed in medium or low pressure supply ductwork to VAV systems.
7. Clean and pretreat surfaces before application of sealant. Conform to the manufacturer's cleaning procedures. Install sealants in conformance with manufacturer's instructions.
8. Except where noted, vertical ducts or horizontal ductwork penetrating fire rated ceilings, roofs, walls and floors shall be fire separated with UL listed and labeled fire dampers installed per UL tested assembly including sleeves and retaining angles. Provide additional fire dampers indicated on the Drawings and as otherwise required by the IBC and building inspector. Provide approved firestopping between damper frames and firewalls. Install fire dampers in accordance with NFPA Standards, requirements of the State Fire Marshal, and applicable codes. Ensure that fire dampers are installed in the open position.
9. For penetration of fire rated partitions which meet the IBC Chapter Seven requirements of non-Group H occupancy penetration of tenant separation and corridor walls in buildings with fire sprinklers provide metal sleeves as follows: A minimum 12 inch-long (0.30 m) by 0.060-inch-thick (1.52 mm) steel sleeve shall be centered in each duct opening. The sleeve shall be secured to both sides of the wall and all four sides of the sleeve with minimum 1-1/2" by 1-1/2” by 0.060-inch steel retaining angles. The retaining angles shall be secured to the sleeve and the wall with No. 10 screws. The annular space between the steel sleeve and wall opening shall be filled with rock wool batting on all sides.

B. Hangers and Supports: Securely fasten all ductwork to the building construction by means of hangers, supports, guides, anchors, and sway braces to maintain duct

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alignment, to prevent sagging, and to prevent noise and excessive strain on ductwork due to movement under operating conditions.

1. Maximum spacing between hangers shall not exceed ten (10) feet for rectangular sheet metal ductwork and twelve (12) feet for spiral round sheet metal ductwork. Provide hanger at each change in direction and at each branch takeoff. Refer to “SMACNA HVAC Duct Construction Standards Metal and Flexible” for additional requirements.
2. Provide duct supports within two (2) feet of each: duct elbow; connection to flexible ductwork; connection to terminal units; connection to fan coil units; connection to exhaust fans, connection to air handling units, and fire and/or smoke dampers.
3. Adequately mount and anchor all material and equipment as required. Include lateral bracing as required to prevent horizontal, seismic movement. Refer to IBC and Architectural and Structural Drawings for seismic requirements.
4. Do not support ductwork from other ducts, pipes, fans or any other pieces of equipment.
5. Powder driver fasteners shall not be used to support rectangular ducts larger than 40" maximum dimension. Powder driven fasteners shall not be allowed in existing facilities.
6. Hangers and supports shall conform to SMACNA section "Hangers and Supports". Nail inserts, hangers and supports to formwork before slabs are poured. Cut off or remove nails, strap-ends and other projections, flush with concrete after forms are removed.
7. Support vertical ducts, passing through floors with two continuous angles screwed to the duct and bearing to the floor and conforming to SMACNA section "Riser Support-From Floor". Blocking or shimming ducts will not be permitted.

C. Other:

1. Fans: Align fans, motors, and drives. Install fans to render bearings accessible for lubrication without dismantling fans or ducts. Provide extended bearing oilers as required. Mount all fans on vibration isolators as specified.
2. Insulation: Properly and neatly apply insulation on all material and equipment and apparatus, as specified, including all fittings. Apply insulation over clean, dry surfaces, with adjoining sections firmly butted together and canvas smoothly pasted over. When vapor barriers are specified, install continuous overall external surfaces of the entire system.
3. Duct Sizing: Where duct sizes are not specifically shown on the plans or must be modified due to physical limitations, supply ducts may be sized at a maximum velocity of 1,500 fpm or 0.08" sp friction per 100 feet, whichever provides the larger duct, and return/exhaust/intake ducts may be sized at a maximum velocity of 1,000 fpm or 0.06" sp friction per 100 feet, whichever provides the larger duct. Refer to Basis of Design for further duct sizing criteria.
4. Double Wall Ductwork: Insulated ductwork located and installed outside the building envelope may be constructed of two layers of galvanized sheetmetal encapsulating the insulation layer. The inner duct shall be constructed as the main carrier duct with gauge and fabrication as required per the SMACNA Duct Construction Standards and minimum 24-guage. The insulation layer shall be

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provided as required by the local energy code or Section 230713 Duct Insulation, whichever is greater. The outer sheetmetal layer shall be a non-pressurized layer, minimum 24-gauge, to encapsulate the insulation layer to prevent weather degradation and optimize the insulation effectiveness for the life of the building. The top layer shall be crossbroken and sloped 1% towards edge of duct to eliminate any locations where rainwater can collect. Or, provide additional duct supports and mounting adjustments as necessary to prevent water retention on top of ductwork.

3.5 FLEXIBLE DUCTWORK INSTALLATION

A. Flexible insulated round ductwork connectors may be utilized where shown on the Drawings and for transitions between air handling equipment and rigid ductwork. A five (5) foot (maximum) length of flexible air duct shall be allowed to be used as an elbow at a terminal devices or air outlet/inlet, unless shown otherwise on the Drawings. No intermediate joints are allowed. Seal each end using two wraps of tape listed in accordance with UL 181B and marked 181B-FX, followed by a mechanical stainless steel screw operated drawband. Plastic drawbands are not allowed. Support duct to maintain smooth shape without sagging. All connections shall utilize welded conical tees, aluminum conical fitting, Flexmaster #CBD, or 45° boot take-offs by Flexmaster #STO. Spin-in type or other types of butt tees, bullhead tees or straight taps are not permitted. Damper regulators shall include end bearings as manufactured by DuraDyne, Ventlok.

B. Flexible duct runouts to diffusers and grilles is limited to the following sizes:

1. 6” diameter: Up to 100 cfm
2. 8” diameter: Up to 200 cfm.
3. 10” diameter: Up to 360 cfm.
4. 12” diameter: Up to 600 cfm.
5. 14” diameter: Up to 900 cfm.

3.6 DUCT SILENCER REQUIREMENTS

A. Install the duct silencer per manufacturer's basic installation instruction.

B. Do not locate duct silencers within one duct diameter from fan discharge/intake openings, elbows, or takeoffs.

C. Where multiple duct silencer units are grouped together in parallel within the duct system they shall be sealed airtight at all joints.

3.7 DUCTWORK SEALANT METHODS

A. General

1. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
2. All installation shall be in accordance with manufacturer’s published recommendations.
3. Cleanliness:

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a. Before installing sealant, Surface must be dry and be free of dirt, oil, grease, and loose or foreign matter that could impair adhesion wipe ductwork to a visibly clean condition.
b. During construction, provide temporary closures of metal or taped polyethylene on open ductwork and duct taps to prevent construction dust or contaminants from entering ductwork system. Seal ends of ductwork prior to installation to keep ductwork interior clean. Remove closures only for installation of the next duct section.
c. During duration of construction, maintain the integrity of all temporary closures until air systems are activated.
d. Follow the Advanced Level requirements as found in the SMACNA Duct Cleanliness for New Construction Guidelines.

B. Installation of Mastic/Sealant Duct System

1. One Part Sealant System:

a. Apply one-part sealant system at a 20 to 30 wet mil thickness with a brush, putty knife; caulk gun or spray to duct joints, fasteners and seams. Tool, if necessary, caulk bead with putty knife or brush. Let dry per manufacturer data sheet of a minimum of 48 hours.

2. Or, One Part Spray Applied Sealant System:

a. Use a manufacturer approved airless sprayer capable of application pressure up 2,000 psi spraying through a minimum 0.111 tip. Apply in a smooth application perpendicular to the substrate at a rate of 20 to 30 wet mils to joints, seams and duct wall penetrations per manufacturer's technical data sheet. Let dry per manufacturer data sheet of a minimum of 48 hours.

C. Installation of Mastic/Sealant Duct System with 10-Year Warranty

1. Installation of Rolled Sealant Tape over Mastic/Sealant:

a. Cut desired length for each side of the ductwork; peel off release liner and center over joint, seam or penetration. The rolled sealant should completely cover the sealant. Use hand pressure to place the rolled sealant followed by a squeegee application. Lap tape end 2 inches (50 mm minimum). Squeegee rolled sealant to insure bond and complete adhesion to the duct. Instant adhesion requires precise positioning. Not re-positional. Four-Bolt flange requires applying corner pieces prior to applying the edge strips.

D. Field Quality Control

1. Allow duct sealant system to cure minimum 48 hours before pressure testing for the fluid applied Sealants. Rolled sealants can be tested immediately with duct leakage tester.
2. Ductwork leakage testing and/or inspection shall be performed prior to installation of external ductwork insulation.
3. Notify Owner's Representative a minimum of seven (7) calendar days in advance of leakage testing.

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4. Leaks identified during ductwork air leakage testing shall be repaired by:
    a. Complete removal of the sealing materials.
    b. Thorough cleaning of the joint surfaces.
    c. Installation of multiple layers of sealing materials.
5. Discrepancies found during testing and balancing between duct traverses and diffuser/grille readings shall result in re-inspection, repair and retest until discrepancies are eliminated.

3.8 INSTALLATION OF EXPOSED DUCTWORK

A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.

D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.9 FIRE, SMOKE AND COMBINATION FIRE/SMOKE DAMPER INSTALLATION

A. Install per UL and manufacturer’s installation requirements.

B. For buildings with no fire alarm system all fire/smoke dampers shall be interconnected with the HVAC unit’s controls and duct smoke detectors. The detection of smoke at any fire/smoke damper shall stop for HVAC unit fans and close all fire/smoke dampers. A single test/reset station shall be capable or resetting all devices back to normal operation.

C. Smoke and fire/smoke dampers shall close upon activation of a listed smoke detector or detectors installed in accordance with Chapter 7 of the Building Code. Other than in mechanical smoke control systems, smoke and fire/smoke dampers shall be closed upon fan shutdown where local smoke detectors require a minimum velocity to operate. Coordinate with electrical installer for all work associated with smoke and fire/smoke damper wiring and smoke detector initiation.

D. Smoke dampers shall be installed in systems with a capacity greater than 15,000 cfm to isolate the air handling equipment, including filters, from the remainder of the system on both the supply and return side, in order to restrict the circulation of smoke per NFPA 90A. Smoke dampers are not required where combination fire/smoke dampers are utilized in a smoke control system or where air handling systems serve only one floor. Refer to other exemptions as applicable per local AHJ.

E. Provide interlock to automatically shut down associated air handling unit fan upon closure of any single fire damper, smoke damper, or combination fire/smoke damper that obstructs greater than 50 percent of the design airflow.

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3.10 SEISMIC REQUIREMENTS

A. See Section 230549 for specific requirements.

B. All HVAC equipment and machinery shall be anchored to withstand forces generated by earthquake motions. As a minimum, equipment and equipment frames shall be designed to withstand a force of 100% of the weight of the equipment and frame acting at its center of gravity. Anchorage of the equipment and/or frame to the structure shall be for a force of four times gravity also acting at the center of gravity.

C. The seismic calculations shall be the responsibility of contractor.

D. Install ducts with hangers and braces designed to support the duct and to restrain against seismic forces required by applicable building codes. Comply with SMACNA-Seismic Restraint Manual: Guidelines for Mechanical Systems and ASCE/SEI 7.

1. Space lateral supports a maximum of 40 feet (12 m) and longitudinal supports a maximum of 80 feet (24 m) on center.
2. Brace each change of direction longer than 12 feet (3.7 m).

E. Select seismic-restraint devices with capacities adequate to carry present and future static and seismic loads.

F. Install cables so they do not bend across edges of adjacent equipment or building structure.

G. Install cable restraints on ducts that are suspended with vibration isolators.

H. Install seismic-restraint devices using methods approved by the AHJ.

I. Attachment to Structure: If specific attachment is not indicated, anchor bracing and restraints to structure, to flanges of beams, to upper truss chords of bar joists, or to concrete members.

J. Drilling for and Setting Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcement or embedded items during drilling. Notify the Architect if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Set anchors to manufacturer's recommended torque, using a torque wrench.
5. Install zinc-coated steel anchors for interior applications and stainless-steel anchors for applications exposed to weather.

3.11 EQUIPMENT

A. Install equipment as shown on plans and in accordance with manufacturer's installation recommendations. Provide hard ducted connections into equipment per PSU TDS.

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3.12 SUPPLY DIFFUSER AND REGISTER LOCATIONS

A. Coordinate location of supply outlets with ceiling mounted smoke detectors. Locate outlets or outlet distribution so as to prevent airflow from inhibiting the operation of smoke detectors. Locate ceiling outlets a minimum of 3'-0" from smoke detectors.

3.13 PAINTING

A. Where the interior surfaces of ductwork are visible through the blades of supply outlets, return inlets, and exhaust inlets - paint the interior visible surfaces with one coat of flat black paint.

B. Ductwork exposed on the roof or exterior to the building shall be painted. Coordinate with Division 9 for requirements.

3.14 FIELD QUALITY CONTROL

A. Do not insulate or conceal ductwork before inspection by Owner's Representative, Architect or Engineer. If ductwork is insulated and concealed prior this inspection the Contractor shall remove insulation and ceiling to permit inspection at no additional cost to the Owner. The Contractor shall replace the insulation and ceiling after final inspection at no additional cost to the Owner.

B. Ductwork Deflection Criteria:

1. Maximum inward and/or outward deflection at sheet metal panels and longitudinal joints shall be 3/4" under maximum static pressure operating conditions. Additional intermediate stiffening angles shall be installed where deflections exceed 3/4".
2. Maximum inward and/or outward deflection at sheet metal elbows and lateral joints shall be 1/4" under maximum static pressure operating conditions. Additional stiffening angles shall be installed where deflections exceed 1/4".

C. Acceptance of duct systems shall be contingent upon conformance with the requirements specified in Section 230593 "Testing, Adjusting and Balancing".

3.15 ADJUSTING AND CLEANING

A. Clean the inside of plenums, casings, enclosures, fans, and accessible ductwork before starting fans. Blowout coils and condensate piping with compressed air. Comb all coil fins that may be bent. Install a clean set of filters in each system prior to testing and balancing. Proceed with testing and balancing. All dampers shall be locked in place.

3.16 DUCT SEALING ALTERNATIVE

A. Occasionally a ducted system will experience leaks after the ductwork has been installed and sealed per one of the SMACNA duct sealant classifications. These leaks may not be identifiable until after ductwork has been installed and system air balancing and leakage testing has been engaged. At the contractor’s option an alternative solution to sealing such leaks may include the use of a water based sealing agent that is introduced to the interior of the duct system.

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1. Manufacturer: Aeroseal LLC. Application must be performed by manufacturer approved provider.
2. Sealant must be UL 723 approved for smoke and flame spread.
3. Sealant must be UL 181 approved for humidity, mold growth, temperature, erosion and puncture resistance.

B. Duct Sealing Procedure:

1. Preparation:

   a. Inspect the entire duct shaft and horizontal plenums for major leakage sites (larger than 1/2” across).
   b. Mechanically clean duct shaft per NADCA (National Air Duct Cleaners Associations) standards if more than 1/8” of surface contaminants are visible on duct surfaces.
   c. Repair all major leakage sites using mastic and fiberglass mesh tape per SMACNA standards.
   d. Temporarily remove or protect all building controls and smoke detectors from aerosol particles as recommended by the Manufacturer.
   e. Temporarily disable fire alarms and notify appropriate authorities.
   f. Temporarily isolate air-moving equipment and block off air inlets and air outlets as recommended by the manufacturer.
   g. Protect occupied spaces from aerosol particles as recommended by the Manufacturer.
   h. Protect air-moving equipment, air inlets and outlets and other devices and appurtenances as recommended by the manufacturers.

2. Duct Sealing:

   a. Seal existing ductwork from the inside using automated aerosolized sealant injection as recommended by manufacturer or by manually caulking internally with sealant.
   b. Sealant must cure within 2 hours with no odor or VOC off-gasing thereafter.
   c. Sealant shall remain elastic (not harden rigidly) after curing.
   d. Sealant shall be deposited substantially at areas of leakage only, and shall not coat interior duct walls, duct lining material, dampers, or turning vanes.
   e. Seal all test holes using patching plates sealed with mastic.
   f. Repair or replace insulation to match existing.
   g. Seal all injection openings with duct access doors or replace ductwork to match existing.

3. Duct Reassembly and Cleanup:

   a. Reinstall building controls and smoke detectors.
   b. Enable fire alarms and notify appropriate authorities.
   c. Remove blocking, reinstall grills and registers, and enable air handling fans.
   d. Cleanup sealant residue that may have adhered to surfaces in occupied areas as recommended by the Manufacturer.
   e. All work shall be done in a substantial and workmanlike manner by factory-trained technicians.

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4. Testing:
    a. Provide pre-sealing and post-sealing leakage profile reports indicating percentage reduction of duct leakage for both supply and return ductwork.
    b. Retest ductwork and document compliance with air leakage requirements as identified in section 230593 Testing, Adjusting and Balancing.
5. Warranty:
    a. The Contractor shall warrant that the aerosol sealant application will be free from defects for a period of 3 years from date of the sealing application. If defects should occur during this period, the Contractor shall repair or replace the defective duct seals, including the direct labor costs for performing the repair or replacement, at no additional cost to the Owner.

END OF SECTION 233113

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