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. Chimneys, Stacks and Flue Vents
3. Ductwork Specialties
4. Flexible Connections
5. Sealants, Adhesives and Tapes
6. Flashings
7. Bird Screens
8. Duct Access Panels and Doors
9. Control Dampers
10. Backdraft and Relief Dampers
11. Louvers
12. Diffusers, Grilles, and Registers
13. Combination Fire and Smoke Dampers
14. Fire Dampers
15. Smoke Dampers
16. Sound Traps
17. Fan Powered Terminal Units
18. Variable Air Volume (VAV) Terminal Units
19. Elevator Shaft Vents

1.3 RELATED WORK SPECIFIED ELSEWHERE

A. Section 230500: Basic Materials and Methods

B. Section 230593: Testing, Adjusting and Balancing

C. Section 230700: Mechanical Insulation

D. Section 230900: Controls and Instrumentation

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 S1.23 - Designation of Sound Power Emitted by Machinery and Equipment.
4. ASC-A7001 - Standard for Duct Sealants.
5. ASTM A167 - Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip. Type 304 or 304 stainless steel.
6. ASTM A525 - Standard Specification for General Requirements for Steel Sheet, Zinc-Coated (Galvanized) Hot-Dip Process. G90 zinc-coated.
7. ASTM A527/A527M - Standard Specification for Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Lock-Forming Quality.
8. TIMA AAC-101 - Standard for fiberglass duct liner with erosion proof facing.
9. UL 181 - Factory-Made Air Ducts and Connections, Class 1.
10. ASHRAE Standard 130-2008 Methods of Testing Air Terminal Units
11. AHRI Standard 885-2008, Procedures for Estimating Occupied Space Sound Levels in the Application of Air Terminals and Air Outlets.

B. Conform to NFPA 90A "Standards for the Installation of Air Conditioning and Ventilating Systems".

C. Provide and construct ductwork systems in conformance with the latest editions of the following documents:
1. SMACNA "HVAC Duct Construction Standards-Metal and Flexible - 2005"
2. 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 gauge or construction method of the submitted ductwork shall be the more stringent of the two standards
3. ASHRAE Systems and Equipment Handbook "Duct Construction" chapter
4. ASHRAE Fundamentals Handbook "Duct Design" chapter

D. 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.

E. All ductwork and equipment shall be seismically supported and braced per the SMACNA “Seismic Restraint Manual: Guidelines for Mechanical Systems”.

F. Flame/Smoke Rating: All materials, including sealants and adhesives, exposed within plenum shall 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.

1.5 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. Bird Screens
7. Duct Access Panels and Doors
8. Backdraft Dampers
9. Control Dampers
10. Diffusers, Grilles, and Registers
11. 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.
12. Sound Traps
13. VAV Boxes
14. 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.

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 CEC.

~~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.~~**D.** 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. Dampering of supply and returns and sealing of 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.
   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.~~**E.** Field Manual: Submit one copy of the SMACNA "HVAC Duct Construction Standards - Metal and Flexible". Maintain a second copy on the project site.

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

~~H.~~**G.** 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.~~**H.** At the discretion of the specifier, sheet metal gauges, and reinforcing may be checked at various times to verify all duct construction is in compliance.

1.6 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.

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, Kaiser, Rolok or equal.

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 per SMACNA pressurization classifications to meet ~~150% of the pressure~~**SMACNA** 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 two standards. Refer to Part III - Execution for matrix of pressure and leakage requirements.

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.
   a. 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.
   b. ~~Finishes for Surfaces Exposed to View: Mill phosphatized.~~

C. PVC-Coated, Galvanized Sheet Steel: Comply with ASTM A653/A653M.
   1. Galvanized Coating Designation: [G60 (Z180)] [G90 (Z275)].
   2. Minimum Thickness for Factory-Applied PVC Coating: 4 mils (0.10 mm) thick. On sheet metal surface of ducts and fittings exposed to corrosive conditions, and minimum 1 mil (0.025 mm) thick on opposite surface].
   3. Coating Materials: Acceptable to authorities having jurisdiction for use on ducts listed and labeled by an NRTL for compliance with UL181, Class 1.

D. Carbon-Steel Sheets: Comply with ASTM A1008/A1008M, with oiled, matte finish for exposed ducts.

E. Stainless-Steel Sheets (for laboratory and hazardous material exhaust ductwork): Comply with ASTM A480/A480M, Type 304 or 316, as indicated in the "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in the "Duct Schedule" Article.

F. Aluminum Sheets: Comply with ASTM B209 (ASTM B209M) Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for

duct surfaces exposed to view.

G. 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.

H. 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. Joints – Sealing
1. Duct tape is not allowed. Rolled elastomeric duct sealants are not allowed.
2. Solvent-based and oil-based sealants are not allowed indoors.
3. Seal all transverse joints - this includes mechanical joints similar to Ductmate on all supply, return, exhaust and outside air intake ducts.
4. All sealant systems for outdoor application to be suitable for use in exposure to water.
5. 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 gram/Liter for ductliner adhesives and 250 grams/Liter for duct sealants.
6. Manufacturers: Tremco, Dure Dyne, Hardcast, Ductmate, Mon-Eco Industries, McGill AirSeal LLC, or equal, as recommended for ductwork application.
7. Water-Based Joint and Seam Sealant: 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. Outdoor Application: Not permitted where subject to moisture exposure.
   b. Indoor Application: Hardcast Iron Grip, Ductmate PROseal, Mon-Eco EZ Seal 44-44, or equal.
8. Two-Part Tape Sealing System: Woven-fiber tape impregnated with gypsum mineral compound and modified acrylic/silicone activator to react exothermally with tape to form hard, durable airtight seal. Hardcast Two Part II, McGill Uni-Cast, or equal.

B. Joints - Rectangular Ducts
1. Slip drive joints, standard seams, flanges or welding as required by SMACNA HVAC Duct Construction Standards for system static pressure. Ductmate, MEZ Industries, or equal 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. Joint T-2, T-3, T-6 and T-7 reinforced slip joints are allowed below 2" static pressures..

C. Joints - Round
1. Exposed Ductwork: Slip drive and sheet metal screws.
2. Concealed Ductwork: Sheet metal screws.

D. 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. Provide single thickness turning vanes on all short rectangular radius elbows less than 25" wide. Provide double thickness turning vanes for short rectangular radius elbows 25" wide and greater. Number of vanes per SMACNA. ~~Elbows with square throat and radius heel are NOT allowed.~~

E. Transitions
1. Construct transitions with minimum slope of 1 to 5 ratio and in conformance to SMACNA.

F. Branch Connections
1. Provide 45º entry boots or radius taps for rectangular duct take-offs. Provide conical, bellmouth or 45º lo-loss boot taps for round duct take-offs. Straight 90° taps are not allowed, except where round take-off duct size equals round branch duct size. Provide volume dampers at take-offs for balancing if not specifically noted as provided at outlet or inlet. Provide insulation guards at transitions to lined ductwork.

2.4 RECTANGULAR DUCTWORK

A. Construct rectangular ductwork to meet all functional criteria defined in Section VII, of the SMACNA “HVAC Duct Construction Standards Metal and Flexible” 1995 Edition. This shall be subsequently referred to as the SMACNA Manual. 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.

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's "HVAC Duct Construction Standards - Metal and Flexible", Chapter 3, "Round, Oval, and Flexible Duct", based on indicated static-pressure class unless otherwise indicated. Longitudinal seams shall be spiral lock seams or continuous welded. Flat oval shall be utilized in space-restricted areas. ~~Elbows shall be 5-piece mitered and welded.~~ 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. Or equal.

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

E. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "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's "HVAC Duct Construction Standards - Metal and Flexible.” All longitudinal joints shall be sealed air tight with sealant or continuous welding.
   1. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
   2. Fabricate flat-oval ducts larger than 72 inches in width (major dimension) with butt-welded longitudinal seams.

F. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible”, Figure 3-5, "45 Degree Tees and Laterals”, and Figure 3-6, "Conical Tees” and “45 Degree Boot Tees" for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible.”
   1. Spin-in type or other types of butt tees, bullhead tees or straight taps are not permitted.

2.6 FLEXIBLE DUCTWORK

A. Flexible one-inch thick insulated round ductwork may be utilized where shown on the Drawings and at the last seven (7’) feet to each air outlet and inlet, unless shown otherwise on the plans.

B. See Part III Execution for installation requirements. ~~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. Dampers regulators shall include end bearings as manufactured by DuraDyne, Ventlok or equal.

C. Flexible ductwork for low pressure systems with positive static pressure at or below 2” w.g. positive pressure shall be a trilaminate of aluminized foil, fiberglass insulation, and aluminized polyester, mechanically locked to galvanized steel helix without adhesives, exterior 1” fiberglass insulation and fire retardant plastic outer jacket. Flexmaster #Type 5B, Thermaflex Model M-KE**, Atco #031 Polymer Inner** or approved equal.

D. Flexible ductwork for medium and high pressure systems with static pressures above 2” w.g. through 10” w.g. positive pressure shall be a heavy coated fiberglass cloth fabric mechanically locked to galvanized steel helix without adhesives, exterior

1" fiberglass insulation and fire retardant plastic outer jacket. Flexmaster #Type 4B, Thermaflex Model M-KC or approved equal.

E. Flexible aluminum ductwork for use in magnetic/electrically sensitive room environments, such as MRI rooms, in low pressure systems with static pressure at or below 2" w.g. positive pressure shall be a trilaminate of aluminized foil with aluminum helix with exterior 1" aluminum jacket fiberglass insulation. Flexmaster #TL-B or approved equal.

~~2.7 FIBERGLASS DUCTBOARD~~

~~A. Fiberglass ductboard may be utilized in the following instances and where indicated on plans:~~
~~1. Downstream of VAV boxes.~~
~~2. In the construction of return air transfer boots~~

~~B. Ductboard shall be 1" thick finished with a factory-applied thermosetting acrylic polymer coating to the air stream side resistant to potential dust incursion into the material substrate, containing an immobilized EPA-approved anti-microbial agent to further inhibit potential microbial growth as indicated by ASTM G-21 and G-22 test data and resistant to fiber shed and damage during duct cleaning operations.~~

~~C. Duct materials shall be Schuller #475 Duct board or equal. Round to be Schuller Super Round or equal.~~

~~D. Reinforce as necessary to assure no collapse of ducts under positive or negative pressures up to 1.0" W.G. of static pressure. Seaming shall be provided using Schuller Therm-Lock PFR heat activated tape. Application shall be applied with iron in accordance with manufacturer's instructions. All Therm-Lock PFR joints shall be factory assembled by an approved shop. Field joints shall be Ductmate or equal, flanged joints. Support ductwork with ¾" wide galvanized sheet metal straps at intervals recommended by manufacturer. Protect duct wall against abrasion from support straps. Support at all fittings and each change in direction.~~

~~2.8~~**2.7** FRP & HDPE DUCTWORK FOR UNDERGROUND APPLICATION

A. Code Compliance: All duct and fittings shall be designed and constructed to meet the applicable requirements of the mechanical codes for direct burial application. These requirements include:
1. Ducts to be approved for underground installation.
2. Plastic and HDPE duct and fittings described below may be utilized in underground installations only. The maximum design temperature for systems utilizing plastic duct and fitting shall be 150°F and -10" to 52" w.g.

B. Underground ductwork, including fittings, shall be constructed of fiberglass reinforced plastic as manufactured by Spunstrand Inc or HPDE manufactured by Blue Duct All ductwork and fittings shall include labels certifying this and shall be installed in strict accordance with the manufacturer's instructions.
1. Resin - The resin used shall be isophthalic polyester, tested and approved to meet requirements for underground installation and suitable for corrosion against all normal soil and moisture conditions.
2. Inner Lining - All duct and fittings shall have a UL listed Class 1 inner liner for both flame spread and smoke developed ratings.

3. Structural Layer - The structural layer shall be filament wound of resin and glass to meet the specified working pressures and depths of burial requirements.
4. Insulation – Insulation shall be closed cell polyisocyanurate foam that is 5/8" thick, R-5.
5. Fittings - Fittings shall be fabricated from straight duct and have the same working pressure and will also be corrosion and moisture resistant.
6. Reducers shall be filament wound as specified for the duct.

C. Joints - Field joints are to be watertight by using an internal aluminum sheet metal sleeve secured with sheet metal screws. The joints shall then be of the wet lay-up type in strict accordance with the manufacturer's instructions. This includes thoroughly cleaning and sanding areas to be joined and using polyester resin and fiberglass mat. See wet lay-up joint instructions.

D. Underground ductwork shall be factory pre-insulated including all fittings. The duct shall be ICBO listed and installed in strict accordance with the manufacturer's instructions.

~~2.9~~**2.8** FLUE VENTS AND STACKS

A. Refer to Section 235100 – Breechings, Chimneys, and Stacks for boiler flues and generator exhaust stacks.

~~2.10~~**2.9** DUCT/VAV UNIT SOUND CONTROL LAGGING

A. External wrapped with minimum 2" thick glass or mineral fiber blanket, 1.5 lb/ft^3 minimum density and two layers of "mass-loaded" vinyl sheet. Each lead vinyl sheet shall weight 0.4-0.5 lb/ft^2 and shall be 0.025 - 0.040 inches thick. The lead vinyl shall be applied to the fiber base fabric with edges overlapped by at least 2 inches and sealed with duct tape. Complete system or lead/vinyl material shall provide a minimum STC-20 as measured in an independent accredited acoustical laboratory in accordance with ASTM E90 and/or E413.

B. The following are acceptable:
1. Gray Loaded Vinyl from Singer Partitions, Inc., Chicago, IL.
2. Soundfab from The Soundcoat Company, Inc., Santa Ana, CA.
3. EAR WB-5 from EAR Corporation, Indianapolis, IN or approved equal.

~~2.11~~**2.10** PLENUMS AND EQUIPMENT CASINGS

A. Construct casings and plenums in conformance with SMACNA.

B. Minimum Pressure Class: Unless otherwise indicated construct plenums and casings to withstand either a negative or positive static pressure of 4" W.G.

C. Single-Wall: Provide single-wall, casings and plenums where indicated on the drawings.
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.

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

D. Double-Wall: Provide where indicated on the drawings, constructed as follows:

1. Provide 4" thick prefabricated double wall insulated metal panel assemblies, with 16MS gauge aluminum or 18 gauge minimum galvanized steel outer sheets.
2. Provide 22 gauge Type 304 stainless steel inner sheets.
3. Casings shall be fully metal enclosed, insulated with 4" thick rigid fiberglass insulation and conforming to NFPA 90A, with maximum flame spread of 25 and maximum smoke developed of 50.
4. Field or factory fabricate to size and configuration indicated on the drawings, using field verified dimensions.
5. Provide coordinated shop drawings.
6. Reinforce spans 10' or greater with structural steel sections to yield maximum deflection ¼" at minus 10" or plus 10" W.G. static pressure.
7. Provide openings and doors, all factory framed, and reinforced with 304 stainless steel structural sections.
8. 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.
9. Provide doors, hinges and hardware factory fabricated and mounted.
10. Door swings shall open against air pressure, with door latches operable from either side.
11. Provide door seals with neoprene gaskets, which have an airtight seal.
12. Provide each door with a 10" by 10" wire reinforced double pane window.
13. Bolt base channel to 3" high concrete pads.

~~2.12~~**2.11** 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. Volume and Splitter Dampers: Galvanized sheet metal blade and frame with Ventfabrics Inc., Ventlok operating hardware. 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" W.G., 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.

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

D. Flexible Connections: 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. Neoprene impregnated glass cloth with 24 gauge

galvanized metal frame. Neoprene-only connectors are not allowed. Minimum dimensions - 3" metal, 3" fabric, 3" metal. Ventfabrics #Ventglas or approved equal by Duro Dyne, Q Industries, consolidated Kinetics, Ductmate Proflex or Elgen.

E. ~~Ducts through roof shall be 16 gauge (or minimum of 2 gauges heavier than attaching ductwork),~~ flashed and counterflashed, and provided with storm collars to secure a watertight construction.

F. Bird Screens: 14 gauge, 1/2", galvanized wire mesh, set in a galvanized steel frame, screw set.

~~2.13~~2.12 DUCT ACCESS PANELS AND DOORS

A. In sheet metal work, hollow core double construction of same or heavier gauge material as duct in which installed. Use no door smaller than 12" by 12" for simple manual access or smaller than 24" by 24" where personnel must pass through infrequently. Use 24" by 60" minimum for filters and more frequent maintenance. Use Ventlok or approved hinges and latches on all doors; 100 Series hinges and latches on low pressure system doors up to 18 " maximum dimension, 200 Series on larger low pressure system doors and 333 Series on high pressure systems. Construct doors up to 18 " maximum dimension with one inch overlap fit and gasket with ¾" by ⅛" sponge rubber, fit larger doors against 1½" by ⅛" flat stock or angle frame and gasket with ¾" by ⅛" sponge rubber or felt. Door swing to be opposite airflow. CESCO, Pottorff, Vent Products, Air Balance, Ductmate Sandwich or equal. Access doors smaller than 12" x 12" can be used for visual inspection of dampers, etc. on small ductwork less than 12" wide but must be of maximum size that will fit on duct with 6" x 6" as minimum size. All access doors smaller than 12" x 12" must be approved by Engineer for the specific application prior to ordering.

~~2.14~~2.13 CONTROL DAMPERS

A. General: Low leakage dampers are to have a maximum leakage rate of 3 cfm/ft^2 at 1.0 in w.g. pressure difference when tested to AMCA Standard 500.

B. Damper Type One: Airfoil Low Leakage Dampers
1. Application: Commercial supply, return, and general exhaust air systems up to 3,000 fpm velocity.
2. Frames to be 5" x 1"x 16 gauge steel channel
3. Blades to be 6" wide, 14 gauge galvanized steel design.
4. Axles to be 1/2" diameter plated steel.
5. Bearings to be stainless steel sleeve type pressed into frame.
6. Linkage to be concealed in frame
7. Crank lever for operator to be provided.
8. Provide with mill finish on blades and frame.
9. Silicone rubber blade seals.
10. Flexible metal jamb seals.
11. Maximum temperature rating to be 300°F.
12. Edit options as applicable Required Options:
    a. Damper position indicator switch
13. Manufacturer: Ruskin #CD60, Swartout, NCA PBD/OPD-AF-101, American Warming, Air Balance, Greenheck, Pottorff, Nailor or approved equal.

C. Damper Type Two: Airfoil low Leakage for coastal environments.

1. Application: Commercial supply, return, and general exhaust air systems where damper will be exposed to damp marine air and where velocity is less than 3,000 fpm.
2. Frame to be 5" x 1" x 0.125 anodized extruded aluminum with silicon side seals.
3. Blades to be 6" wide, 6063-T-5 anodized aluminum at approximately 6" centers, opposed blade design.
4. Seals to be PVC coated polyester on blade edges, suitable for -25°F to +180°F. Jamb seal to be flexible metal compression type.
5. Bearing to be molded synthetic.
6. Linkage to be exposed on larger units and concealed on units under 14" high.
7. Stainless Steel hardware
8. Control shaft to be 1/2" diameter. Outboard support bearing to be supplied with all single section dampers for field mounted operators. Factory installed jackshaft supplied on multiple section dampers.
9. Unit to meet leakage rate of 5 cfm/sf at 3" W.G. when tested in accordance with AMCA Standard 500.
10. Manufacturer: TAMCO SW Series, Ruskin, Swartout, NCA, Pottorff, American Warming, Air Balance, Greenheck or approved equal.

D. Damper Type Three: Heavy Duty
1. Application: Velocity over 3,000 fpm and fan outlet damper.
2. Frames to be 10" x 2" x 12 gauge steel channel.
3. Blades to be 7¾" wide, 0.080 thick extruded aluminum airfoil design.
4. Axles to be 3/4" diameter plated steel.
5. Bearings to be stainless steel sleeve type pressed into frame.
6. Linkage to be out of airstream with 10 gauge galvanized steel clevis type arms on 7/8" diameter brass trunnions at 3" radius. Tie bar to be ⅜" diameter plated steel.
7. Crank lever for operator to be provided.
8. Provide with mill finish on blades and frame.
9. Maximum temperature rating to be 300°F.
10. Edit options as applicable Options:
    a. Silicone rubber blade seals.
    b. Flexible stainless steel jamb seals.
    c. Bearings with integral shaft seals.
    d. Bearings bolted to frame.
    e. Bolt holes in frame.
    f. Special finishes.
    g. Electric or pneumatic operator.
11. Manufacturer: Ruskin #CD102, Nailor, Swartout, Pottorff, American Warming, Air Balance, Greenheck or approved equal.

E. Damper Type Four: Airfoil Low Leakage Insulated Dampers
1. Application: Natural Ventilation inlets and outlets.
2. Frames to be steel or aluminum channel thermally broken with insulation within frame channels.
3. Blades to be 6" wide, insulated (1/2” polystyrene), airfoil shaped, galvanized steel double skin construction of 14 gauge equivalent design.
4. Blade Seals: Extruded silicone rubber with flexible metal compression type jamb mating seal.
5. Axles to be 1/2" diameter plated steel or stainless steel.
6. Bearings to be synthetic sleeve type pressed into frame.

7. Linkage to be concealed in frame.
8. Crank lever for operator to be provided.
9. Provide with mill finish on blades and frame.
10. Maximum temperature rating to be -40 to 200°F
11. Damper position indicator switch.
12. Manufacturer: Greenheck Model ICD-45, Ruskin #CD40x2, Pottorff, TAMCO Series 9000 BF, or approved equal performance insulating damper.

~~2.15~~**2.14** BACKDRAFT AND RELIEF DAMPERS

A. Light Duty Counterbalanced Backdraft Damper
1. Applications: Low pressure ductwork systems, including outside air intake and exhaust locations.
2. Frame: Extruded aluminum channel frame with flanges to match ductwork requirements.
3. Blades: Parallel blades, horizontal orientation, 0.025” (0.6 mm) minimum formed aluminum. Maximum 6” wide blades. Extruded vinyl blade seals mechanically attached to blade edge.
4. Counterbalance: Adjustable steel weights mechanically attached to blade.
5. Mounting: Vertically or horizontally oriented as shown on the drawings.
6. Sized for maximum velocity of 1,500 fpm (7.6 m/s).
7. Maximum back pressure of 2.0” w.g. (1.1 kPa).
8. Maximum Pressure Drop Fully Open: 0.06” w.g. (15 Pa).
9. Manufacturer: Ruskin #CBD2, Greenheck #WD Series, or equal.

B. Heavy Duty Counterbalanced Backdraft Damper
1. Application: Medium pressure air ductwork and generator exhaust.
2. Frame: Galvanized steel, 16 gage (1.5 mm) wall thickness minimum with flanges to match ductwork requirements.
3. Blades: Parallel blades, horizontal orientation, 0.05” (1.2 mm) minimum formed aluminum. Maximum 6” wide blades. Extruded vinyl blade seals mechanically attached to blade edge.
4. Counterbalance: Adjustable steel weights mechanically attached to blade.
5. Mounting: Vertically or horizontally oriented as shown on the drawings.
6. Sized for maximum velocity of 2,500 fpm (12.7 m/s).
7. Maximum back pressure of 4.5” w.g. (1.1 kPa).
8. Maximum Pressure Drop Fully Open: 0.20” w.g. (50 Pa).
9. Manufacturer: Ruskin #BD6, Greenheck #HB Series, Nailor #1380, or equal.

C. Barometric Relief Damper
1. Applications: Gravity hood exhaust, room pressurization control and stairwell pressurization relief.
2. Frame: Extruded aluminum channel frame, 0.090” (2.3 mm) wall thickness minimum with flanges to match ductwork requirements.
3. Blades: Parallel blades, horizontal orientation, 0.063” (1.6 mm) minimum formed aluminum. Maximum 6” wide blades. Extruded vinyl blade seals mechanically attached to blade edge.
4. Counterbalance: Adjustable on-blade counterweights for tuning of start-to-open and full open blade operation.
5. Axle: 3/8” (9.5 mm) galvanized steel rod with roller bearings.
6. Mounting: Vertically or horizontally oriented as shown on the drawings.
7. Sized for maximum velocity of 1,000 fpm (5.1 m/s).
8. Maximum back pressure of 2.0” w.g. (0.5 kPa).

9. Start-Open Pressure: 0.05” w.g. (12.5 Pa).
10. Manufacturer: Greenheck #BR-30 for vertical mounting, Greenheck #BD-10 for horizontal mounting, or equal.

D. Round Counterbalanced Backdraft Damper
1. Dampers shall be of the two-blade design with separate axles. Blades shall be retained in closed position with tensioned spring and field adjustable for required opening pressure. Not allowed for installation in dryer exhaust, kitchen exhaust or bypass air applications.
2. Frame: 20 gage (1.0 mm) minimum galvanized steel.
3. Blade: 0.016” thick (0.40 mm) minimum aluminum.
4. Blade Seals: Vinyl foam.
5. Axle: 3/16” (4.8 mm) minimum steel.
6. Maximum Velocity: 1,000 fpm (7.6 m/s).
7. Maximum Pressure Drop Fully Open: 0.06” w.g. (125 kPA).
8. Manufacturer: Ruskin #BDR2, Greenheck #WDR-53 or equal.

E. Light Duty Non-Counterbalanced Neoprene Backdraft Damper
1. Applications: Low pressure exhaust from small mechanical equipment less than 2,500 cfm.
2. Frame: 16 gage galvanized steel with flanges to match ductwork requirements.
3. Blades: Neoprene coated fiberglass. Maximum 6” wide blades.
4. Mounting: Vertically or horizontally oriented as shown on the drawings.
5. Sized for maximum velocity of 1,000 fpm (5.1 m/s).
6. Manufacturer: Ruskin #NMW2 or equal.

~~2.16~~**2.15** LOUVERS

A. Louvers are generally to be provided under Division 10 or as specified in the equipment schedules on the drawings.. Where louvers are not covered on architectural plans and specifications, contractor is to provide louvers with the following minimum specifications:
1. Louvers to be 6" deep, 35° drainable fixed blade design, constructed of galvanized steel or extruded aluminum, or as specified on the plans.
2. Frames to be constructed of 6" deep channel, aluminum or galvanized steel.
3. Provide with 1/2" x 1/2" aluminum mesh birdscreen mounted on backside of louver.
4. Finish/color per architect/engineer's review of manufacturers color chart or custom color matching if required.
5. Manufacturer: Ruskin #ELF6375DX or equal.

~~2.17~~**2.16** 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 25 or less. 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 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 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, Metal Aire, Nailor, Anemostat, Carnes,Tuttle&Bailey, or equal.

~~2.18~~**2.17** DUCT SMOKE DETECTORS (DSD)

A. Duct mounted photoelectric smoke detector. One required for each heating or cooling system supplying air in excess of 2,000 cfm, for systems serving more than one occupancy type, and for control of each combination fire/smoke damper when not controlled by Div. 26 area wide detection system. Coordinate with Div 16. work and electrical installer for power to smoke detector. Detector shall be mounted in the supply air ductwork downstream of the air handler and filters, or upstream of combination dampers. Coordinate with control installer to assure that detector shall shut down the air-moving equipment when smoke is detected and close associated damper actuator(s). Sensor shall be selected to operate with air velocity rating from 100 to 4000 fpm. Provide with metal sampling tube. Provide remote test and reset station at ceiling or as otherwise indicated. Duct smoke detector shall be installed in compliance with the applicable mechanical or building code. Coordinate with Section 230900 and 230593 work. System Sensor #D2 series or approved equal.

B. Additional requirements for duct smoke detectors include requirements per Section 6.4 of NFPA-90A. Provide one duct smoke detector at each story to the connection to a common supply and/or return and prior to any recirculation or fresh air inlet connection in air return systems having a capacity greater than 15,000 cfm and serving more than one story.

~~2.19~~**2.18** 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-60A.
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. Access doors shall be tight fitting hinged or sliding and shall have 1" high label reading "FIRE DAMPER", “SMOKE DAMPER”, or “FIRE/SMOKE DAMPER”.

8. All dampers to be designed for use in dynamic systems.
9. 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.
10. Dampers shall be certified for use by State and local authorities.
11. 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.
12. 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 drops 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.
13. Coordinate with "Security Bars" for installation in detention housing and high security areas.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 165°F fusible link.
3. Installation shall be in accordance with damper manufacturer's instructions.
4. Provide fire blanket where required to obtain listed fire rating.
5. Manufacturer: Ruskin #CFD Series, Greenheck #CRD Series, or equal by Pottorff, Cesco, Nailor, or Air Balance.

C. Dynamic Fire Dampers (FD):
1. Curtain fire damper constructed and tested in conformance with UL-555C.
2. Fire damper shall have a 165°F fusible link. 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. Provide duct and ceiling access panel as required.
5. Manufacturer: 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: 250°F (121°C)

d. Mounting: Vertical or horizontal

e. Frame: 5” wide by 16 gage roll formed, galvanized steel hat-channel, minimum.

f. Sleeve: Minimum 20 gage 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.

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. 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.

2) Damper position shall fail closed on lose 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 0.23A at 120V running, or 0.1A holding at 120V (27 VA and 10 VA respectively for 24V power) for 70 in-lb torque.

5) Stall and instantaneous type actuators are not acceptable.

6) Do not install in area where moisture can penetrate damper or actuator nor where actuator temperature exceeds 120°F.

7) Manufacturer: Belimo FSNF120 or FSNF24 actuators equal.

a) If a Honeywell ML-4115 actuator is submitted as an alternate, it must be provided with a time delay relay to cause the actuator to reset to drive open mode on momentary loss of power for less than 3 seconds.

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.

e. Temperature limited override: Provide a two temperature electronic high temperature limit. A primary sensor at 165°F 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.
   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 #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, 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 w.g. at full air flow.
   d. Pressure rating: 4” w.g.
   e. Manufacturer: Ruskin #FSD60 or #FSD60-3, Greenheck #FSD-211 or #FSD-231 or #FSD-311 or #FSD-331, or equal by Pottorff, 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 gage 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” sp w.g. at full air flow.
   d. Pressure rating: 4” w.g.
   e. Manufacturer: Ruskin #FSDR25 or #FSDR60, Greenheck #FSDR-511, or equal by Pottorff, 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. Manufacturer: Ruskin #FSD60-C, Greenheck #CFSD-211, or equal by Pottorff, Cesco or Air Balance.

~~E. Smoke Dampers (SD):~~

~~1. Required Locations:~~

~~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: 250°F (121°C)~~

~~d. Mounting: Vertical or horizontal~~

~~e. Frame: 5" wide by 16 gage roll formed, galvanized steel hat-channel, minimum.~~

~~f. Sleeve: Minimum 20 gage 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.~~

~~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. 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.~~

~~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 0.23A at 120V running, or 0.1A holding at 120V (27 VA and 10 VA respectively for 24V power) for 70 in-lb torque.~~

~~4) Stall and instantaneous type actuators are not acceptable.~~

~~5) Do not install in area where moisture can penetrate damper or actuator nor where actuator temperature exceeds 120°F.~~

~~6) Manufacturer: Belimo FSNF120 or FSNF24 actuators equal.~~

~~a) If a Honeywell ML-4115 actuator is submitted as an alternate, it must be provided with a time delay relay to cause the actuator to reset to drive open mode on momentary loss of power for less than 3 seconds.~~

~~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 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 w.g. at full air flow.~~

~~d. Pressure rating: 4" w.g.~~

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

~~2.20~~**2.19** SOUND TRAPS

A. Sound traps shall be I.A.C., Vibro-Acoustics, Aerosonics, United McGill, Pottorff, Ruskin, Nailor or approved equivalent. 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.
   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 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.

~~2.21~~**2.20** VARIABLE AIR VOLUME TERMINAL UNITS

A. Furnish and install variable volume zone 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 0.25" W.G. for all sizes with inlet velocities of 2,000 FPM or less.

C. The air valve shall be galvanized steel or die cast aluminum; damper shafts shall operate in rustproof Delrin or equal, 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 assemblies shall be contained in a welded 26 gauge (minimum) galvanized steel

box internally lined with minimum 1" thick insulation complying with NFPA 90A and UL 181 standards. Refer to Section 230700 "HVAC Insulation" for additional requirements.

F. Fabricate and install 5 foot (minimum) acoustically lined sheet metal discharge plenum on all air terminal units. 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 or reheat coil, whichever is greater. Refer to detail on plans for additional information. This is required for acoustic noise dissipation.

G. Hot Water Coil: Where scheduled on drawings, provide a single or double row hot water heating coil with aluminum fins mechanically bonded to copper coils. Coil velocity shall not exceed 700 FPM and static pressure loss shall not exceed .35" w.g. for a double row coil or 0.20"w.g. for a single row coil. Coil shall be pressure tested to 200 PSIG. Coil section to be based on 180°EWT and 140°LWT unless otherwise noted on schedule and include access door. Maximum water pressure drop shall be limited to 5 feet w.g. unless otherwise noted.

H. Controls to be direct digital and connected to the BAS.

I. 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.

J. Manufacturer: Titus ESV-3000, Price SDV, Trane VC, Enviro-Tec SSD, Carnes AV, Tuttle & Bailey SDV, Nailor 3000, or approved equal by Krueger, or Anemostat.

~~2.22 FAN POWERED BOXES~~

~~A. Furnish and install fan powered boxes of the type, sizes and capacities shown on the Drawings.~~

~~B. Casing: 22 gauge galvanized steel with rectangular discharge with slip and drive type connection. One piece aluminum backdraft damper provided on fan discharge. Damper factory set and aligned for precise seal. Leak rate 2% at 0.5 WG.~~

~~C. 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.~~

~~D. The assemblies shall be contained in a welded 26 gauge (minimum) galvanized steel box internally lined with minimum 1" thick insulation complying with NFPA 90A and UL 181 standards. Refer to Section 230700 "HVAC Insulation" for additional requirements.~~

~~E. Air Valve: Galvanized steel or cylindrical die cast aluminum airflow control device. Valve tapered to fit standard round flexible duct diameters. Normally open sequencing for reverse acting thermostat. Leak rate 4% at 2 WG. Integral flow ring taps, calibration chart for flow measurement, ±10% accuracy regardless of inlet~~

~~condition.~~

~~F. Fan: Fan style galvanized steel wheel. Housing is 18 gauge steel and fan board is 16 gauge steel.~~

~~G. Motor: Motor is permanent split capacitor type, direct drive, 3 speed. Motor temperature rise design criteria less than 50°C on all speeds. Optional 115 or 277 voltage.~~

~~H. Motor to be an Electrically Commutated Motor (ECM) with a minimum efficiency of 70% throughout the operating range. Motor speed to be controlled for a constant delivery fan cfm regardless of varying external static pressure. Provide remote adjustment option for integration with DDC controls by others.~~

~~I. Fan Controls: Factory mounted on off toggle switch, for disconnect and normally open P.O. switch to energize fan.~~

~~J. Disconnect Switch: Provide factory mounted fused disconnect switch with interlocking door handle on terminal box door.~~

~~K. Dust Cover: Integral control panel shall be gasketed for tight seal.~~

~~L. Hot Water Coil: Where scheduled on drawings, provide a single or double row hot water heating coil with aluminum fins mechanically bonded to copper coils. Coil velocity shall not exceed 700 FPM and static pressure loss shall not exceed .35" W.G. for a double row coil or 0.20 for a single row coil. Coil shall be pressure tested to 200 PSIG.~~

~~M. Manufacturer: Trane VFWC, Titus, Price FDV, FDVLP, FDC, FDCLP, Carnes, Enviro-Tec, Nailor 35P (parallel boxes), 35SST (Series) or approved equal by Krueger, or Anemostat.~~

~~2.23 STEAM HUMIDIFIERS (H'S)~~

~~A. Steam separator type that discharges steam into the air stream through a steam jacketed distribution manifold or dispersion tube. Humidifiers shall be complete with Y-type steam supply strainer, normally closed modulating steam control valve; normally closed condensate temperature switch; and inverted bucket steam trap. Control valve actuator to be 24 VAC powered with 0-10 VDC modulating input signal compatible with the control system as provided by Section 230900.~~

~~B. Steam Separator: Stainless steel or cast iron.~~

~~C. Distribution Manifold: Stainless steel, composed of dispersion pipe and surrounding system jacket, manifold shall span the width of duct and shall be multiple manifold type designed for full steam absorption within 2 feet.~~

~~D. Manufacturer: Armstrong, Spirax Sarco, Dristeem and Neptronic.~~

PART 3 - EXECUTION

3.1 DUCTWORK MATERIAL APPLICATION SCHEDULE

A. Fabricate ducts with galvanized sheet steel, except as otherwise indicated and as follows:
   1. Humidifier ductwork: Ductwork for humidifiers shall be constructed of 20 gauge stainless steel ductwork with longitudinal seam at top of horizontal runs and all joints sealed watertight. Duct length shall be as required by humidifier manufacturer, or as shown on drawings whichever is greater, to allow for full absorption of water vapor. This portion of duct shall include an integral drain pan and drain line connection.
   2. Environmental exhaust ductwork serving domestic clothes dryers shall be constructed of metal and shall have smooth interior surface. Provide backdraft damper at discharge to atmosphere.
   3. All duct system appurtenances are to be the same material as ductwork including volume dampers and access panels.
   4. Underground Ducts:
      a. For ductwork 24” diameter or smaller: Concrete-encased: [galvanized sheet steel] [PVC-coated, galvanized sheet steel with thicker coating on duct exterior] [stainless steel].
      b. Fiberglass reinforced plastic (FRP)
      c. Blue Duct (HDPE) with clamping system.
   5. Non-toxic and non-hazardous wet vapor exhaust:
      a. Material: Type 316L stainless steel, minimum 24 gage spiral or sheet metal ductwork. Type 316 stainless steel fittings.
      b. Joints: welded, or swaged lap-joint with silicon caulk and stainless steel sheet metal screws.
      c. All accessories shall be stainless steel including dampers, damper hardware and turning vanes.
   6. Chemical fume hood and hazardous/corrosive exhaust:
      a. Material: Type 316L stainless steel, minimum 18 gage fully welded ductwork and fittings.
      b. Joints: ~~TIG~~ welded. Weld may be either butt-weld or swaged joint with lap weld with lap running in direction of airflow. Welding rod shall be type 316L material. ~~MIG welding technique not allowed~~. Inert gas purging inside ductwork not required.
      c. All accessories shall be 316 stainless steel including dampers, air valves, damper hardware, etc..
      d. Pressure testing: refer to pressure classification and testing procedure table this specification section.
   7. Magnetically or Electrically sensitive rooms including MRIs:
      a. All ductwork, fittings, grilles/diffuser, etc, shall be constructed of aluminum in and around magnetically/electrically sensitive rooms. Refer to all construction documents for location of these critical rooms.

3.2 DUCTWORK AND 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. Clean and pretreat surfaces before application of sealant. Conform to the manufacturer's cleaning procedures. Install sealants in conformance with manufacturer's instructions.
2. 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.
3. ~~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~~**Fire caulking per as required per manufacturer instructions.**
4. 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 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.
5. Install turning vanes in all mitered elbows in all ducts, so that tips are parallel with the sides of the ducts. ~~Vanes shall be single thickness type~~. Tips of ~~acoustical~~ turning vanes on outside radius shall be flush with acoustical lining.
6. Provide flexible connections to completely isolate fans from direct contact with all sheet metal work.
7. Provide access panels or doors, as required, for access to valves, controllers, fire dampers and humidifier dispersion tubes. Access doors required in Product Conveying Vapor/Moisture Ductwork (see applicable paragraph above) shall not be installed in the bottom of the duct or in a manner to allow leaks.
8. Volume Dampers: Provide manual volume dampers in all low pressure

supply, return and exhaust branch ductwork to grilles, diffusers, inlet and outlet openings to facilitate balancing of 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 operator.

9. Splitters and splitter dampers shall not be installed in medium or low pressure supply ductwork to VAV systems.

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 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 eight (8) feet.
2. 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 Drawings for seismic requirements.
3. Do not support ductwork from fans or any other pieces of equipment.
4. Powder driver fasteners shall not be used to support rectangular ducts of 40" maximum dimension. Powder driven fasteners shall not be allowed in existing facilities where electronic equipment is located.
5. Support round duct, 30" and larger, with two hangers at each support point.
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.
4. Humidifiers: Humidifier installation shall be approved by manufacturer and coordinated with all other systems. Condensate piping shall include p-traps as recommended by the humidifier manufacturer. Insulate exposed piping as required by the code
5. Access Floor Diffusers: The mounting ring for floor mounted diffusers are to be affixed to the floor tiles using a clamp insert or other method approved for use with the floor diffuser.

3.3 FLEXIBLE DUCTWORK INSTALLATION

A. Flexible insulated round ductwork may be utilized where shown on the Drawings and at the last seven (7') feet to each air outlet and inlet, unless shown otherwise on the plans.

B. Maximum of only one 90° bend in any length. Elbows in flex ductwork are to be supported ~~using Flexmaster Flexright elbow support,~~ or equal. No intermediate joints are allowed. Seal each end using 2 wraps of tape listed in accordance with UL 181B and marked 181B-FX, followed by a mechanical stainless steel screw operated drawband. 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. Dampers regulators shall include end bearings as manufactured by DuraDyne, Ventlok or equal.

3.4 STAINLESS STEEL DUCTWORK

A. For installations serving moisture, vapor, or fume exhaust.
1. For connections to hoods or equipment provide minimum 12" length flanged ~~and bolted stainless steel~~ spool piece connection.
2. All fittings shall be long radius. Round elbows shall be minimum 5 gore.
3. Slope horizontal ductwork back toward source connected equipment minimum 1% slope so that moisture and liquids may drain back toward equipment.
4. Low point "traps" in the ductwork shall be fitted with a low point drain valve, 1/2" welded connection, stainless steel piping and valve.
5. All welding to be completed by certified welders experienced in 316 grade stainless.

3.5 CONSTRUCTION AND SEALING CRITERIA

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

Duct system:	**Location**	**Working Pressure**	**Build to SMACNA Pressure Class**	**Build to SMACNA Seal Class:**
Outdoor air intake	From ambient intake to AHU	-1" wc	-2" wc	B
Med press Supply Air	From AHU to air terminal units	+6" wc	+10" wc	A
Low press Supply Air	Downstream of air terminal units to grilles, registers or diffusers.	Low pressure	+1" wc	B
Med. Press Return air	From air terminal units to AHU	-2" wc	-3" wc	B
Med. Press Return air	From air terminal units to AHU	-1" wc	-2" wc	B
Low press Return air	From return grilles to AHU	Low pressure	-1" wc	B

Duct system:	**Location**	**Working Pressure**	**Build to SMACNA Pressure Class**	**Build to SMACNA Seal Class:**
Transfer air	From grille to grille, or acoustic boots or "z" bends	Low pressure	+0.5" wc	C
Relief air	From AHU to discharge at ambient	+1" wc	+2" wc	B
General exhaust	From grille to exhaust fan	-1" wc	-2" wc	B
General exhaust	From exhaust fan to discharge at ambient	+1" wc	+2" wc	B
General Lab exhaust	Branches from grilles to air valve and mains to exhaust fan	-2" wc	-3" wc	A, or welded. Refer to specification
Chemical fume hood and biosafety cabinet exhaust	From Hood to exhaust fan	-2" wc	-3" wc	A, or welded. Refer to specification

B. The default leakage classification of ductwork is as follows:

Duct working press. class:	**Low pressure less than +/-0.5"wc**	**+/-0.5" to +/-2.99"**	**+/-3" to +/-10" wc**
SMACNA Seal Class	C	B	A
Sealing Applicable	Transverse joints only	Transverse and longitudinal Joints	Joints, seams, and all wall penetrations
Rectangular sheet metal SMACNA Leakage Class	24	12	6
Round sheet metal SMACNA Leakage Class	12	6	3

3.6 MANDATORY DUCTWORK TESTING

A. Ductwork leakage testing may be required to meet local energy code requirements. Refer to local codes for applicability.

B. All California duct systems shall be sealed to a leakage rate not to exceed 6% of the fan flow if the duct systems are:
   1. Connected to a constant volume, single zone system, air conditioners, heat pumps or furnaces, and
   2. Serve less than 5,000 square feet of floor area, and
   3. Have more than 25% duct surface area located in one or more of the following places:
      a. Outdoors, or
      b. In a space directly under a floor where the U-factor of the roof is

greater than the U-factor of the ceiling, or

c. In a space directly under a roof with fixed vents or openings to the outside or unconditioned spaces, or

d. In an unconditioned crawlspace, or

e. In other unconditioned spaces.

4. The leakage rate shall be confirmed through field verification and diagnostic testing in accordance with procedures defined by Oriflow Air Leakage Test, or equivalent procedure.

3.7 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.

~~1. Manufacturer: Aeroseal LLC or approved equal. Application must be performed by manufacturer approved provider.~~

~~2.~~ **1.** Sealant must be UL 723 approved for smoke and flame spread.

~~3.~~ **2.** Sealant must be UP 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 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.
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.

3.8 FIBERGLASS DUCTWORK INSTALLATION

A. Ductwork fabrication and installation to be inspected by a Qualified Fabricator certified by the material manufacturer

3.9 FIRE AND COMBINATION FIRE/SMOKE DAMPER INSTALLATION

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

B. Interlock operation of all fire/smoke dampers to close dampers when the fans associated with the dampers are shut down. This also includes dampers in transfer ducts associated with system fans.

C. For buildings with no fire alarm system all fire/smoke dampers shall be interconnected with the HVAC units 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.

3.10 CONTROL DAMPER INSTALLATION

A. Note that installation of control dampers is a part of the mechanical contractor's work regardless of whether they are specified in this section or as part of products to be selected by the Control Contractor.

B. When electric actuators are provided, dampers shall be installed to allow direct over the shaft mounting of actuators. No connecting rods and stand off brackets shall be necessary.

C. 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 (parallellogramming), bowing, or other installation error.

D. Blades shall close completely. Leakage shall not exceed manufacturer's specifications at rated static.

E. Structural support shall be provided as necessary for all multi-section dampers.

F. Where blankoffs or structural supports obstruct duct or air passages, the decrease in free area shall not exceed 15% of the damper face area unless otherwise specified here or on plans.

G. No individual damper section may exceed 20 sq. ft.

H. Dampers shall be parallel blades style for outside air economizer to facilitate improved mixing of outside air and return air. Airflows shall be directed towards each other.

3.11 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.

3.12 EQUIPMENT

A. Install equipment as shown on plans and in accordance with manufacturer's installation recommendations.

3.13 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.

3.14 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.

3.15 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 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 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".

3.16 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. 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.

END OF SECTION