**PART 1 – GENERAL**

* 1. **SUMMARY**

1. Section Includes: Ductwork and appurtenances required for a complete air transmission and distribution system for the heating, ventilating, and air conditioning systems indicated on Drawings and as specified.
2. Related Requirements:
3. Division 01: General Requirements.
4. Section 09 90 00: Painting and Coating.
5. Section 23 05 00: Common Work Results for HVAC.
6. Section 23 05 13: Basic HVAC Materials and Methods.
7. Section 23 05 48: HVAC Sound, Vibration and Seismic Control.
8. Section 23 07 00: HVAC Insulation.
9. Section 23 09 23: Environmental Control and Energy Management Systems.
10. Section 23 38 13: Kitchen Ventilation System.
11. Section 23 80 00: Heating, Ventilating and Air Conditioning Equipment.
    1. **SUBMITTALS**
    2. Provide in accordance with Division 01 and Section 23 05 00: Common Work Results for HVAC.
    3. Manufacturer's Data:
       1. Complete list of items to be furnished and installed under this Section. Material lists that do not require performance data shall include manufacturer names, types and model numbers.
       2. Manufacturer's specifications and other data required to demonstrate compliance with specified requirements.
       3. Literature shall include descriptions of equipment, types, models, sizes, capacity tables or curves marked to indicate performance characteristics, electrical requirements, options selected, space requirements, including allowances for servicing, and other data. Data shall include name and address of nearest service and maintenance organization that regularly stocks repair parts. Listings of items that function as parts of an integrated system shall be furnished at one time.
       4. Submit complete acoustical test reports showing that proposed products have been tested in accordance with latest editions of relevant ASHRAE and AHRI Standards (ANSI/ASHRAE Standard 70 for air inlets and outlets; ANSI/ASHRAE Standard 130 and AHRI 880 for terminal units) and will be suitable for operation in Project spaces with specified maximum noise criteria (NC) requirements. The results of all testing shall be certified by an independent testing agency and submitted to the ARCHITECT for approval. The submittal shall include a complete description of the test conditions, methods, and procedures.
       5. Submittals shall include a tabulation of proposed products, identification of Project spaces where proposed products are to be installed, maximum allowable NC for all Project spaces, and product NC (at specific design air volume) for all Project spaces.
       6. Shop Drawings: Shop Drawings indicating methods of installation of equipment and materials, sizes and gages of ducts, and details of supports. Items to be covered shall include but not be limited to following:
    4. Layout of ductwork and equipment drawn to scale to establish that equipment will fit into allotted spaces with clearance for installation and maintenance. Indicate proposed details for attachment, anchoring to, and hanging from structural framing of building. Indicate vibration isolation units, foundations, supports, and openings for passage of pipes and ducts.
    5. Drawings indicating locations and sizes of sleeves and prepared openings for pipes and ducts.
    6. Typical details of supports for equipment and ductwork.
    7. **QUALITY ASSURANCE**
    8. Installer's and Manufacturer's Qualifications: Comply with provisions stated under Section 23 05 00: Common Work Results for HVAC.
    9. Sound power level measurements and Manufacturers' NC value calculations shall be conducted in complete accordance with the latest version of ANSI/ASHRAE Standards 70 and 130 and AHRI 880.
    10. **DELIVERY, STORAGE AND HANDLING**
12. Comply with provisions stated in Section 23 05 00: Common Work Results for HVAC.
13. Ensure ducts are clean and free of dirt, dust, moisture, oils and other contaminants that can lead to poor air quality. Cover openings of ductwork with a self-adhering protective film. Film shall not leave a residue on metal after removal and shall be highly resistant to tears and punctures.
    1. **COORDINATION**
    2. Coordinate activities in accordance with provisions of Section 23 0500: Common Work Results for HVAC.

**PART 2 – PRODUCTS**

* 1. **GENERAL**

1. Unless otherwise noted, provisions, including amendments thereto, of the latest edition of the HVAC Duct Construction Standards of Sheet Metal and Air Conditioning Contractor’s National Association (SMACNA) and the California Mechanical Code (CMC), are hereby made part of this Section.
2. Rectangular, round, and flat oval ducts shall be manufactured and installed in accordance with requirements of the latest edition of the HVAC Duct Construction Standards – Metal and Flexible of SMACNA.
3. Sheet metal ducts shall be fabricated from galvanized steel, aluminum, or stainless steel.
4. Galvanized steel ducts shall be fabricated of galvanized steel sheet, lock forming grade, conforming to ASTM A653 and A924.
5. Galvanized steel ducts gage thickness and permissible joints and seams of ductwork shall conform to requirements of the latest edition of the HVAC Duct Construction Standards – Metal and Flexible of SMACNA and the CMC unless noted otherwise on the drawings. The more stringent requirements shall prevail.
6. Button punch snap-lock seams, using Ductmate Industries, Lockformer or equal, shall be permitted only in concealed areas using 20 and 22 gage galvanized steel ducts with screws added at the ends. Button punch snap-lock is not permitted for aluminum or duct lighter than 22 gage.
7. Ducts shall be reinforced in accordance with the latest edition of the SMACNA HVAC Duct Construction Standards: Cross-broken Duct: Duct sizes 19 inches wide and larger which have more than 10 square feet of unbraced panel shall be beaded or cross-broken. This requirement is applicable to 20 gage or less thickness and 3 inches w.g. or less pressure. For details, refer to SMACNA manual.
8. Round and Oval Galvanized Steel and Aluminum Ducts:
   * 1. Round Spiral Ducts and Fittings: Fabricated from galvanized sheet steel shall be machine-formed spiral pipe with sealed spiral locking joints. Fittings shall be furnished with continuous corrosion-resistant welds. Provide gages of ducts and fittings recommended by manufacturer.
     2. Details of seams and transverse joints for round duct and fittings shall conform to SMACNA standards.
     3. Flat oval ducts shall be provided as indicated on the Drawings. Reference standard details in SMACNA manual.
     4. Minimum duct wall thickness, and permissible joints and seams of ductwork for flat oval duct construction shall conform to requirements in the latest edition of the HVAC Duct Construction Standards – Metal and Flexible of SMACNA and the CMC. The more stringent requirements shall prevail.
     5. These provisions apply for ducts furnished for indoor comfort heating, ventilating and air conditioning service only.
9. Flexible Ducts
   * 1. Flexible duct shall be non-metallic, insulated for conditioned air supply and return. The flexible ducts shall be factory fabricated with exterior reinforced laminated vapor barrier, 1 ½-inch thick fiber glass insulation (K = 0.25 at 75 degrees F), encapsulated zinc‑coated spring steel wire helix and impervious, smooth, non-perforated interior vinyl liner and factory fabricated steel connection collars. For the composite assembly, including insulation and vapor barrier, comply with NFPA Standard 90A or 90B and tested in accordance with UL Standard, UL 181. Non-insulated metallic ducts shall be provided for exhaust only. Ductmate Industries Inc., Flexmaster U.S.A. Inc., Hart & Cooley Inc., McGill Airflow Corp.
     2. Methods of installations, standards for joining and attaching, and supporting flexible duct shall conform to applicable provisions of SMACNA manual.
     3. Specifications herein shall not supersede installation requirements by flexible duct manufacturer if those are more stringent.
10. Aluminum Ducts:
    * 1. Material for aluminum duct shall be of 3003-H14 alloy aluminum sheets, with such designation embossed or stenciled on each sheet. Minimum tensile strength shall be 19,000 psi.
      2. Aluminum duct thickness and permissible joint and seams shall conform to requirements of the latest edition of the HVAC Duct Construction Standards-Metal and Flexible of SMACNA, and CMC.
      3. Aluminum ductwork shall be furnished to transport moisture-laden air from shower rooms, shower drying rooms, dishwashers and discharge ducts from evaporative condenser and cooling towers.
      4. Unless otherwise noted, follow SMACNA Duct Construction Details for steel construction standards as indicated for unreinforced duct, reinforced duct, or cross-broken duct.
      5. Button punch snap-lock seams on aluminum ducts are not permitted.
11. Stainless Steel Duct:
12. Materials for stainless steel duct shall be stainless steel conforming to ASTM A167 and A480.
13. Stainless steel ducts shall be provided as required and indicated on the Drawings.
14. Fume hood exhaust shall be stainless steel Type 304.
15. Kitchen exhaust duct system shall be stainless steel Type 304.
16. Stainless steel ducts shall be constructed with welded joints except for connections to equipment which shall be flanged joints with gaskets.
17. Entire stainless steel duct systems shall comply with current CMC requirements for product conveying ducts except where the requirements of this Section are more stringent.
18. Fittings and Other Construction Details: Details of fittings such as elbows, turning vanes, branch take-off and connections, duct access doors, connections for grilles, registers and ceiling diffusers, flexible connector at fan, etcetera, shall conform to applicable provisions of this Section or SMACNA manual.
19. Duct Seam and Joint Sealant: Provide sealant for metal ducts at duct joints which are defined as transverse joints between duct sections including girth joints, branch and sub-branch intersections, duct collar tap-ins, fitting subsections, louver and air terminal connections, access doors and frames, and abutments to building structure. Also provide the same at duct seams which are defined as longitudinal joint between duct sections. Spiral lock seams in factory fabricated round or oval ducts are excluded.
20. Sealant for low-pressure ducts shall be: Ductmate Industries PROseal or FIBERseal, Ward Industries Inc, or equal.
21. Provide sealing material for medium-pressure ducts as described in the SMACNA manual for those pressures.
22. Sealant materials shall comply with the flame spread and smoke developed rating of current CMC when tested in accordance with ASTM E84.
23. Sealant for exposed to weather ducts shall pass the Weather Resistance Test per ASTM G154 at 2000 hours QUV.
24. Restrictions:
25. Zinc-coated steel duct shall not be installed for ductwork transporting moisture-laden air. Flexible duct may only be furnished where specifically indicated on Drawings. Aluminum ducts shall not be installed for internal pressures above 2 inches of water.
26. Fiberglass duct is not permitted as a substitute for sheet metal duct.
    1. **DAMPERS**
27. Manually Operated Volume Control Dampers:
    * 1. VD-1, Rectangular: Multi-blade type, opposed blade operation, 16 gage galvanized steel blades; center pivoted on 3/8” inch diameter steel trunnions; inter­locking edges; dampers shall be in own angle frame, full duct size as indicated on Drawings; frame of minimum 16 gage steel channel construction. Provide with damper operator and axles positively locked to blade. Ruskin MD35 or equal.
      2. VD-2, Round: Frame shall be constructed of not less than 20 gage galvanized steel, blades of not less than 20 gage galvanized steel channel construction with factory neoprene seals, ½ inch diameter axle shafts and locking hand quadrant. Ruskin MDRS25, or equal.
      3. VD-3, Oval: Frame shall be constructed of not less than 14 gage galvanized steel channels with factory blade seals of not less than 12 gage galvanized steel with not less than ½ inch diameter axle shafts. Provide Ruskin standard construction for frame, blade and axle size, thickness and material variation. Provide adjustable locking hand quadrant. Ruskin CDO25, or equal.
28. Motorized Volume Control Dampers:
    * 1. MVD-1, Rectangular: Multi-blade type opposed blade operation, 16 gage minimum steel channel frame construction; 16 gage galvanized steel blades center pivoted on ½ inch diameter steel trunnions. Interlocking edges. Dampers shall be in own angle frame. Full duct size as indicated on the Drawings. Provide with matching two position motorized actuator with linkages, 24VAC by Belimo, Honeywell, Invensys, or equal. Ruskin CD35, Pottorff CD-42, Greenheck VCD Series, or equal.
      2. MVD-2, Round: Butterfly type constructed with minimum 20 gage galvanized steel frame with steel angle reinforcement on above 20-inch diameter. Blade shall be 14 gage minimum thickness. Neoprene seal to ensure air tightness in closed position. Furnish with matching two position motorized actuator with linkage 24 VAC by Belimo, Honeywell, Invensys, or equal. Ruskin CDRS25, American Warming and Ventilating (AMV) VC-25, Air Balance, Inc. AC530, or equal.
      3. Electronic Damper Actuators: Belimo, Honeywell, or equal.
    1. Sized for torque required for damper seal at load conditions.
    2. Coupling: V-bolt dual nut clamp with a V-shaped toothed cradle. Aluminum clamps or set screws are not acceptable.
    3. Overload Protection: Microprocessor or an electronic based motor controller providing burnout protection if stalled before full rotation is reached. Actuator shall be electronically cut off at full open to eliminate noise generation with the holding noise level to be inaudible.
    4. Power Requirements: As indicated on Drawings.
    5. Actuator Timing: Shall meet 15 seconds.
    6. Temperature Rating: Actuator shall have a UL 555S listing by damper manufacturer for 350 F.
    7. Auxiliary Switches: Provide for signaling, fan control, and position indications.
29. Automatic Fire Dampers:
    * 1. FD, Fire Dampers: Shall conform to requirements of and be listed by State of California Fire Marshal and NFPA 90A. Dampers shall provide airflow resistance not to exceed 0.05 inch water gage static pressure at 900 fpm or 0.25 inch water gage at 2,000 fpm. Dampers shall be installed in required steel sleeve at each penetration of a rated partition.
    1. Vertical-mounted fire dampers: Fire damper shall be curtain type with blades removed from the air stream to allow for maximum free area. Dampers will be provided in factory sleeves as tested and listed by manufacturer. Dampers shall be rated for 1 ½ hours for installation in one or 2-hour partitions. Provide UL listed fusible links of adequate size and temperature rating. Dampers will be installed according to the manufacturer's recommended installation instructions provided with units. Provide suitable access for inspection and servicing of each damper. Pottorff VFD-10/VFD-10D Series, Ruskin IBD/DIBD Series, or equal.
    2. Ceiling fire dampers: Ceiling fire dampers shall be butterfly type with ceramic material to minimize heat radiation. Dampers shall be rated for one hour and shall be furnished as a part of an integral sleeve ceiling box that will accept air distribution, have a UL listed and pre-mounted hanger tabs. Dampers shall be installed according to the manufacturers recommended installation instructions. Pottorff CFD-15 Series, Ruskin CFD Series, or equal.
    3. Combination fire and smoke dampers: Combination fire and smoke dampers shall be louver bladed type. Units shall be tested and listed under UL 555 and UL 555S. Rating 1 ½ hours for installation in one or 2-hour partitions. The seals shall be non-degradable steel to steel. Leakage shall not exceed 15 cfm/sq. ft. at one inch w.g. and shall be tested at 850 degrees F. Dampers shall be capable of being remotely controlled and reset for pressurization and smoke evacuation. Fire-releasing device shall be UL 33 listed melting fusible links. Dampers shall be provided in sleeves with pre-mounted non-stall motor actuators and dual-position indicators for remote annunciation, if required. The complete assembly shall be factory cycled and tested prior to shipment. Provide suitable access for inspection and servicing of each damper. Pottorff FSD-141 with non-stall motor, Ruskin FSD37 or FSD60 with electric fuse link Model EFL 200, with electric non-stall motor, or equal.
       1. Electronic Damper Actuators: Refer to Sub-paragraph 2.04.B.3.
30. Relief Dampers: Parallel multi-blade, counter balanced type with adjustable counter weights. Constructed of 20 gage galvanized sheet steel or extruded aluminum with solid stops all around. Bearings shall be dust proof, ball bearings. Damper shall open on a positive pressure of 0.01 inch within space and close to a backdraft. Interlocking edges shall prevent dust infiltration when closed. Air Balance, Inc., Pottorff, Ruskin, or Metal Form Manufacturing Co. Inc.
31. Duct Access Panels: Provide factory fabricated access panels in ducts where required for servicing fire or smoke dampers, and at other locations as specified in this Section. Units shall consist of removable panel, gasketed and pressure sealed by controlled spring tension locks. Construct unit, including interior parts, of same material as duct. Units shall be constructed to be suitable for installation in systems of up to 5 inches water gage static pressure. Cesco Products, Ductmate industries Inc., Flexmaster U.S.A. Inc., Greenheck, McGill Airflow Corp., Ventfabrics Inc., Ward Industries Inc.
    1. **AIR DISTRIBUTION DEVICES**
    2. General:
32. Grilles, registers, diffusers, and appurtenances shall conform to requirements specified herein and shall be of type and sizes as specified and indicated on Drawings. Performance shall be in accordance with ANSI/ASHRAE Standard 70 including airflow velocity, pressure, temperature, and sound measurements.
33. Sponge neoprene, rubber, vinyl or felt border gaskets shall be provided for surface-mounted registers, grilles, or diffusers.
34. The noise generating characteristics of all specified grilles, registers, and diffusers shall be tested to, and comply with, all requirements of this specification. Representative samples shall be subjected to tests in accordance with applicable standards and procedures to demonstrate such compliance. A special test for this project is not required if the manufacturer has previous certified test results that can be made applicable to this project. Maximum Sound Levels of diffusers, grilles and registers shall be as follows:

Administrative office area: NC 30

Classrooms: NC 20

Libraries and other noise sensitive areas: NC 25

Gymnasiums, cafeterias, lockers areas: NC 30

1. Provide suitable frame types to match the ceiling types as specified or indicated on the Architectural Drawings.
2. Ceiling diffusers shall be provided with equalizing grids.
3. Ceiling mounted grilles, registers and diffusers shall be provided with a factory applied, baked enamel, dull finish, bone white to match acoustical ceiling tile.
4. Grilles or registers mounted on painted walls or other surfaces shall be furnished with a baked prime coat and finish painted in accordance with Section 09 9000: Painting and Coating.
5. Do not provide opposed blade dampers at diffusers and registers to balance the airflow, as they tend to create noise. Provide a manual volume damper at each branch take-off and at each branch the duct to each diffuser and register upstream of the flexible duct connections. Air throw patterns shall be as indicated on the drawings.
6. Diffusers, registers, and grilles indicated or scheduled on the drawings to comply with special requirements shall take precedence over the standard items specified.
   1. Ceiling Diffusers - Round, Square, Rectangular:
7. For areas of less than 10 feet ceiling height only. Units shall be square or rectangular modular core type as indicated on the drawings. Anemostat QC Series, Titus, Krueger, Metal-Aire.
8. For areas of higher than 10 feet ceiling height. Units shall be square or rectangular louver faced type. Anemostat D Series, Titus, Krueger, Metal-Aire.
9. Units shall be round, adjustable pattern, and surface-mounted type. Anemostat C-27, Titus, Krueger, Metal-Aire.
10. Units shall be adjustable linear slot type. Anemostat SLAD Series, or equal.
    1. Grilles - Return, Exhaust, Ceiling, Square, Rectangular:
11. Acoustical Tile on Plaster Ceiling: Return and exhaust grilles shall be single deflection type with horizontal fixed face bars set at straight or 45° degree angle, ½ inch spacing and flush and flanged for surface mounting. Anemostat S3HD Series, Titus, Krueger, Metal-Aire.
12. Prefabricated Acoustical Tile Ceiling with Inverted Exposed T-Bars: Return and exhaust grilles shall be with single deflection horizontal fixed face bars, set at straight or 45° degree angle, ½ inch spacing and flush, lay-in panel type with nominal overall dimension of 24-inch by 24-inch. Anemostat Type SAC3LD Series, Titus, Krueger, Metal-Aire.
    1. Registers, Supply, Return, Wall:
13. Sidewall supply register shall be double deflecting type with volume control. Anemostat 20/L Series, Titus, Krueger, Metal-Aire.
14. Sidewall return register shall be single deflecting type with horizontal fixed face bars set at 45° degree angle flush and flanged for surface mounting and complete with volume control. Anemostat 30/L/45 Series, Titus, Krueger, Metal-Aire.
    1. **SOUND ATTENUATING EQUIPMENT - DUCT SILENCERS**
15. Provide factory fabricated duct silencers of tubular or rectangular type, for high or low velocity service, with arrangements, sizes and capacities as indicated on Drawings. Construct silencers of galvanized steel with casing seams sealed or welded to be airtight at a pressure differential of 8 inches water gage between inside and outside of unit and stiffen or brace as required to prevent structural failure or deformation at same condition, or audible vibration during normal operation. Filler material shall comply with the following:

Fire Safety Standards: NFPA 90A and 90B

Temperature: ASTM C411

Air velocity: ASTM C1071, UL 181

Fire Hazard Classification: ASTM E84, UL 723-Class 1, NFPA 255

Corrosion Resistance: ASTM C739, C665

Fungi Resistance: ASTM G21

Water Vapor Sorption: ASTM C1104, less than 1 percent by weight

Formaldehyde, Phenoloc Resins or other Volatile Organic compounds: 0 percent.

1. Select and provide silencers from acoustical and aerodynamic rating tables based on actual test readings or interpolated values of such readings obtained from tests made by recognized independent laboratories. Tests shall be in accordance with ASTM E477.
2. Select and provide silencers for air pressure drops not exceeding those indicated on Drawings, and of types, sizes and models for which noise reduction values, dynamic insertion loss, in decibels reference 10 to 12 watts, are not less than indicated on Drawings.
   1. **ZONE TEMPERATURE CONTROL DEVICES**
   2. Variable Air Volume Control Terminals:
      1. AHRI 880 certified, single duct, pressure independent, variable air volume control terminal with reheat coil, sound attenuators, multi-point flow sensor, electric actuators and electronic direct digital controls. The controllers shall comply with Section 23 0923: Environmental Control and Energy Management Systems. The coils shall be copper tubes with copper fins. Casings shall be 22 gage galvanized steel lined with minimum ½ inch, 1.5 pound density, foil faced insulation that complies with NFPA 90A and UL 181.

Anemostat, or equal.

* 1. **SMOKE DETECTORS**

1. Refer to Section 28 31 00: Fire Detection and Alarm.

**PART 3 – EXECUTION**

* 1. **EXAMINATION**

1. Examine areas and conditions under which Work of this Section will be performed. Correct conditions detrimental to proper and timely completion of Work. Do not proceed until unsatisfactory conditions have been corrected.
   1. **DUCTWORK**
2. Construct ductwork according to details of fabrication and methods of support, as indicated in the SMACNA manuals and CMC, unless specified or indicated otherwise in this Section or on Drawings. In event of conflict, the most stringent requirement shall be provided.
3. Unless otherwise required, construct ducts to conform accurately to dimensions indicated and to be straight and smooth on inside, with joints neatly finished.
4. Duct dimensions indicated are net inside dimensions.
5. Where aluminum is welded, provide a minimum thickness of 16 gage, and use gas inert tungsten process of welding.
6. Anchor ducts to building structural slab, framing and roof decking and detail method of anchoring and fastening if not indicated on Drawings. Supports shall be seismically constructed as required by the latest edition of the SMACNA guidelines.
7. Construct and install ducts to be completely free from vibration under operating conditions.
8. Indicate on layout drawing, required for suspended ductwork, location of supports, loads imposed on each fastening or anchor, typical details for anchorage, and details for special anchorage for supports attached to metal roof decking.
9. Attach supports only to building structural framing members and concrete slabs.
10. Where supports are required between structural framing members, detail and install suitable intermediate metal framing.
11. Ducts transporting air-conditioned or heated supply air shall be insulated in accordance with requirements of Section 23 07 00: HVAC Insulation.
12. Ducts exposed to weather shall be lined type from HVAC equipment through building envelope.
13. Ferrous angles and structural members and joining collars specified for construction and support of ductwork and plenums shall be primed with one heavy coat of required asphaltic aluminum paint before installation or fabrication. Metal surfaces shall be thoroughly cleaned before installation of paint. Galvanizing may be provided instead of painting. Installed duct hanger rods concealed in furred ceilings and walls are not required to be primed or painted.
14. Broken places in galvanized coating shall be acid washed and then completely soldered over or painted with galvanizing paint.
    1. **DUCT CONSTRUCTION**
15. Minimum ductwork gages, joints, reinforcing, and bracing of ductwork shall conform to SMACNA and CMC. The most stringent standards shall prevail. Additional bracing shall be provided to prevent objectionable panel vibration.
16. Button punch snap-lock seams, using Lock-former or equal, shall be permitted only in non-accessible areas using 20 and 22 gage galvanized steel ducts with screws added at the ends. Button punch snap-lock is not permitted for aluminum or duct lighter than 22 gage.
17. Provide longitudinal seams of the grooved snap lock, or Pittsburg and standing, sealed spiral or continuously welded.
18. Ferrous angles and structural members and joining collars specified for the construction and support of ductwork and plenums shall be primed with one heavy coat of asphalt aluminum paint before installation or fabrication. The metal surface shall be thoroughly cleaned before application of the paint.
19. Galvanizing may be provided instead of painting. Installed duct hanger rods concealed in furred ceilings and walls is not required to be primed or painted. Devcon Z or ZRC.
20. Broken places in galvanized coating shall be acid washed and then completely soldered over or painted with galvanizing paint.
21. S-type or drive-slip type girths or longitudinal seams shall not be furnished for ductwork installed outdoors or mounted on roofs.
22. Broken places in galvanized coating shall be acid washed and then completely soldered over or painted with galvanizing paint.
23. Duct taping Duro-Dyne, Arabol, Miracle Tape.
    1. **DUCT ELBOWS AND TURNING VANES**
24. Duct elbows, including supply, exhaust, and return, shall be provided with a centerline radius of 1.5 times duct width parallel to radius whenever possible; centerline radius shall not be less than width of duct parallel to radius. Titus, Tuttle & Bailey, Duro-Dyne, or equal.
25. Where space does not permit above radius, or where square elbows are indicated on Drawings, turning vanes shall be installed whether indicated on Drawings or not.
26. Turning vanes shall conform to SMACNA and CMC. Ductmate Industries Inc., Duro-Dyne Corp., Metalaire Inc., Ward Industries Inc.
    1. **DUCT JOINTS AND SEAMS**
27. Conditioned air supply ducts shall be furnished with joints and seams sealed, welded for air tightness, except spiral seam factory machine formed duct components. Spiral seam is exempted. Joints between slip-fit components may be assembled with all seams and joint connections fastened with screws.
28. Other ducts shall be furnished with joints and seams sealed by using sealant, taping, soldering, or welding. Ducts for grease hood exhaust shall be furnished with grease-tight welding or brazing on external surface for joints and seams. Fiberglass ducts shall be provided with a thermally activated closure system, Johns Manville Fortifiber Therm-Lock with Automatic Bond Indicator dots, or equal.
29. S-slip or drive-slip type girths or longitudinal seams are not permitted on exterior or exposed rooftop mounted ductwork.
30. Caulking, taping, or other joint or seam treatment shall be provided in accordance with recognized standards.
31. Seams around fan, coil housing and plenums shall be sealed with gaskets or sealing compound to provide an airtight assembly.
32. Stainless steel ductwork connected to range hoods and fume hoods shall be provided with grease-tight, gas tight welded seams, and shall be constructed and installed so that grease or other material cannot become pocketed in any portion thereof, and system shall slope downward toward hood not less than 1/4 inch per lineal foot. Gasketed flanged joints with sealing compound shall be used only at fan and fume hood connections.
33. Alternative duct connectors such as Ductmate Industries, Mez Industries, or equal may be used if the following conditions are met:
34. One of the specifically listed connectors is submitted and approved by the ARCHITECT and OAR.
35. The correct size connector, application, and gage of material conform to SMACNA Standards.
36. The connector is installed per manufacturer’s specifications.
    1. **DUCT TRANSITION**
    2. Slopes in sides of transition pieces shall be no greater than 1 to 5. Abrupt changes or offsets in duct system are not permitted, except when reviewed by the ARCHITECT.
    3. **DUCT TEST HOLES**
37. Holes in ducts and plenums shall be provided for pilot or static tubes for obtaining air measurements to balance or check air systems. Holes shall be covered with neoprene gasketed sheet metal cover or plugged with a fitted neoprene plug chained to duct.
    1. **SOUND ATTENUATING EQUIPMENT**
38. Install sound attenuators where required and indicated on Drawings. Refer to manufacturer’s instructions for required installation.
    1. **FLEXIBLE CONNECTIONS**
39. At points where sheet metal connections are installed to fans or air handling units, or where ducts of dissimilar metals are connected, a flexible connection of commercial grade, Duralon by Duro-Dyne Corp., Ventfabrics Inc., Ward Industries Inc.. non-combustible material shall be installed and securely fastened by zinc-coated steel clinch-type bands or a flange type connection. Inlet and outlet openings shall be axially in-line, maximum deviation of centerline shall be less than 5 percent of diameter or shortest dimension of a rectangular inlet of fan or air handling unit, with system at rest. Duct end of connection shall be seismically restrained if more than 4 feet from last support.
    1. **AIR TERMINAL DEVICES**
40. General: Install supply devices after ducts, plenums, and casings have been cleaned and blown free of small particles, as specified. Devices shall be aligned to be parallel to ceiling construction or walls and ceiling surfaces and shall be pulled tightly to compress gaskets and to fit neatly against surfaces.
41. Diffusers: Support surface mounted ceiling diffusers from angles or channels resting on and fastened to ceiling construction. Do not support from ducts. Install lay-in diffusers on T-bar ceilings with hanger wires from each corner and not supported by ceiling structure. Provide sheet metal adaptor box above each diffuser to allow space for volume controller with round collars for connection to round ducts where indicated on Drawings. Fasten duct-mounted diffusers to duct collars.
42. Registers and Grilles:
    * 1. Install wall supply registers at least 6 inches below ceiling, unless otherwise indicated. Locate return and exhaust registers 6 inches below ceiling unless otherwise indicated.
      2. Support ceiling diffuser type inlets, registers, and grilles as required above for ceiling diffusers.
      3. Fasten wall mounted and duct mounted registers and grilles to flanges of duct collars.
    1. **DAMPERS**
    2. Manually operated dampers, gravity dampers, fire dampers, and motor operated dampers shall be furnished and installed as specified and indicated. Upon completion of installation, dampers shall be checked, lubricated, and adjusted so that they operate freely, without binding. Dampers shall be of standard commercial manufacture, complete with damper frame. Where painting is required, they shall be shop finished unless otherwise noted.
43. Provide and install manual volume dampers per SMACNA standards to allow balancing per AABC, NEBB or TABB Procedures and Standards whether indicated on the drawings or not. Duro-Dyne, Ruskin Co.
44. Balancing dampers shall be installed in main supply ducts from fan discharge plenums, where two or more ducts are connected to each plenum, although such balancing dampers may not be indicated. Each zone shall be provided with a manual volume damper. Sheet metal screws shall be installed through handles and into ducts to lock damper in place after test and balance.
45. Each supply, return, and exhaust branch shall be provided with manual volume dampers.
46. Do not provide opposed blade dampers at air inlets and outlets.
47. Each supply, return, and exhaust inlet or outlet shall be provided with a manual volume damper. This damper shall be a minimum of 5 feet upstream of the air outlet and inlets. An acoustic flexible duct should be provided between the outlet and inlet and the damper for concealed ducts.
48. Dampers installed in accessible locations shall be provided with locking and indicating quadrants.
49. Dampers installed in ductwork in furred ceiling spaces or in roof spaces with less than 30 inches of clearance below beams, joists, or other construction, and where access panels are not provided shall be furnished with damper rods extended below ceiling and terminated with a concealed damper regulation.
50. Dampers not identified as splitter, extractor, or butterfly dampers shall be of multi-louver type arranged for volume damper operation. Damper shall be same dimension as adjoining duct and be tight closing. Blades shall not be greater than 9 inches. Dampers shall be not less than 18 gage steel.
51. Motor operated dampers shall be furnished by temperature control manufacturer as part of temperature control equipment and shall conform to requirements of Section 23 0923 Environmental Control and Energy Management Systems.
52. Dampers shall be provided with accessible operating mechanisms. Where operators are exposed in finished portions of building, operators shall be chromium-plated with exposed edges rounded. Splitter dampers are not permitted unless specified and reviewed by the ARCHITECT.
53. Dampers shall not be installed in combustion air ducts.
54. Access panels shall be installed for access at each damper’s operating mechanism.
    1. **FIRE AND SMOKE DAMPERS**
55. Fire dampers or combination fire and smoke dampers shall be installed and accessible at duct penetrations of rated walls and partitions and as required by State Fire Marshal and NFPA 90A, 92A, 92B, and 101. Pottorff, Ruskin Co.
56. Fire dampers shall be sized, and adjoining duct enlarged, to assure full size air passage of connecting ductwork. Pottorff, Ruskin Co.
57. Install smoke dampers as indicated on Drawings and as required in ducts penetrating smoke isolation separations. Pottorff, Ruskin Co.
58. Fire dampers or combination fire and smoke dampers shall be electrically actuated, power open-fail close type, UL 555 and UL 555S classified for 1-1/2 hours. Pottorff, Ruskin Co.
59. Provide a service disconnect switch for each and every combination smoke and fire damper.
    1. **DETECTORS**
60. Smoke detectors shall be installed in accordance with requirements of the California Mechanical Code.
61. Smoke detectors shall be installed in systems of over 2000 CFM capacity to detect presence of smoke and automatically shut down air handling units or fans unless it has been verified with the electrical installer that Exception 1 to CMC 609.0: Automatic Shutoffs, regarding automatic shutdown of systems with total coverage smoke detection systems is applied.
62. Smoke detectors shall be installed in supply system downstream of filters.
    1. **BACKDRAFT DAMPERS**
63. Backdraft dampers shall be installed at locations indicated in accordance with the State of California Building Energy Efficiency Standards, Title 24, CCR.
    1. **DUCT SLEEVES AND PREPARED OPENINGS**
64. Furnish duct sleeves for 15-inch diameter ducts or less passing through floors, walls, ceilings, or roof and install during construction of the floor, wall, ceiling, or roof. Install round ducts larger than 15 inches diameter and square and rectangular ducts passing through floors, walls, ceilings or roof through prepared openings. Provide duct sleeves and prepared openings for duct mains and duct branches.
65. Provide one inch clearance between duct and sleeve or between insulation and sleeves for insulated ducts, except at grilles, registers and diffusers.
66. Provide prepared openings for round ducts larger than 15 inches in diameter and for square and rectangular ducts with one inch clearance between duct and openings or between insulation and opening for insulated ducts, except at grilles, registers and diffusers.
67. Provide closure collar of galvanized sheet metal not less than 4 inches wide unless otherwise indicated on Drawings on each side of walls or floors where sleeves or prepared openings are provided except where grilles or diffusers are installed. Install collar tight against surface. Fit sharp edges of collar installed around insulated duct to preclude tearing or puncturing insulation covering vapor barrier. Fabricate collars from round ducts in steel. Provide not less than 4 nails to attach collar where openings are 12 inches in diameter or less and not less than 8 nails where openings are 20 inches in diameter or less.
68. Pack space between sleeve or opening and duct or duct insulation with commercial grade packing yarn.
    1. **FLEXIBLE DUCT RUNOUTS**
    2. Runouts from branches, risers or mains to air terminal units and outlets may be pre-insulated, factory fabricated flexible ducts complying with NFPA 90A. Flexible ductwork shall not exceed 7 feet in length. When required to suspend flexible ducts, furnish hangers of type recommended by manufacturers of pre-insulated flexible duct and install at intervals recommended. Method of attachment to other components of air distribution system for a vapor-tight joint shall be in accordance with printed instructions of flexible duct manufacturer. Bend radius shall be 1-1/2 times diameter of duct, measured from centerline. Bends greater than 90-degree angle are not permitted. Non-metallic flexible duct shall be permitted only in T-bar suspended ceilings.
    3. **DUCT HANGERS AND SUPPORTS**
69. Exposed or easily accessible ductwork: All exposed ducts shall be supported by all-thread Rod as a single hanger and or a trapeze support for rectangular duct work in accordance with requirements of the latest edition of the HVAC Duct Construction Standards – Metal and Flexible of SMACNA.
70. Non-accessible ductwork: Non-exposed and hidden from sight during regular school operations ductwork, rigid round, rectangular, and flat oval metal ducts, shall be installed with support systems conforming to SMACNA Standards.
71. Where ducts are installed one above the other, they shall be individually supported on a trapeze of steel angles with 3/8 inch supporting steel rods securely fastened to overhead construction. A minimum distance of 3 inches shall be maintained between ducts wherever possible, but in no event shall distance be less than 2 inches. Minimum sizes of steel angles shall be 1 ½-inch by 1 ½-inch by 1/8 inch for duct sizes through 60 inches in greatest dimension, 2-inch by 2-inch by 1/8 inch for duct sizes 61 inches through 84 inches, 2-inch by 2-inch by 3/16 inch for duct sizes 85 inches through 96 inches, and 2-inch by 2-inch by 1/4 inch for duct sizes over 97 inches.
72. Ducts six square feet area and greater and or minimum 28” round or greater shall be seismically restrained. Refer to Section 23 0548: HVAC Sound, Vibration and Seismic Control.
73. Hangers shall not be supported by, or fastened to, non-structural members including blocking. Toggle or Molly type bolts are not permitted.
74. Vertical ducts shall be supported with suitable angles on each side of each duct located at each floor and at intervals not to exceed 8 feet. Angles shall be sized and installed according to SMACNA Standards for required span so that they will be rigid, without bending or sagging.
75. Roof-mounted ductwork shall be installed a minimum 12 inches above roof and shall be supported by galvanized welded pipe, one on each side, fastened to roof structure, flashed and sealed to roof membrane. Install supports at each turn, unit connections, and each penetration, and space at maximum 6 feet off-center in general. Pitch pockets are not allowed.
    1. **ACCESS PLATES AND DOORS**
76. Access plates and doors shall be furnished and installed where stops, valves, fire dampers, fusible links, coils, damper operating mechanism, control equipment, lubrication fittings, air filters, air handling equipment and similar items normally requiring adjustment or servicing are installed in concealed spaces.
77. Access plates and doors shall be located to permit convenient access to equipment sized to permit removal of equipment for servicing. Access plates shall be no less than 12-inch by 12-inch in clear opening. Proper servicing of equipment requires adequate access for maintenance personnel. Access doors shall not be less than 24-inches by 24-inch, unless otherwise detailed. Two or more valves shall not be located in same access area unless sufficient clearance is provided for operation, servicing and removal of each valve.
78. Openings in ducts or plenums whose longer dimension does not exceed 12 inches may be covered by a plate of same material as duct, gasketed and fastened to duct or plenum with sheet metal screws.
79. Access plates in floors shall not be less than 8-inch by 8-inch and shall be carborundum surface brass with cast brass frames anchored into concrete. Access plates in tile walls shall be chromium plated brass and polished. Serrated plates furnished as part of a clean-out assembly are permitted in floors instead of a separate plate.
80. Access plates and doors in walls and ceilings of finished rooms and in locations normally accessible to students shall be furnished with continuous piano hinges, unless otherwise specified, and a special flush type spring-loaded latch requiring an Allen wrench to operate. Access devices shall be installed after plastering in plaster ground openings.
81. Access panels or doors penetrating one-hour fire resistive ceilings shall meet code requirements for such openings.
82. Access panels shall be fire-rated; Milcor, or equal. Access doors shall be as required for installation in openings penetrating one-hour fire resistive ceilings. Access doors shall be furnished with a flush, key-operated cylinder lock, furnished with two keys each, instead of Allen headlock for non-rated ceilings.
83. Access panels that are part of an integrated ceiling are specified in Section 09 8433: Wood Fiber Acoustical Units. Identification markers shall be affixed to adjacent supports, under this portion of Work, to indicate location and type of mechanical device to be serviced.
84. Access panels installed in ducts or plenums located in heater or equipment rooms containing gas-fired equipment shall be furnished with heavy-duty spring closing hinges and refrigerator door type catches unless otherwise required. When these panels are intended for maintenance personnel access, catches shall be operable from both interior and exterior.
85. Other access panels, except those specified above, shall be furnished with suitable hinges and one or more sash fasteners.
86. Panels located in ducts and plenums shall be installed with gaskets made of synthetic rubber, felt, or similar material to provide an airtight installation. Panels shall be constructed and reinforced to prevent vibration.
87. Label the words "FIRE DAMPERS" on panels over fire dampers and words "DO NOT OPEN - HEATER IS OPERATING" on panels located in heater or equipment rooms. Letters shall be approximately 3 inches high if space is available.
88. Furnish a key to operate latch access plates, one for each access plate, but not to exceed five keys for any one Project.
89. Access plates and panels shall be furnished with manufacturer's name or trademark and model number cast or stamped thereon, or upon a label permanently affixed thereon.
90. Provide duct through roof flashing as detailed in the SMACNA standards or as indicated on Drawings.
91. Refer to SMACNA for access plate and door construction.
    1. **CLEANUP**
92. Remove rubbish, debris and waste materials and legally dispose off the Project site.
    1. **PROTECTION**
93. Protect the Work of this Section until Substantial Completion.

END OF SECTION