

SECTION 23 31 16.16
THERMOSET FIBERGLASS-REINFORCED PLASTIC DUCTS
AND ACCESSORIES

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. Air Movement and Control Association (AMCA): 500-D, Laboratory Methods of Testing Dampers for Rating.
 2. American National Standards Institute (ANSI).
 3. American Society of Mechanical Engineers (ASME):
 - a. B16.1, Gray Iron Pipe Flanges and Flanged Fittings (Classes 25, 125, and 250).
 - b. B16.5, Pipe Flanges and Flanged Fittings NPS 1/2 through NPS 24.
 - c. B18.22.1, Plain Washers.
 4. ASTM International (ASTM):
 - a. A193/A193M, Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High Temperature or High Pressure Service and Other Special Purpose Applications.
 - b. A194/A194M, Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
 - c. C582, Standard Specification for Contact-Molded Reinforced Thermosetting Plastic (RTP) Laminates for Corrosion Resistant Equipment.
 - d. D3982, Standard Specification for Contact Molded "Fiberglass" (Glass Fiber Reinforced Thermosetting Resin) Duct and Hoods.
 - e. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
 5. Sheet Metal and Air Conditioning Contractors' National Association, Inc., (SMACNA): Thermoset FRP Duct Construction Manual.

1.02 DEFINITIONS

- A. The following is a list of abbreviations which may be used in this section:
1. CFM: Cubic feet per minute.
 2. FPM: Feet per minute.
 3. FRP: Fiberglass reinforced plastic.
 4. H₂S: Hydrogen sulfide.
 5. MDFT: Mean dry film thickness.
 6. PCF: Pounds per cubic foot.

7. ppmV: Parts per million (volume).
8. PWPE: Profile wall polyethylene.
9. WC: Water-column.

1.03 SUBMITTALS

A. Action Submittals:

1. Duct:
 - a. Statement of resins and reinforcing proposed for use.
 - b. Pressure, vacuum, and temperature rating of duct.
 - c. Dimensions of subassemblies to be shipped.
 - d. Manufacturer's data and descriptive literature for duct accessories, including hardware and gaskets.
 - e. Drawings showing overall layout, slopes, supports, and joint details.
 - f. Shop spool drawings including location of field joints, flexible connectors, dampers and any other duct accessories.
 - g. Stamped and signed structural engineering design calculations.
 - h. Information, details, and requirements for installation and support of duct and torque values for flange bolting.
 - i. Documentation indicating duct strength is adequate to support duct at elevated spans, as shown on the Drawings.
 - j. Name of manufacturer.
2. Supports:
 - a. Location plan.
 - b. Type and details.
 - c. Materials of construction.
 - d. Stamped and signed structural engineering design calculations for special supports, such as supports to accommodate extended spans or cantilevered loading or as shown on the Drawings.
 - e. Anchorage and bracing drawings, load criteria, and cutsheets, as required by Section 01 88 15, Anchorage and Bracing, for ducting systems and supports.
3. Ductwork Load Calculations:
 - a. Complete ductwork calculations for confirming required wall or gauge thickness, stiffeners, joint placement, expansion joint placement, and support spacing.
 - b. Calculations shall be stamped by an engineer licensed in the State of Arizona.
 - c. Conform to manufacturer's requirements as well as design criteria provided in Structural General Notes on the Drawings, requirements set forth herein, and other referenced standards.
 - d. Run calculations for all ductwork spans shown on the Drawings as well as cantilevered assemblies where shown on the Drawings.

- e. Include, as a minimum, the following duct loadings:
 - 1) Self-weight.
 - 2) Internal pressure/vacuum.
 - 3) Wind.
 - 4) Seismic.
 - 5) Ancillary (electrical conduit, dampers, actuators).
 - 6) Snow loads.
- 4. Expansion Joints/Flexible Connectors:
 - a. Type and model.
 - b. Materials of construction.
 - c. Allowable movements in all three directions.
 - d. Name of manufacturer.
- 5. Butterfly and Backdraft Dampers:
 - a. Statement of resins and reinforcing proposed for use.
 - b. Pressure, vacuum, and temperature rating.
 - c. Materials of construction.
 - d. Total weight including operator.
 - e. Drawings showing overall dimensions and connection size.
 - f. Type and model.
 - g. Name of manufacturer.

B. Informational Submittals:

- 1. Qualifications:
 - a. Fabricator: List of references substantiating experience.
 - b. Installer: Manufacturer's certification that installer is qualified for installation work.
- 2. Anchorage and bracing calculations or loading information as required in Section 01 88 15, Anchoring and Bracing, for ducting systems and supports.
 - a. Anchorage, bracing, and support design criteria and calculations:
 - 1) Stamped by a civil or structural engineer licensed in the State of Arizona.
 - 2) Conform to manufacturer's requirements as well as design criteria provided in Structural General Notes on the Drawings and other referenced standards.
 - b. Indicate edge distance, embedment, concrete thickness and strength, and other conditions assumed in anchor calculations.
 - c. Verify assumed field conditions prior to anchor and bracing installation.
- 3. Manufacturer's factory inspection report.
- 4. Manufacturer's installation instructions.
- 5. Detailed information on structural, mechanical, electrical, or other modifications necessary to adapt the arrangement or details shown to the ductwork installation.

6. Component and attachment testing seismic certificate of compliance as required by Section 01 45 33, Special Inspection, Observation, and Testing.
7. Dampers: AMCA 500-D leakage test results by AMCA-approved laboratory.
8. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 79 00, Demonstration and Training.

1.04 QUALITY ASSURANCE

A. Qualifications:

1. Fabricator: Minimum 5 years' experience.
2. Installer: Minimum 5 years' experience.
3. Joint Installer: Manufacturer certified.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Shipping:

1. Do not ship ducting by nesting small diameter components inside larger diameter components.
2. Protect flanged sections by bolting to wooden blinds 2 inches greater than outside diameter of flange.
3. For nonflanged components, use either rigid plugs inside ends to prevent deflection or protect with wooden boxes.
4. Crate materials whenever practical prior to shipment.
5. Firmly fasten and pad components shipped to prevent shifting or flexing of components while in transit.

1.06 ENVIRONMENTAL REQUIREMENTS

- ##### A. Temperature: Make field joints only when ambient temperature is above 55 degrees F and below 100 degrees F.

PART 2 PRODUCTS

2.01 GENERAL

A. Physical Characteristics:

1. Ductwork and accessories shall be located in hydrogen sulfide (H₂S) rich environment. Ductwork and accessories will be exposed to (H₂S) gas to maximum of 5 ppmV saturated with water vapor.
2. FRP Ducting: Drawings do not indicate all field joint locations. It is anticipated bell and spigot, or flanged duct connections shall be used throughout where inside overlay is not possible. Duct manufacturer

shall indicate all field joint locations and type on submitted Shop Drawings. Flange duct connections shall be provided as needed and as shown. Coordinate with duct supports. Field butt joints are not allowed.

B. Functional Characteristics: None.

C. Performance Characteristics: None.

2.02 MATERIALS

A. Physical Characteristics:

1. Resin:

- a. Resin System: Premium corrosion-resistant, fire-retardant vinylester, or other qualified thermosetting resin. Resin to be selected by fabricator, subject to approval of Contracting Officer, and suitable for intended service with no fillers or thixotropic agents.
- b. Liner Resin: Premium grade and corrosion resistant.
- c. Structural wall resin may be of different chemical resistance, subject to conditions of service and approval of Contracting Officer.
- d. Flame Spread Index: ASTM E84, less than 25; fire retardant additives used only in structural layer.
- e. Structural wall resin shall not exceed a flame spread index of 25 without the need for additives.
- f. Add ultraviolet absorbers to surfacing resin to improve weather resistance.
- g. Color: Use no dyes, pigments, or colorants except in exterior gel coat. Exterior gel coat shall be white.

2. Reinforcement:

- a. Veil: Chemical surfacing mat, Type C (chemical) glass, 10 mils thick, with finish and binder compatible with lay-up resin.
- b. Corrosion Barrier: Resin-rich interior surface of nominal 100 mils to 120 mils thick, using chopped strand mat backing the veil. Use no additive in corrosion barrier.
- c. Chopped Strand Mat: Type E glass, minimum 1-1/2 ounces per square foot, with silane finish and styrene soluble binder.
- d. Continuous Roving for Chopper Gun Spray-Up: Type E glass.
- e. Woven Roving: Type E glass, nominal 24 ounces per square yard, 4 by 5 weave, with silane type finish.
- f. Continuous Roving for Filament Winding: Type E glass with silane type finish.

3. Fasteners:
 - a. Bolts: ASTM A193/A193M, Type 316 stainless steel, ANSI coarse thread series, Grade B 8M hex head.
 - b. Nuts: ASTM A194/A194M, Type 316 stainless steel, Grade 8M.
 - c. Washers: ASME B18.22.1, flat, Type 316 stainless steel.

B. Functional Characteristics: None.

C. Performance Characteristics: None.

2.03 DUCTWORK

A. Physical Characteristics:

1. Conform to ASTM D3982, ASTM C582, and/or SMACNA Thermoset FRP Duct Construction Manual.
2. Duct manufacturer's design for round section, including duct wall thickness and stiffeners.
 - a. Round duct to be fabricated per SMACNA filament wound (Type X) composites laminate Table 5 to Table 6.
3. Provide duct with extra wall thickness as required to support duct at elevated spans and to withstand moments resulting from cantilever arrangement, where shown on the Drawings.
4. Corrosion liner and barrier thicknesses shall not be included in ductwork structural calculations.
5. Round duct shall have a safety factor of 10 to 1 for pressure and 5 to 1 for vacuum service. Rectangular duct design criteria shall be submitted to the Contracting Officer for review and approval. Rectangular duct design shall be based on maximum 1 percent side wall deflection.
6. Take into account expansion from seasonal temperature variations.

B. Functional Characteristics:

1. SMACNA Duct Class: Class 5 (corrosive, moist, nonabrasive) for odor control duct system(s).
2. System Maximum Pressure: 10 inches of water column.
3. System Maximum Vacuum: 10 inches of water column.
4. Location: Outside.
5. Ambient Temperature: 0 degree F to 100 degrees F.
6. Seismic Requirements: As shown on the Structural Drawings.
7. Wind and Snow Loads: As shown on the Structural Drawings.

C. Performance Characteristics: None.

2.04 FABRICATION

- A. Physical Characteristics: Meet or exceed requirements of ASTM D3982 and ASTM C582. Fiberglass ductwork manufactured from a mesh of fiberglass fibers held together with a resin to create a lightweight corrosion resistant duct and fittings.
- B. Fittings and special sections shall be reinforced, or their shell thickness increased where combined stresses because of internal pressure and bending will exceed maximum stress. Shell thickness or reinforcing shall be as required to keep combined stresses below maximum recommended.
- C. Flanged connections or bell and spigot wrapped connections shall be used as required.
- D. Squareness of ends, fittings, elbows, and butt joints shall meet or exceed requirements of ASTM D3982.
- E. Keep use of flanges to a minimum; butt joints are preferred method of joining sections of duct.
- F. Butt joints shall only be permitted in duct sections that are accessible for inside overlay. Internal overlay to consist of two layers of 1-1/2 ounce per square foot of fiberglass mat followed by one layer of surfacing veil, as a minimum.
- G. Flanges for Duct-to-Duct Connections and Duct Wall Thicknesses: ASTM D3982, rated for specified pressure and vacuum.
- H. Flange dimensions (except thickness) and drilling patterns for flanges that connect to equipment, valves, or dampers are to correspond to ASME B16.5, Class 150 or ASME B16.1, Class 125. All other flanges shall comply with ASTM D3982 Table 1.
- I. Furnish gussets on flanged nozzles from ducts.
- J. Back Face of Flanges: Spot-faced, flat, and parallel to flange face, and of sufficient diameter to accept ANSI metal washer under bolt head or nut.
- K. Laminate:
 - 1. Reinforce inner surface of ducts with resin-rich surfacing veil 10 mils thick to 20 mils thick.
 - 2. Construct interior layer of resin reinforced with at least two plies of chopped strand mat; thickness at least 100 mils.
 - 3. Glass content of combined inner surface and interior layer shall be 27 percent plus or minus 5 percent.

4. Structural Layer:
- a. Fabricated using either hand lay-up construction per ASTM 3982 or filament wound. Structural layer shall not be less than the following thicknesses:

Diameter (inches)	Thickness (inches)
6 - 20	1/8
22 - 28	3/16
30 - 58	1/4

L. Duct and Fittings:

1. Physical Characteristics:
- a. Type: Contact molded or filament wound, meeting requirements of ASTM D3982.
- b. Joints: Butt wrapped except flanged at connections to expansion joints, butterfly valves, blast gates, or mechanical equipment.
- c. Fittings: Plain end or flanged, manufacturer's standard sizes. Comply with ASTM D3982 with chemical resistance equal to or greater than the duct.
- d. Gaskets: EPDM, 3/16-inch thick, full-face, Type A Durometer of 50-60.
- e. Flanges shall have minimum thickness in accordance with ASTM D3982, rated for specified pressure and vacuum.
- f. Transitions: Glass-fiber reinforced, with wall stiffness equal to that of duct, designed using pipe design criteria. Maximum deflection of side shall be less than 1 percent of width of that side at design internal pressure. Shop-installed reinforcing (such as, ribs or angles) shall be used if required to meet deflection requirements.
- g. Elbow fittings shall have centerline radius of 1.5 times duct diameter unless Site conditions dictate less. Elbow fittings shall have smooth non-segmented radius.
2. Functional Characteristics: None.
3. Performance Characteristics: None.

M. Cure products to at least 90 percent of minimum Barcol hardness specified by resin manufacturer.

N. Marking:

1. Identify each duct component with fabricator's name, resin, minimum thickness, and manufacture date.

2. Use permanent marking. Seal decals and labels into laminate exterior with resin.
3. For piece marking used for installation, use oil-based paint for easy removal.

O. Sample and Test Ports:

1. Field-installed or factory-installed as shown.
2. Materials of construction FRP or PVC.
3. Port configuration shall allow free passage of a pitot tube.
4. Provide ports at inlet and outlet of each fan or as shown. Locate to allow for pressure testing and air sampling.
5. Provide ports for each branch connection upstream of each balancing damper. Locate to allow for flow rate measurement pressure testing and air sampling.
6. Where possible, locate port on the side of the duct. Test ports shall not be located in bottom 90-degree arc of duct.

P. Supports:

1. Physical Characteristics:
 - a. Supports for FRP ductwork shall be provided in accordance with Section 40 05 15, Piping Support Systems and the requirements of this section.
 - b. Maximum Duct Deflection: 1/2 inch, including special sections at road crossings.
 - c. Support Spacing:
 - 1) 24 Inch Diameter and Larger: 15 feet, maximum.
 - 2) 20 Inch Diameter and Smaller: 10 feet, maximum.
 - d. Where fixed collars or lugs are shown for fixed type supports, Supplier will provide such duct elements for meeting imposed loads while meeting design criteria stipulated herein and will coordinate with duct support supplier.
 - e. Where duct supports induce localized distributed loads on ductwork, ductwork shall be designed to accommodate such loads while meeting design criteria stipulated herein.
 - f. Duct support material as shown on the Drawings.
 - g. Extended Span Lengths:
 - 1) Where extended span lengths are shown, Supplier will design self-supporting ducting to meet maximum duct deflection as specified.
 - 2) Special stiffening systems shall be submitted for approval.
 - 3) Provide structural calculations to support stiffening system and proposed wall thicknesses as called out in Article Submittals.

2. Functional Characteristics: None.
3. Performance Characteristics: None.

2.05 EXPANSION JOINTS/FLEXIBLE CONNECTIONS

A. General:

1. Physical Characteristics:
 - a. Provide as shown or as required for proper duct installation. Flanged type expansion joints and flexible connections unless specifically indicated to be plain end (slip-on) type.
 - b. Type: W-design configuration with integral flanges suitable for service with FRP duct. Corners on rectangular expansion joints shall be molded and free of splices.
 - c. Material: Fabric-reinforced EPDM resistant to UV light; continuous wrapping of material shall not be permitted.
 - d. Backing Rings: 3/8-inch thick, 2 inches wide, Type 316 stainless steel to match drilling pattern of connecting flange.
 - e. Length: 12 inches, flange-to-flange.
 - f. Thickness: 1/4 inch, minimum.
 - g. Flanges shall be a minimum of 1/4-inch thick.
 - h. Slip-on type expansion joints and flexible connections shall be sized to fit tightly on the outside diameter of the duct, secured in place by stainless steel worm screw type adjustable clamps to provide gas-tight connection.
2. Functional Characteristics:
 - a. Extension: 1 inch (12 inches long) or 0.5 inch (6 inches long).
 - b. Compression: 4 inches (12 inches long) or 2 inches (6 inches long).
 - c. Lateral Offset: 3 inches (12 inches long) or 1 inch (6 inches long).
3. Performance Characteristics: None.

2.06 BUTTERFLY DAMPERS

A. Dampers:

1. Physical Characteristics:
 - a. Single-blade type, complete with channel-type frame, close-fitting axle, and bearings.
 - b. Same inside diameter as connecting ductwork.
 - c. Axles not less than 3/4 inch in diameter and shall be continuous through damper.
 - d. When used for isolation service, dampers shall be furnished with blade seal and shaft seal.
 - e. When used for balancing only, dampers shall be furnished with full circumference molded in blade stop.

- f. Design Requirements:
 - 1) Each damper shall be designed for the following conditions:
 - a) Air Temperature Range: 0 degree F to 100 degrees F.
 - b) Differential Pressure: Six-inch WC.
 - g. Materials:
 - 1) FRP materials for dampers shall be same resin as used in ductwork.
 - 2) Requirements for flame spread and smoke development shall be same as required for ductwork.
 - h. Construction:
 - 1) Frames: Fiberglass reinforced plastic with resin as described herein.
 - 2) Blades: Fiberglass reinforced plastic with resin as described herein. Blade thickness and stiffeners as required to meet design conditions.
 - 3) Axles: Continuous FRP rod with resin as described herein. Axle to extend 6 inches beyond frame.
 - 4) Bearings: Molded PTFE.
 - 5) Blade Stops: FRP with resin as described herein.
 - 6) Blade Seals: Polychloroprene.
 - 7) Shaft Seals: Polychloroprene.
 - 8) Flanges: As specified to match ductwork flanges.
 - 2. Functional Requirements:
 - a. Isolation dampers shall have maximum leakage rate of 6.93 cubic feet per minute per square foot of damper area, at a differential pressure of 12 inches WC. AMCA leakage tests shall be furnished as part of the submittal.
 - 3. Performance Requirements: None.
- B. Lever Actuators:
- 1. Provide for dampers 24-inch diameter and smaller:
 - a. Hand quadrant type.
 - b. Constructed of Type 316 stainless steel.
 - c. Locking quadrant suitable for positioning blade at intermediate position.
- C. Hand Actuators: Provide for dampers larger than 24-inch diameter.
- 1. Hand actuators shall be worm geared driven.
 - 2. Actuators shall be totally enclosed, weather-proof, and permanently lubricated in die-cast aluminum housing.
 - a. Housing shall be epoxy coated in factory with minimum dry film thickness of 8 mils.
 - 3. Hand wheel sizes shall be computed assuming a maximum rim effort of 80 pounds.

4. Actuator shall be bolted to damper with Type 316 stainless steel bolts as required.
5. Minimum of four turns and maximum of 12 turns of hand wheel to rotate blade 90 degrees.
6. Provide indicating arrows identifying direction of rotation for correct operation of dampers with OPEN and CLOSE clearly marked. Indication shall be legible and of substantial durability.
7. Chain Wheels:
 - a. Dampers installed with shaft centerlines more than 5 feet 6 inches above floor shall be provided with chain wheels and operating chains.
 - b. Chain wheels shall be equipped with chain guide, which will permit rapid handling of the operating chain without “gagging” of wheel.
 - c. Reasonable side pull on chain shall be permitted by chain wheel without “gagging” of wheel.
 - d. Provide suitable actuator extensions, if necessary, to prevent interference of chain and adjacent piping or facilities below.
 - e. Operating chains shall be hot-dip galvanized carbon steel. Loop and extend within 4 feet of floor below damper.
 - f. Provide and install galvanized tie-back hooks on adjacent pipe supports or structures to hold operating chains out of walkways or access areas when damper is not in operation.

2.07 FIBERGLASS REINFORCED PLASTIC BACKDRAFT DAMPERS

A. General:

1. Physical Characteristics:
 - a. Backdraft dampers shall be of multi-blade rectangular type complete with channel-type frame, blades, linkage, full-length axles, adjustable counterbalance assembly, and bearings.
 - b. Same inside dimensions as connecting fan discharge size or connecting ductwork.
 - c. FRP materials for backdraft dampers shall be same resin as used in ductwork.
 - d. Requirements for flame spread and smoke development shall be same as required for ductwork.
 - e. Axles not less than 3/4-inch in diameter.
 - f. Color: Exterior gel coat shall match connecting duct.
 - g. Frames: Fiberglass reinforced plastic with resin as described herein.
 - h. Blades: Fiberglass reinforced plastic with resin as described herein. Airfoil shape.
 - i. Axles: Continuous FRP rod with resin as described herein. Axle to extend 6 inches beyond frame.

- j. Bearings: Molded PTFE.
- k. Blade Seals: Polychloroprene.
- l. Shaft Seals: Polychloroprene.
- m. Flanges: As specified to match ductwork flanges or where connected to fan discharge match bolt pattern and flange dimensions of fan discharge.
- n. Hardware to be Type 316 stainless steel.
- o. Linkage: Fiberglass reinforced plastic with vinylester resin as described herein with monel rivets.
- p. Adjustable Counterbalance Assembly: Type 316 stainless steel.
- 2. Functional Requirements:
 - a. Backdraft dampers shall have maximum leakage rate of 15 cubic feet per minute per square foot of damper area, at differential pressure of 5 inches WC. AMCA leakage tests shall be furnished as part of Submittal.
 - b. Air Temperature Range: Plus 20 degrees F to 122 degrees F.
 - c. Maintained Differential Pressure Across Blades: 0.1-inch WC.
 - d. Design for differential pressure of 10 inches WC minimum when closed.
- 3. Performance Requirements: None.

2.08 SOURCE QUALITY CONTROL

- A. Factory Inspection: Inspect fabrications for required construction, intended function and conformance with referenced standards.
- B. Inspection of products is required prior to shipment, unless specifically waived in writing by Contracting Officer.
- C. Notify contracting officer 1 week prior to estimated date of inspection.
- D. Repairs authorized by Contracting Officer will be reinspected before final acceptance, unless specifically waived.

PART 3 EXECUTION

3.01 GENERAL

- A. Install ductwork in accordance with manufacturer's recommendations using specified gaskets, hardware, and accessories.
- B. Align ductwork accurately at connections, within 1/8-inch misalignment tolerance, and with internal surfaces smooth.
- C. Ductwork shall be free of vibration when in operation. Necessary vibration isolation devices shall be provided and installed by Contractor.

- D. Install plumb and straight and in proper alignment. For straight duct runs, slope ductwork at 1/8-inch per foot minimum in direction of flow or 1/4-inch per foot minimum in opposite direction of flow to allow internal condensation to drain to drainage points.
- E. Provide drain connections at low point locations whether shown on the Drawings or not. Drain pipe shall include P-trap or valve as shown.
- F. Necessary provisions shall be taken to provide for adequate expansion and contraction of ductwork and fittings.
- G. Antiseize thread compound shall be applied to nuts and bolts.
- H. Proper alignment and grade of ductwork shall be maintained by use of laser beam equipment or surveying instruments. Surveying instruments shall be utilized for verifying laser equipment accuracy because of thermal deflection from differences between ground temperature and air temperature within duct.
- I. Provide flanges and flexible connectors where shown on the Drawings, at each duct to equipment connection to facilitate installation and removal.
- J. Install duct so no load or movement in excess of that stipulated by equipment manufacturer will be imposed upon equipment connection; install to allow for contraction and expansion without stressing pipe, joints, or connected equipment.

3.02 PREPARATION

- A. Verify dimensions and conditions in field.
- B. Layout routing in straight lines parallel to building lines.
- C. Coordinate support locations with layout and joints.

3.03 INSTALLATION

- A. FRP Ductwork:
 - 1. Cut, fit, and install in accordance with duct manufacturer's recommendations. SMACNA manual may be used for guidance, but duct manufacturer's recommendations shall take precedence.
 - 2. Seal cut edges and field-drilled holes with compatible resin.
 - 3. Provide for expansion and contraction of ductwork and fittings.
 - 4. Flange bolts shall be tightened to torque values specified by manufacturer. Install flat washer under each nut and bolt head.

B. Field Joints:

1. Provide material in kit form; one kit for one joint.
2. Make joints only when ambient temperature is above 55 degrees F and below 100 degrees F.
3. Made by manufacturer certified installer.

C. Dampers:

1. Inspection:
 - a. Inspect areas to receive dampers.
 - b. Notify Contracting Officer of conditions that would adversely affect installation or subsequent utilization of dampers.
 - c. Do not proceed with installation until unacceptable conditions are corrected.
2. Install dampers at locations as shown and in accordance with manufacturer's installation instructions.
3. Install with damper shaft in horizontal position.
4. Install square and level.
5. Handle damper using sleeve or frame. Do not lift damper using blades or jackshaft.
6. Confirm damper blades and hardware operate freely without obstruction.
7. Damper blades and hardware that bind within frame or obstructed by adjacent construction will not be acceptable.
8. Provide gasketed damper frames to eliminate leakage between duct and damper frames.
9. Suitable for installation in mounting arrangement shown.
10. Do not compress or stretch damper frame into duct or opening.

D. Manual Dampers:

1. Provide balancing and isolation dampers as shown.
2. Add or remove balancing dampers as requested by air balancing firm for necessary control of air.

E. Expansion Joints/Flexible Connectors Installation: Install such that flexible molded boot is not concave or otherwise twisted or deformed during normal operating conditions.

F. Ductwork Hangers and Supports:

1. Supports: As specified in Section 40 05 15, Piping Support Systems.
2. Install seismic restraints on ductwork systems and sway bracing as described in SMACNA Guidelines for Seismic Restraints of Mechanical Systems and as required by the Building Code for seismic zone indicated.

3.04 PROTECTION OF INSTALLED WORK

- A. Cover open ends of installed ductwork systems to prevent dust, foreign objects, and water from entering ductwork.
- B. Do not use ductwork systems for air conveyance until adequate air filtration devices are installed in air handling equipment, to prevent ingress of construction dust.

3.05 FIELD TESTING

- A. Field test ductwork after installation and before concealment or burying, with fan running at design conditions for a period of 4 hours. Leaks shall be corrected and duct retested until no further leaks appear.
 - 1. FRP Ductwork:
 - a. Suction Side of Fan (Vacuum): Use smoke stick or smoke emitter and pass along every field joint and flanged connection while system is operating under normal operating conditions. Smoke stick or smoke emitter to be passed along entire duct perimeter. Provide temporary enclosure to prevent impact because of wind, rain, and other outdoor environmental conditions. Observation of smoke entering ducting shall be evidence of gross leakage and shall be corrected by methods approved by Contracting Officer.
 - b. Discharge Side of Fan (Pressure): Apply soap bubble mixture to every field joint and flanged connection; examine for leakage and correct as necessary by methods approved by Contracting Officer.

3.06 ADJUSTING

- A. After duct leakage testing, provide complete air balancing of entire system as described in Section 23 05 93, Testing, Adjusting, and Balancing for HVAC

3.07 CLEANING

- A. Blow ductwork clean using system fans; purged continuously for not less than 48 hours at a flow rate not less than design flow rate. If required, system fan shall be throttled on inlet side to prevent motor overload. Temporary screen shall be installed on system fan inlet to protect fan from entering debris.
- B. Dampers shall be smooth, clean, and free of dirt when installed.

END OF SECTION