

SECTION 23 31 00
HVAC DUCTS AND CASINGS

SPEC WRITER NOTES:

1. Use this section only for NCA projects.
2. Delete between // // if not applicable to project. Also delete any other item or paragraph not applicable in the section and renumber the paragraphs.
3. References to pressure in this section are gage pressure unless otherwise noted.
4. DESIGNER'S NOTE: Coordinate Specification with applicable standard equipment details and schedules:
 - a. 23 31 00-01 Ductwork Square Vane Elbows
 - b. 23 31 00-02 Ductwork Radius Elbows
 - c. 23 31 00-03 Ductwork Transitions (with Equipment Mounted in Duct)
 - d. 23 31 00-04 Supply Ductwork Take-Offs
 - e. 23 31 00-05 Supply Duct Takeoff-Air Terminal Units
 - f. 23 31 00-06 Alternate Supply Duct Takeoff-Air Terminal Units
 - g. 23 31 00-07 Exhaust or Return Branch Ductwork
 - h. 23 31 00-08 Volume Damper Detail
 - i. 23 31 00-09 Access Panel and Door Detail
 - j. 23 31 00-10 Access Section Round Duct
 - k. 23 31 00-11 Flexible Duct Connections
 - l. 23 31 00-12 Section Thru Fire Damper Installation
 - m. 23 31 00-14 Round Duct Hangers
 - n. 23 31 00-24 Flexible Air Duct Connector
 - o. 23 31 00-26 Linear Slot Diffuser
5. NCA Master Specifications do not include information for fibrous glass ductwork, flat oval ductwork, or double wall ductwork. If project is to include any of these types of ductwork, the applicable information must be added to this section and any other applicable section.

PART 1 - GENERAL**1.1 DESCRIPTION**

- A. Ductwork and accessories for HVAC including supply air, return air, outside air, exhaust, roof hoods, goosenecks, and relief systems.
- B. A complete listing of common acronyms and abbreviations are included in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- C. Definitions:
 - 1. SMACNA Standards as used in this specification means the HVAC Duct Construction Standards, Metal and Flexible.
 - 2. Seal or Sealing: Use of liquid or mastic sealant, with or without compatible tape overlay, or gasketing of flanged joints, to keep air leakage at duct joints, seams, and connections to an acceptable minimum.
 - 3. Duct Pressure Classification: SMACNA HVAC Duct Construction Standards, Metal and Flexible.
 - 4. Exposed Duct: Exposed to view in a finished room, //exposed to weather//.

1.2 RELATED WORK

SPEC WRITER NOTE: Retain one of two paragraphs below.

- A. //Section 01 00 01, GENERAL REQUIREMENTS (Major NCA Projects).//
- B. //Section 01 00 02, GENERAL REQUIREMENTS (Minor NCA Projects).//
- C. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- D. Section 01 42 19, REFERENCE STANDARDS.
- E. Section 01 81 13, SUSTAINABLE DESIGN REQUIREMENTS.
- F. //Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.//
- G. Section 07 84 00, FIRESTOPPING: Fire Stopping Material.
- H. Section 08 90 00, LOUVERS AND VENTS: Outdoor and Exhaust Louvers.

SPEC WRITER NOTE: If Section 13 05 41 is included in this project the section shall be obtained from VA Masters.

- I. //Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS: Seismic Reinforcing.//
- J. Section 23 05 11, COMMON WORK RESULTS FOR HVAC: General mechanical requirements and items which are common to more than one section of Division 23.
- K. Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT: Noise Level Requirements.

- L. Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC: Testing and Balancing of Air Flows.
- M. Section 23 07 11, HVAC INSULATION: Duct Insulation
- N. //Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.//
- O. //Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC: Duct Mounted Instrumentation.//
- P. Section 23 34 00, HVAC FANS: Return Air and Exhaust Air Fans.
- Q. Section 23 36 00, AIR TERMINAL UNITS: Air Flow Control Valves and Terminal Units.
- R. Section 23 40 00, HVAC AIR CLEANING DEVICES: Air Filters and Filters' Efficiencies.
- S. Section 23 82 16, AIR COILS: Duct Mounted Coils.
- T. Section 28 31 00, FIRE DETECTION AND ALARM: Smoke Detectors.

1.3 APPLICABLE PUBLICATIONS

SPEC WRITER NOTE: Make material requirements agree with requirements specified in the referenced Applicable Publications. Verify and update the publication list to that which applies to the project, unless the reference applies to all mechanical systems. Publications that apply to all mechanical systems may not be specifically referenced in the body of the specification, but, shall form a part of this specification.

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. Air Movement and Control Association (AMCA):
512-2009.....AMCA Listing Label Program
- C. American Society of Civil Engineers (ASCE):
ASCE/SEI 7-2010.....Minimum Design Loads for Buildings and Other Structures
- D. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE):
62.1-2016.....Ventilation for Acceptable Indoor Air Quality
90.1-2013.....Energy Standard for Buildings Except Low-Rise Residential Buildings

- E. American Society for Testing and Materials (ASTM):
- A653/A653M-2015e1.....Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
 - B209-2014.....Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
 - C916-2014.....Standard Specification for Adhesives for Duct Thermal Insulation
 - C1071-2012.....Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material)
 - E84-2015b.....Standard Test Method for Surface Burning Characteristics of Building Materials
- F. Environmental Protection Agency (EPA):
- CFR 40, PART 59, Subpart D, EPA Method 24
- G. National Fire Protection Association (NFPA):
- 90A-2015.....Standard for the Installation of Air Conditioning and Ventilating Systems
 - 90B-2015.....Standard for the Installation of Warm Air Heating and Air-Conditioning Systems
 - 96-2014.....Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations
- H. North American Insulation Manufacturers Association (NAIMA):
- AH124-2002.....Fibrous Glass Duct Liner Standard, 3rd Edition
- I. Sheet Metal and Air Conditioning Contractors National Association (SMACNA):
- 2005.....HVAC Duct Construction Standards, Metal and Flexible, 3rd Edition
 - 2012.....HVAC Air Duct Leakage Test Manual, 2nd Edition
 - 2008.....IAQ Guidelines for Occupied Buildings Under Construction, 2nd Edition
- J. Underwriters Laboratories, Inc. (UL):
- 33-2010 (R2015).....Standard for Heat Responsive Links for Fire-Protection Service
 - 181-2013.....Standard for Factory-Made Air Ducts and Connectors
 - 555-2006 (R2013).....Standard for Fire Dampers
 - 555S-2014.....Standard for Smoke Dampers

1978-2010 (R2013).....Standard for Grease Ducts

1.4 SUBMITTALS

- A. Submittals, including number of required copies, shall be submitted in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. Information and material submitted under this section shall be marked "SUBMITTED UNDER SECTION 23 31 00, DUCTS AND CASINGS", with applicable paragraph identification.
- C. Manufacturer's Literature and Data including: Full item description and optional features and accessories. Include dimensions, weights, materials, applications, standard compliance, model numbers, size, and capacity.
 - 1. Rectangular ducts:
 - a. Schedules of duct systems, materials, and selected SMACNA construction alternatives for joints, sealing, gage, and reinforcement.
 - b. Duct liner.
 - c. Sealants and gaskets.
 - d. Access doors.
 - 2. Round:
 - a. Manufacturer's details for duct fittings and joints.
 - b. Duct liner.
 - c. Sealants and gaskets.
 - d. Access sections.
 - e. Installation instructions.
 - 3. Volume dampers, control dampers, and back draft dampers.
 - 4. Hanger attachments.
 - 5. Fire dampers, fire doors, and smoke dampers with installation instructions.
 - 6. Turning Vanes.
 - 7. Sound attenuators, including pressure drop and acoustic performance.
 - 8. Flexible ducts and clamps, with manufacturer's installation instructions.
 - 9. Flexible connections.
 - 10. Instrument test fittings.
 - 11. Details and design analysis of alternate or optional duct systems.
- D. Coordination Drawings: Refer to paragraph, SUBMITTALS, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

- E. Complete operating and maintenance manuals including wiring diagrams, technical data sheets, information for ordering replacement parts, and troubleshooting guide:
 - 1. Include complete list indicating all components of the systems.
 - 2. Include complete diagrams of the internal wiring for each item of equipment.
 - 3. Diagrams shall have their terminals identified to facilitate installation, operation and maintenance.
- F. //Completed System Readiness Checklist provided by the Commissioning Agent and completed by the contractor, signed by a qualified technician and dated on the date of completion, in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.//
- G. //Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.//

1.5 QUALITY ASSURANCE

- A. Refer to paragraph, QUALITY ASSURANCE, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- B. Fire Safety Code: Comply with NFPA 90A.
- C. Duct System Construction and Installation: Referenced SMACNA Standards are the minimum acceptable quality.
- D. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- E. Duct Sealing, Air Leakage Criteria, and Air Leakage Tests: Ducts shall be sealed as per duct sealing requirements of SMACNA Standards for duct pressure classes shown on the drawings.
- F. Duct accessories exposed to the air stream, such as dampers of all types (except smoke dampers) and access openings, shall be of the same material as the duct or provide at least the same level of corrosion resistance.
- G. ASHRAE Compliance: Applicable requirements in ASHRAE 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."
- H. Sealants and Adhesives: Comply with NFPA 90A and with ASTM C916.
 - 1. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

1.6 AS-BUILT DOCUMENTATION

SPEC WRITER NOTE: Coordinate O&M Manual requirements with Section 01 00 01, GENERAL REQUIREMENTS (Major NCA Projects) or Section 01 00 02, GENERAL REQUIREMENTS (Minor NCA Projects). O&M manuals shall be submitted for content review as part of the close-out documents.

- A. Submit manufacturer's literature and data updated to include submittal review comments and any equipment substitutions.
- B. Submit operation and maintenance data updated to include submittal review comments, substitutions and construction revisions shall be //in electronic version on CD or DVD// inserted into a three ring binder. All aspects of system operation and maintenance procedures, including applicable piping isometrics, wiring diagrams of all circuits, a written description of system design, control logic, and sequence of operation shall be included in the operation and maintenance manual. The operations and maintenance manual shall include troubleshooting techniques and procedures for emergency situations. Notes on all special systems or devices shall be included. A List of recommended spare parts (manufacturer, model number, and quantity) shall be furnished. Information explaining any special knowledge or tools the owner will be required to employ shall be inserted into the As-Built documentation.
- C. The installing contractor shall maintain as-built drawings of each completed phase for verification; and, shall provide the complete set at the time of final systems certification testing. As-built drawings are to be provided, and a copy of them in Auto-CAD version //____// provided on CD or DVD. Should the installing contractor engage the testing company to provide as-built or any portion thereof, it shall not be deemed a conflict of interest or breach of the 'third party testing company' requirement.
- D. Certification documentation shall be provided to COR 10 working days prior to submitting the request for final inspection. The documentation shall include all test results, the names of individuals performing work for the testing agency on this project, detailed procedures followed for all tests, and certification that all results of tests were within limits specified.

PART 2 - PRODUCTS**2.1 DUCT MATERIALS AND SEALANTS**

- A. General: Except for systems specified otherwise, construct ducts and accessories of galvanized sheet steel, ASTM A653/A653M, coating G90; or, aluminum sheet, ASTM B209, alloy 1100, 3003, or 5052.
- B. Joint Sealing:
1. Sealant: Elastomeric compound, gun or brush grade, maximum 25 flame spread and 50 smoke developed (dry state) compounded specifically for sealing ductwork as recommended by the manufacturer. Generally provide liquid sealant, with or without compatible tape, for low clearance slip joints and heavy, permanently elastic, mastic type where clearances are larger. Oil base caulking and glazing compounds are not acceptable because they do not retain elasticity and bond.
 2. Tape: Use only tape specifically designated by the sealant manufacturer and apply only over wet sealant. Pressure sensitive tape shall not be used except as designated by sealant manufacturer.
 3. Gaskets for Flanged Joints: Soft neoprene.
- C. Approved factory made joints such as DUCTMATE SYSTEM may be used.

2.2 DUCT CONSTRUCTION AND INSTALLATION

- A. Follow SMACNA HVAC Duct Construction Standards.
- SPEC WRITER NOTE: Verify that appropriate duct pressure classes as required by SAMCNA are shown on the drawings and in the paragraph below.
- B. Duct Pressure Class: //500 Pa (2 inch WG)// //750 Pa (3 inch WG)// //1000 Pa (4 inch WG)//.
- C. Seal Class: As shown on the drawings and in accordance with SMACNA Standards.
- D. Round Ducts: Furnish duct and fittings made by the same manufacturer to ensure good fit of joints. When submitted and approved in advance, round ducting, with size converted on the basis of equal pressure drop may be furnished in lieu of rectangular duct design shown on the drawings.
1. Elbows: Diameters 150 mm through 200 mm (6 through 8 inches) shall be two sections die stamped; all others shall be gored construction, maximum 18 degree angle, with all seams continuously welded or standing seam. Coat galvanized areas of fittings damaged by welding with corrosion resistant aluminum paint or galvanized repair compound.

2. Provide bell mouth, conical tees or taps, laterals, reducers, and other low loss fittings as shown in SMACNA HVAC Duct Construction Standards.

E. Volume Dampers: Single blade, opposed blade, or multi-blade type as detailed in SMACNA Standards.

F. Duct Hangers and Supports: Refer to SMACNA Standards. Do not use trapeze hangers for round duct.

SPEC WRITER NOTE: For Outside air ducts, duct liner is prohibited. Provide exterior insulation only.

2.3 DUCT LINER (WHERE INDICATED ON DRAWINGS)

A. Duct sizes shown on drawings for lined duct are clear opening inside lining.

B. Rectangular Duct Liner: ASTM C1071, Type I (flexible), or Type II (board), 25 mm (one inch) minimum thickness, applied with mechanical fasteners and 100 percent coverage of adhesive in conformance with SMACNA HVAC Duct Construction Standards.

2.4 DUCT ACCESS DOORS, PANELS AND SECTIONS

A. Install access doors with swing against duct static pressure.

B. Provide access doors, sized and located for maintenance work, in the following locations:

1. Upstream and downstream of each duct mounted coil.
2. Each fire damper (for link service), smoke damper, and automatic control damper.
3. Each duct mounted smoke detector.
4. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
5. Upstream //and downstream// from turning vanes.
6. Upstream or downstream from duct silencers.
7. Control devices requiring inspection.

C. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 7-2 (7-2M), "Duct Access Doors and Panels," and 7-3, "Access Doors - Round Duct."

1. Door:

- a. Double wall, rectangular.
- b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.

- c. Hinges and Latches: 25 by 25 mm (1 by 1 inch) butt or piano hinge and cam latches.
- d. Fabricate doors airtight and suitable for duct pressure class.
- 2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
- 3. Number of Hinges and Locks:
 - a. Access Doors Less Than 300 mm (12 inches) Square: No hinges and two sash locks.
 - b. Access Doors up to //450 mm (18 inches)// Square: //Two hinges// //Continuous// and two sash locks.
 - c. Access Doors up to 600 by 1200 mm (24 by 48 inches): //Three hinges// //Continuous// and two compression latches// with outside and inside handles//.
- D. Access Doors Greater Than 600 by 1200 mm (24 by 48 inches): //Four hinges// //Continuous// and two compression latches with outside and inside handles, labeled according to UL 1978 by an NRTL.
- E. Panel and Frame: Minimum thickness //1.3 mm (0.05 inch) carbon// //1.1 mm (0.045 inch) stainless// steel.
- F. Fasteners: //Carbon// //Stainless// steel. Panel fasteners shall not penetrate duct wall.
- G. Gasket: Comply with NFPA 96; grease-tight, high-temperature ceramic fiber, rated for minimum 1093 degrees C (2000 degrees F).
- H. Minimum Pressure Rating: 2500 Pa (10 inch WG), positive or negative.
- I. Openings shall be as large as feasible in small ducts, 300 mm by 300 mm (12 inch by 12 inch) minimum where possible. Access sections in insulated ducts shall be double-wall, insulated.
 - 1. Refer to SMACNA HVAC Duct Construction Standards.

2.5 FIRE DAMPERS

- A. Type: Static and dynamic; rated and labeled according to UL 555 by an NRTL.
- B. Closing rating in ducts up to 1 kPa (4 inch WG) static pressure class and minimum 10 m/s (2000 fpm) velocity
- C. Mounting Orientation: Vertical or horizontal as indicated.
- D. Galvanized steel, interlocking blade type, UL listing and label, //1-1/2// //3// hour rating, 74 degrees C (165 degrees F) fusible link, 100 percent free opening with no part of the blade stack or damper frame in the air stream.

- E. Fire dampers shall be galvanized steel.
 1. The damper frame may be of design and length as to function as the mounting sleeve, thus eliminating the need for a separate sleeve, as allowed by UL 555. Otherwise provide sleeves and mounting angles, minimum 1.9 mm (14 gage), required to provide installation equivalent to the damper manufacturer's UL test installation.
 2. Submit manufacturer's installation instructions conforming to UL 555 rating test.

2.6 SMOKE DAMPERS

- A. Maximum air velocity through free area of open damper: 450 m/min (1500 fpm).
- B. Maximum static pressure loss at maximum velocity: 32 Pa (0.13 inch WG).
- C. Leakage: Class I.
- D. Minimum requirements for dampers:
 1. Shall comply with requirements of UL 555S, except for the Fire Endurance and Hose Stream Test.
 2. Frame: Galvanized steel channel with side, top, and bottom stops or seals.
 3. Blades: Galvanized steel, parallel type preferably, 300 mm (12 inch) maximum width, edges sealed with neoprene, rubber, or felt if required to meet minimum leakage. Airfoil (streamlined) type for minimum noise generation and pressure drop are preferred for duct mounted dampers.
 4. Shafts: Galvanized steel.
 5. Bearings: Nylon, bronze sleeve or ball type.
 6. Hardware: Zinc plated.
 7. Smoke Detector: Integral, factory wired for single-point connection.
 8. Operation: Automatic open/close. Modulating or two-position action as indicated on the drawings. No smoke damper that requires manual reset or link replacement after actuation is acceptable. See drawings for required control operation.
 9. Auxiliary switches for //signaling// //fan control// //or// //position indication// as indicated in the drawings.
- E. Motor operator (actuator): Provide electric as required by the automatic control system, externally mounted on stand-offs to allow complete insulation coverage.

2.7 BACKDRAFT AND PRESSURE RELIEF DAMPERS

- A. Description: Gravity balanced.

- B. Maximum Air Velocity: //5.1 m/s (1000 fpm)// //6.4 m/s (1250 fpm)//
//10 m/s (2000 fpm)// //15 m/s (3000 fpm)// // //.
- C. Maximum System Pressure: //0.25 kPa (1 inch WG)// //0.5 kPa (2 inch
WG)// //0.8 kPa (3 inch WG)// //1.5 kPa (6 inch WG)// // //.
- D. Frame: Hat-shaped, //1.3 mm (0.05 inch) thick, galvanized sheet steel//
//2.4 mm (0.094 inch) thick, galvanized sheet steel// //1.6 mm (0.063
inch) thick extruded aluminum// //0.8 mm (0.03 inch) thick stainless
steel// //1.3 mm (0.05 inch) thick stainless steel//, with welded
corners or mechanically attached// and mounting flange//.
- E. Blades: Multiple single-piece blades, //center pivoted,// //off-center
pivoted,// //end pivoted,// maximum 150 mm (6 inch) width, //0.6 mm
(0.025 inch) thick, roll-formed aluminum// //1.2 mm (0.047 inch) thick
aluminum sheet// //noncombustible, tear-resistant, neoprene-coated
fiberglass// with sealed edges.
- F. Blade Action: Parallel.
- G. Blade Seals: //Felt// //Vinyl foam// //Extruded vinyl, mechanically
locked// //Neoprene, mechanically locked//.
- H. Blade Axles:
1. Material: //Nonferrous metal// //Galvanized steel// //Plated steel//
//Stainless steel// //Nonmetallic// //Aluminum//.
 2. Diameter: //5 mm (3/160 inch)// // //.
- I. Tie Bars and Brackets: //Aluminum// //Galvanized steel//.
- J. Return Spring: Adjustable tension.
- K. Bearings: //Steel ball// //or// //synthetic pivot bushings//.
- L. Accessories:
1. Adjustment device to permit setting for varying differential static
pressure.
 2. Counterweights and spring-assist kits for vertical airflow
installations.
 3. Electric actuators.
 4. Chain pulls.
 5. Screen Mounting: Front mounted in sleeve.
 - a. Sleeve Thickness: 1.0 mm (20 gage) minimum.
 - b. Sleeve Length: 150 mm (6 inches) minimum.
 6. Screen Mounting: Rear mounted.
 7. Screen Material: //Galvanized steel// //Aluminum//.
 8. Screen Type: //Bird// //Insect//.
 9. 90 degree stops.

2.8 BAROMETRIC RELIEF DAMPERS

- A. Suitable for horizontal or vertical mounting.
- B. Maximum Air Velocity: //5.1 m/s (1000 fpm)// //6.4 m/s (1250 fpm)//
//10 m/s (2000 fpm)// //13 m/s (2500 fpm)// // //.
- C. Maximum System Pressure: //0.5 kPa (2 inch WG)// //0.8 kPa (3 inch
WG)// //1.5 kPa (6 inch WG)// //2.5 kPa (10 inch WG)// // //.
- D. Frame: Hat-shaped, //1.3 mm (0.05 inch) thick, galvanized sheet steel//
//2.4 mm (0.094 inch) thick, galvanized sheet steel// //1.6 mm (0.063
inch) thick extruded aluminum// //0.8 mm (0.03 inch) thick stainless
steel// //1.3 mm (0.05 inch) thick stainless steel//, with welded
corners or mechanically attached// and mounting flange//.
- E. Blades:
 - 1. Multiple, //0.6 mm (0.025 inch) thick, roll-formed aluminum// //1.2
mm (0.047 inch) thick aluminum sheet//.
 - 2. Maximum Width: 150 mm (6 inches).
 - 3. Action: Parallel.
 - 4. Balance: Gravity.
 - 5. //Eccentrically pivoted// //Off-center pivoted// //End pivoted//.
- F. Blade Seals: //Vinyl// //Neoprene//.
- G. Blade Axles: //Galvanized steel// //Nonferrous metal// //Plated steel//
//Stainless steel// //Nonmetallic//.
- H. Tie Bars and Brackets:
 - 1. Material: //Aluminum// //Galvanized steel//.
 - 2. Rattle free with 90 degree stop.
- I. Return Spring: Adjustable tension.
- J. Bearings: //Synthetic// //Stainless steel// //Bronze//.
- K. Accessories:
 - 1. Flange on intake.
 - 2. Adjustment device to permit setting for varying differential static
pressures.
 - 3. // //.

2.9 MANUAL VOLUME DAMPERS

- A. Standard, Steel, Manual Volume Dampers:
 - 1. Standard leakage rating, with linkage outside airstream.
 - 2. Suitable for horizontal or vertical applications.
 - 3. Frames:
 - a. Frame: Hat-shaped, //2.4 mm (3/32 inch) thick, galvanized sheet
steel// //1.3 mm (0.05 inch) thick stainless steel//.

- b. Mitered and welded corners.
 - c. Flanges for attaching to walls and flangeless frames for installing in ducts.
4. Blades:
- a. Multiple or single blade.
 - b. Parallel- or opposed-blade design.
 - c. Stiffen damper blades for stability.
 - d. //Galvanized// //Stainless// -steel, 1.62 mm (0.064 inch) thick.
5. Blade Axles: //Galvanized steel// //Stainless steel// //Nonferrous metal//.
6. Bearings:
- a. //Oil-impregnated bronze// //Molded synthetic// //Oil-impregnated stainless-steel sleeve// //Stainless-steel sleeve//.
 - b. Dampers in ducts with pressure classes of 750 Pa (3 inch WG) or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
7. Tie Bars and Brackets: Galvanized steel.
- B. Standard, Aluminum, Manual Volume Dampers:
- 1. Standard leakage rating, with linkage outside airstream.
 - 2. Suitable for horizontal or vertical applications.
 - 3. Frames: Hat-shaped, 2.5 mm (0.10 inch) thick, aluminum sheet channels; frames with flanges for attaching to walls and flangeless frames for installing in ducts.
4. Blades:
- a. Multiple or single blade.
 - b. Parallel- or opposed-blade design.
 - c. Stiffen damper blades for stability.
 - d. Roll-Formed Aluminum Blades: 2.5 mm (0.10 inch) thick aluminum sheet.
 - e. Extruded-Aluminum Blades: 1.3 mm (0.050 inch) thick extruded aluminum.
5. Blade Axles: //Galvanized steel// //Stainless steel// //Nonferrous metal//.
6. Bearings:
- a. //Oil-impregnated bronze// //Molded synthetic// //Stainless-steel sleeve//.

- b. Dampers in ducts with pressure classes of 750 Pa (3 inch WG) or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

7. Tie Bars and Brackets: Aluminum.

2.10 CONTROL DAMPERS

- A. Low-leakage rating, with linkage outside airstream, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.
- B. Frames:
 - 1. //Hat// //U// //Angle// shaped.
 - 2. //2.4 mm (0.094 inch) thick, galvanized sheet steel// //1.3 mm (0.05 inch) thick stainless steel//.
 - 3. //Mitered and welded// //Interlocking, gusseted// corners.
- C. Blades:
 - 1. Multiple blade with maximum blade width of //150 mm (6 inches)// //200 mm (8 inches)//.
 - 2. //Parallel// //Parallel- and opposed// //Opposed//blade design.
 - 3. Galvanized-steel// //Stainless steel// //Aluminum//.
 - 4. //1.62 mm (0.064 inch) thick single skin// //1.9 mm (0.0747 inch) thick dual skin//.
 - 5. Blade Edging: //Closed-cell neoprene// //PVC//.
 - 6. Blade Edging: Inflatable seal blade edging, or replaceable rubber seals.
- D. Blade Axles: 15 mm (1/2 inch) diameter; //galvanized steel// //stainless steel// //nonferrous metal//; blade-linkage hardware of zinc-plated steel and brass; ends sealed against blade bearings.
 - 1. Operating Temperature Range: From minus 40 to plus 93 degrees C (minus 40 to plus 200 degrees F).
- E. Bearings:
 - 1. //Oil-impregnated bronze// //Molded synthetic// //Oil-impregnated stainless-steel sleeve// //Stainless-steel sleeve//.
 - 2. Dampers in ducts with pressure classes of 750 Pa (3 inch WG) or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
 - 3. Thrust bearings at each end of every blade.

2.11 FLEXIBLE AIR DUCT

- A. General: Factory fabricated, complying with NFPA 90A for connectors not passing through floors or buildings. Flexible ducts shall not penetrate any fire or smoke barrier which is required to have a fire resistance

rating of one hour or more. Flexible duct length shall not exceed 1.5 m (5 feet). Provide insulated flexible air duct connectors in supply air duct systems and elsewhere as shown.

- B. Flexible ducts shall be listed by Underwriters Laboratories, Inc., complying with UL 181. Ducts greater than 200 mm (8 inches) in diameter shall be Class 1. Ducts 200 mm (8 inches) in diameter and smaller may be Class 1 or Class 2.
- C. Insulated Flexible Air Duct: Factory made including mineral fiber insulation with maximum C factor of 0.25 at 24 degrees C (75 degrees F) mean temperature, encased with a low permeability moisture barrier outer jacket, having a puncture resistance of not less than 50 Beach Units. Acoustic insertion loss shall not be less than 3 dB per 300 mm (1 foot) of straight duct, at 500 Hz, based on 150 mm (6 inch) duct, of 750 m/min (2500 fpm).
- D. Application Criteria:
 1. Temperature range: minus 18 to 93 degrees C (0 to 200 degrees F) internal.
 2. Maximum working velocity: 1200 m/min (4000 fpm).
 3. Minimum working pressure: 2500 Pa (10 inch WG) positive, 500 Pa (2 inch WG) negative.
- E. Duct Clamps: 100 percent nylon strap, 80 kg (175 pounds) minimum loop tensile strength manufactured for this purpose or stainless steel strap with cadmium plated worm gear tightening device. Apply clamps with sealant and as approved for UL 181, Class 1 installation.

2.12 FLEXIBLE CONNECTIONS

- A. Where duct connections are made to fans and air handling units, install a non-combustible flexible connection of 822 g (29 ounce) neoprene coated fiberglass fabric, approximately 150 mm (6 inches) wide.
- B. Coatings and Adhesives: Comply with UL 181, Class 1. For connections exposed to sun and weather provide hypalon coating in lieu of neoprene. Burning characteristics shall conform to NFPA 90A.
 1. Tensile Strength: 84 N/mm (480 lbf/inch) in the warp and 63 N/mm (360 lbf/inch) in the filling.
 2. Service Temperature: Minus 40 to plus 93 degrees C (Minus 40 to plus 200 degrees F)
- C. Securely fasten flexible connections to round ducts with stainless steel or zinc-coated iron draw bands with worm gear fastener. For rectangular connections, crimp fabric to sheet metal and fasten sheet

metal to ducts by screws 50 mm (2 inches) on center. Fabric shall not be stressed other than by air pressure. Allow at least 25 mm (one inch) slack to ensure that no vibration is transmitted.

2.13 TURNING VANES

- A. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
- B. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 4-3, "Vanes and Vane Runners," and 4-4, "Vane Support in Elbows."
- C. Vane Construction: //Single// //Double// wall.
- D. Vane Construction: Single wall for ducts up to //1200 mm (48 inches)// // // wide and double wall for larger dimensions.

2.14 SOUND ATTENUATING UNITS

- A. Casing, not less than 1.0 mm (20 gage) galvanized sheet steel, or 1.3 mm (18 gage) aluminum fitted with suitable flanges to make clean airtight connections to ductwork. Sound-absorbent material faced with glass fiber cloth and covered with not less than 0.6 mm (24 gage) or heavier galvanized perforated sheet steel, or 0.85 mm (22 gage) or heavier perforated aluminum. Perforations shall not exceed 4 mm (5/32 inch) diameter, approximately 25 percent free area. Sound absorbent material shall be long glass fiber acoustic blanket meeting requirements of NFPA 90A.
- B. Entire unit shall be completely air tight and free of vibration and buckling at internal static pressures up to 2000 Pa (8 inch WG) at operating velocities.
- C. Pressure drop through each unit: Not to exceed indicated value at design air quantities indicated.
- D. Submit complete independent laboratory test data showing pressure drop and acoustical performance.
- E. Cap open ends of attenuators at factory with plastic, heavy duty paper, cardboard, or other appropriate material to prevent entrance of dirt, water, or any other foreign matter to inside of attenuator. Caps shall not be removed until attenuator is installed in duct system.

2.15 PREFABRICATED ROOF CURBS

- A. Galvanized steel or extruded aluminum //300 mm (12 inches)// //450 mm (18 inches)// //600 mm (24 inches)// above finish roof service, continuous welded corner seams, treated wood nailer, 40 mm (1-1/2 inch)

thick, 48 kg/cubic meter (3 pound/cubic feet) density rigid mineral fiberboard insulation with metal liner, built-in cant strip (except for gypsum or tectum decks). For surface insulated roof deck, provide raised cant strip (recessed mounting flange) to start at the upper surface of the insulation. Curbs shall be constructed for pitched roof or ridge mounting as required to keep top of curb level.

2.16 FIRESTOPPING MATERIAL

A. Refer to Section 07 84 00, FIRESTOPPING.

2.17 //SEISMIC RESTRAINT FOR DUCTWORK

A. Refer to Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.//

2.18 THERMOMETER (AIR)

A. Refer to Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.

2.19 INSTRUMENT TEST FITTINGS

- A. Manufactured type with a minimum 50 mm (2 inch) length for insulated duct, and a minimum 25 mm (1 inch) length for duct not insulated. Test hole shall have a flat gasket for rectangular ducts and a concave gasket for round ducts at the base, and a screw cap to prevent air leakage.
- B. Provide instrument test holes at each duct mounted temperature sensor or transmitter, and at entering and leaving side of each heating coil, cooling coil, and heat recovery unit.

2.20 ROOF HOODS AND GOOSENECKS

- A. Factory or shop fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figures 6-5 and 6-6.
- B. Materials: Galvanized-steel sheet, minimum 1.62 mm (0.064 inch) thick base and 1.0 mm (0.040 inch) thick hood. //Aluminum sheet, minimum 1.6 mm (0.063 inch) thick base and 1.27 mm (0.050 inch) thick hood; suitably reinforced.//
- C. Roof Curb: Galvanized steel or extruded aluminum //300 mm (12 inches)// //450 mm (18 inches)// //600 mm (24 inches)// above finish roof service, continuous welded corner seams, treated wood nailer, 40 mm (1-1/2 inch) thick, 48 kg/cubic meter (3 pound/cubic feet) density rigid mineral fiberboard insulation with metal liner, built-in cant strip (except for gypsum or tectum decks). For surface insulated roof deck, provide raised cant strip (recessed mounting flange) to start at the upper surface of the insulation. Curbs shall be constructed for pitched roof or ridge mounting as required to keep top of curb level.

- D. Bird Screening: Flattened, expanded aluminum, 20 mm by 1.27 mm (3/4 inch by 0.050 inch) thick.
- E. Insect Screens - Aluminum or Stainless Steel:
 - 1. Exhaust to openings: not less than 6 mm (1/4 inch) and not greater than 15 mm (1/2 inch).
 - 2. Intake openings: greater than 6 mm (1/4 inch) and not greater than 25 mm (1 inch).
- F. Galvanized-Steel Sheet Finish:
 - 1. Surface Preparation: Clean surfaces of dirt, grease, and other contaminants. Clean welds, mechanical connections, and abraded areas.
 - 2. Field-Painted Finish: Apply an air-dried primer immediately after cleaning.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. If an installation is unsatisfactory to the COR, the Contractor shall correct the installation at no additional cost or time to the Government.
- B. Comply with provisions of Section 23 05 11, COMMON WORK RESULTS FOR HVAC, particularly regarding coordination with other trades and work in existing buildings.
- C. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and aluminum accessories in aluminum ducts.
- D. Install //backdraft// //control// dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan, unless otherwise indicated.
- E. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner and terminate liner with nosing at hat channel.
 - 1. Install steel volume dampers in steel ducts.
 - 2. Install aluminum volume dampers in aluminum ducts.
- F. Access Door Sizes:
 - 1. One-Hand or Inspection Access: 200 mm by 125 mm (8 inches by 5 inches).
 - 2. Two-Hand Access: 300 mm by 150 mm (12 inches by 6 inches).
 - 3. Head and Hand Access: 450 mm by 250 mm (18 inches by 10 inches).

4. Head and Shoulders Access: 533 mm by 356 mm (21 inches by 14 inches).
 5. Body Access: 635 mm by 356 mm (25 inches by 14 inches).
 6. Body plus Ladder Access: 635 mm by 432 mm (25 inches by 17 inches).
- G. Label access doors according to Section 230553 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.
- H. Install ducts with fewest possible joints.
- I. Install factory- or shop-fabricated fittings for changes in direction, size, shape, and for branch connections.
- J. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.
- K. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
- L. Install ducts with a clearance of 25 mm (1 inch), plus allowance for insulation thickness.
- M. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.
- N. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 40 mm (1-1/2 inches).
- O. Protect duct interiors from moisture, construction debris and dust, and other foreign materials.// Comply with SMACNA IAQ Guidelines for Occupied Buildings Under Construction, Appendix G, "Duct Cleanliness for New Construction Guidelines."//
- P. Fabricate and install ductwork and accessories in accordance with referenced SMACNA Standards:
1. Drawings show the general layout of ductwork and accessories but do not show all required fittings and offsets that may be necessary to connect ducts to equipment, boxes, diffusers, grilles, etc., and to coordinate with other trades. Fabricate ductwork based on field measurements. Provide all necessary fittings and offsets at no additional cost to the government. Coordinate with other trades for space available and relative location of HVAC equipment and accessories on ceiling grid. Duct sizes on the drawings are inside dimensions which shall be altered by Contractor to other dimensions

- with the same air handling characteristics where necessary to avoid interferences and clearance difficulties.
2. Provide duct transitions, offsets and connections to dampers, coils, and other equipment in accordance with SMACNA HVAC Duct Construction Standards. Provide streamliner when an obstruction cannot be avoided and must be taken in by a duct. Repair galvanized areas with galvanizing repair compound.
 3. Provide bolted construction and tie-rod reinforcement in accordance with SMACNA HVAC Duct Construction Standards.
- Q. Install duct hangers and supports in accordance with SMACNA HVAC Duct Construction Standards.
- R. Install fire dampers and smoke dampers in accordance with the manufacturer's instructions to conform to the installation used for the rating test.
- S. Seal openings around duct penetrations of floors and fire rated partitions with fire stop material as required by NFPA 90A.
- T. Flexible duct installation: Refer to SMACNA HVAC Duct Construction Standards. Ducts shall be continuous, single pieces not over 1.5 m (5 feet) long, as straight and short as feasible, adequately supported. Centerline radius of bends shall be not less than 2 duct diameters. Make connections with clamps as recommended by SMACNA Standards. Clamp per SMACNA Standards with one clamp on the core duct and one on the insulation jacket. Flexible ducts shall not penetrate floors, or any chase or partition designated as a fire or smoke barrier, including corridor partitions fire rated 1-hour or 2-hour. Support flexible ducts per SMACNA HVAC Duct Construction Standards.
- U. Control Damper Installation:
1. Provide necessary blank-off plates required to install dampers that are smaller than duct size. Provide necessary transitions required to install dampers larger than duct size.
 2. Install all damper control/adjustment devices on stand-offs to allow complete coverage of insulation.
- V. //Air Flow Measuring Devices (AFMD): Install units with minimum straight run distances, upstream and downstream as recommended by the manufacturer.//
- W. Low Pressure Duct Liner: Install in accordance with SMACNA HVAC Duct Construction Standards.

- X. Protection and Cleaning: Adequately protect equipment and materials against physical damage. Place equipment in first-class operating condition, or return to source of supply for repair or replacement, as determined by COR. Protect equipment and ducts during construction against entry of foreign matter to the inside and clean both inside and outside before operation and painting. When new ducts are connected to existing ductwork, clean both new and existing ductwork by mopping and vacuum cleaning inside and outside before operation.

3.2 DUCT LEAKAGE TESTS AND REPAIR

- A. Leak testing company shall be independent of the sheet metal company employed by General Contractor.
- B. //Ductwork leak test shall be performed for the entire air distribution supply, return, exhaust system section-by-section including fans, coils, and filter section designated as static pressure class 750 Pa (3 inch WG) and above. All supply ductwork less than 500 Pa (2 inch WG) shall also be tested where there is no air terminal unit employed in the system.//
- C. Test procedure, apparatus, and report shall conform to SMACNA HVAC Air Duct Leakage Test Manual. The maximum leakage rate allowed is 4 percent of the design air flow rate.

SPEC WRITE NOTES: SMACNA requires the system designer to show pressure classes for establishing leakage test requirements for duct systems. Refer to SMACNA HVAC Duct Construction Standards for pressure classes, associated operating pressure ranges and for seals and normal leakage classification. Verify pressure classes are shown on the drawings.

- D. All ductwork shall be leak tested first before enclosed in a shaft or covered in other inaccessible areas.
- E. All tests shall be performed in the presence of the COR and the Test and Balance agency. The Test and Balance agency shall measure and record duct leakage and report to the COR and identify leakage source with excessive leakage.
- F. If any portion of the duct system tested fails to meet the permissible leakage level, rectify sealing of ductwork to bring it into compliance and retest until acceptable leakage is demonstrated to the COR.
- G. All tests and necessary repairs shall be completed prior to insulation or concealment of ductwork.

- H. Make sure all openings used for testing flow and temperatures by TAB contractor are sealed properly.

SPEC WRITER NOTE:

Specify wind velocity as per ASCE/SEI 7 where wind velocity exceeds 90 mph in coastal areas.

3.3 //DUCTWORK EXPOSED TO WIND VELOCITY

- A. Provide additional support and bracing to all exposed ductwork installed on the roof or outside the building to withstand wind velocity of // // km/h (// // mph). //

3.4 TESTING, ADJUSTING, AND BALANCING (TAB)

- A. Refer to Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC.

3.5 STARTUP AND TESTING

- A. Make tests as recommended by product manufacturer and listed standards and under actual or simulated operating conditions and prove full compliance with design and specified requirements. Tests of the various items of equipment shall be performed simultaneously with the system of which each item is an integral part.
- B. When any defects are detected, correct defects and repeat test at no additional cost or time to the Government.
- C. //The Commissioning Agent will observe startup and contractor testing of selected equipment. Coordinate the startup and contractor testing schedules with the COR and Commissioning Agent. Provide a minimum notice of 10 working days prior to startup and testing.//

3.6 //COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.
- B. Components provided under this section of the specification will be tested as part of a larger system.//

3.7 DEMONSTRATION AND TRAINING

- A. Provide services of manufacturer's technical representative for //four// // // hour//s// to instruct each VA personnel responsible in the operation and maintenance of units.
- B. //Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.//

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