

SECTION 23 31 13 - SHEETMETAL WORK

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:

1. Single-wall rectangular ducts and fittings.
2. Double-wall rectangular ducts and fittings.
3. Single-wall round and flat-oval ducts and fittings.
4. Double-wall round and flat-oval ducts and fittings.
5. Sheet metal materials.
6. Duct liner.
7. Sealants and gaskets.
8. Hangers and supports.
9. Seismic-restraint devices.
10. Backdraft and pressure relief dampers.
11. Barometric relief dampers.
12. Manual volume dampers.
13. Control dampers.
14. Fire dampers.
15. Smoke dampers.
16. Combination fire and smoke dampers.
17. Turning vanes.
18. Remote damper operators.
19. Duct mounted access doors.
20. Flexible connectors.
21. Flexible ductwork.
22. Antimicrobial coatings
23. UL listed zero clearance kitchen hood exhaust.

- B. Related Sections:

1. Division 23 Section "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
2. Division 23 Section "Noise Control" for double wall ductwork.

1.3 PERFORMANCE REQUIREMENTS

- A. Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible, latest edition" and performance requirements and design criteria indicated.

1. DESIGN

STATIC PRESSURE PRESSURE CLASS

2 IN. W.G.
6 IN. W.G.
10 IN. W.G.

OPERATING PRESSURE

UP TO 2 IN. W.G.
OVER 2 IN. UP TO 6 IN. W.G.
OVER 6 IN. UP TO 10 IN. W.G. or
as indicated on plans

- a. Based on the following:

- 1) Single duct system: Static pressure at respective point in ductwork during normal operation.
- 2) Variable volume duct systems: Static pressure at beginning of fan discharge duct.

- b. Description of ductwork pressure class and equipment:

- 1) 6" and greater Duct Class: All supply ductwork from discharge of fans, air handling units, or AC units to inlets of terminal boxes on floor, all outdoor ductwork and all ductwork running through unconditioned spaces. Seal Class "A", leakage class 4 (rectangular metal) or Class 3 (round)
- 2) 6" and greater Duct Class: All return and hood exhaust air ductwork from suction of fans, air handling units or AC units to inlets of terminal boxes on floor. Seal Class "A", leakage class 4 (rectangular metal) or Class 3 (round)
- 3) 3" Duct Class: All suction and discharge of kitchen exhaust and other exhaust ductwork. Seal Class "B", leakage class 12 *rectangular metal or Class 6 (round)
- 4) 2" Duct Class and less: All other low pressure ductwork. Seal Class "C", leakage Class 24 (rectangular) or Class 12 (round).

- B. Structural Performance: Duct hangers and supports and seismic restraints shall withstand the effects of gravity and seismic loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and SEI/ASCE 7.

1. Seismic Hazard Level A: Seismic force to weight ratio, 0.48.
2. Seismic Hazard Level B: Seismic force to weight ratio, 0.30.
3. Seismic Hazard Level C: Seismic force to weight ratio, 0.15.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings (CAD Generated and Drawn to 3/8 scale):
 - 1. Sheetmetal shop standards shall be compiled directly from the "SMACNA DUCT CONSTRUCTION STANDARDS- Metal and Flexible" manual. Modifications for a specific project, if any, shall be indicated directly on the SMACNA templates. Modified shop standards not taken directly from the SMACNA templates will not be accepted. Any deviations from SMACNA shall be noted.
 - 2. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
 - 3. Factory- and shop-fabricated ducts and fittings.
 - 4. Duct layout (double line) indicating sizes, transitions, configuration, liner material, and static-pressure classes.
 - 5. Elevation of top of ducts.
 - 6. Dimensions of main duct runs from building grid lines.
 - 7. Sheet metal thicknesses
 - 8. Fittings.
 - 9. Reinforcement details and spacing.
 - 10. Seam and joint construction and sealing
 - 11. Materials, fabrication, assembly, and spacing of hangers and supports.
 - 12. Penetrations through fire-rated and other partitions.
 - 13. Equipment installation based on equipment being used on Project.
 - 14. Access clearance for all equipment and accessories
 - 15. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
 - 16. Hangers and supports, including methods for duct and building attachment, seismic restraints, and vibration isolation.
 - 17. Design Calculations: Calculations, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation] for selecting hangers and supports and seismic restraints.
- C. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - 1. Duct installation in congested spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout.
 - 2. Suspended ceiling components.
 - 3. Structural members to which duct will be attached.
 - 4. Size and location of initial access modules for acoustical tile.
 - 5. Penetrations of smoke barriers and fire-rated construction.
 - 6. Items penetrating finished ceiling including the following:
 - a. Lighting fixtures.
 - b. Air outlets and inlets.
 - c. Speakers.

- d. Sprinklers.
 - e. Access panels.
 - f. Perimeter moldings.
- D. Welding certificates.
- E. Field quality-control reports.

1.5 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.
- B. Welding Qualifications: Qualify procedures and personnel according to the following:
- 1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
 - 2. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.
- C. NFPA Compliance:
- 1. NFPA 90A, "Installation of Air conditioning and Ventilating Systems."
 - 2. NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."
 - 3. NFPA 96, "Ventilation Control and Fire Protection of Commercial Cooking Operations."
- D. Indicate compliance with USGBC LEED rating criteria for Indoor environmental quality (IEQ).

PART 2 - PRODUCTS

2.1 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible", latest edition, based on indicated static-pressure class unless otherwisedicated.
- B. The following fitting connections and duct construction gauges are NOT acceptable
- 1. Drive slip T-1, T-2 fitting connections
 - 2. 26 gauge ductwork.

- C. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," "Transverse (Girth) Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible." Fittings and/or joints of two different gauges, connected joint rating shall meet more stringent conditions
1. Use the following SMACNA Transverse (Girth) Joints
 - a. Duct construction as follows for 2" w.g. class:
 - 1) Up to 12" wide use T-6 or T-7
 - 2) 13" to 28" wide use T-11 or T12
 - 3) 29" wide and up use TDC or TDF
 - b. Duct construction as follows for 3" w.g. class:
 - 1) Up to 20" wide use T-6 or T-7
 - 2) 21" to 24" wide use T-11 or T12
 - 3) 25" wide and up use TDC or TDF
 - c. Duct construction as follows for 6" w.g. class:
 - 1) Up to 12" wide use T-6 or T-7
 - 2) 13" to 18" wide use T-11 or T12
 - 3) 19" wide and up use TDC or TDF

D. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible "Longitudinal Seams - Rectangular Ducts," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

E. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.2 DOUBLE-WALL RECTANGULAR DUCTS AND FITTINGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. McGill AirFlow LLC.
 2. Sheet Metal Connectors, Inc.
- B. Rectangular Ducts: Fabricate ducts with indicated dimensions for the inner duct.

- C. The following fitting connections and duct construction gauges are NOT acceptable
 - 1. Drive slip T-1, T-2 fitting connections
 - 2. 26 gauge ductwork

- D. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

- E. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," "Transverse (Girth) Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 1. Use the following SMACNA Transverse (Girth) Joints
 - a. Duct construction as follows for 2" w.g. class:
 - 1) Up to 12" wide use T-6 or T-7
 - 2) 13" to 28" wide use T-11 or T12
 - 3) 29" wide and up use TDC or TDF

 - b. Duct construction as follows for 3" w.g. class:
 - 1) Up to 20" wide use T-6 or T-7
 - 2) 21" to 24" wide use T-11 or T12
 - 3) 25" wide and up use TDC or TDF

 - c. Duct construction as follows for 6" w.g. class:
 - 1) Up to 12" wide use T-6 or T-7
 - 2) 13" to 18" wide use T-11 or T12
 - 3) 19" wide and up use TDC or TDF

- F. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," "Longitudinal Seams - Rectangular Ducts," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

- G. Interstitial Insulation: Fibrous-glass liner complying with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
 - 1. Maximum Thermal Conductivity: 0.25 Btu x in./h x sq. ft. x deg F (0.034 W/m x K) at 75 deg F (24 deg C) mean temperature.
 - 2. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.
 - 3. Coat insulation with antimicrobial coating.
 - 4. Cover insulation with polyester film complying with UL 181, Class 1.

- H. Inner Duct: Minimum 0.028-inch (0.7-mm) perforated galvanized sheet steel having 3/32-inch- (2.4-mm-) diameter perforations, with overall open area of 23 percent.
- I. Formed-on Transverse Joints (Flanges): Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," "Transverse (Girth) Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 1. Use the following SMACNA Transverse (Girth) Joints
 - a. Duct construction as follows for 2" w.g. class:
 - 1) Up to 12" wide use T-6 or T-7
 - 2) 13" to 28" wide use T-11 or T12
 - 3) 29" wide and up use TDC or TDF
 - b. Duct construction as follows for 3" w.g. class:
 - 1) Up to 20" wide use T-6 or T-7
 - 2) 21" to 24" wide use T-11 or T12
 - 3) 25" wide and up use TDC or TDF
 - c. Duct construction as follows for 6" w.g. class:
 - 1) Up to 12" wide use T-6 or T-7
 - 2) 13" to 18" wide use T-11 or T12
 - 3) 19" wide and up use TDC or TDF
- J. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," "Longitudinal Seams - Rectangular Ducts," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.3 SINGLE-WALL ROUND DUCTS AND FITTINGS

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Lindab Inc.
 - b. McGill AirFlow LLC.
 - c. SEMCO Incorporated.
 - d. Sheet Metal Connectors, Inc.
 - e. Spiral Manufacturing Co., Inc.

- B. Provide spiral seams for all ducts and fittings.
- C. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," "Transverse Joints - Round Duct," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 1. Transverse Joints in Ducts Larger Than 60 Inches (1524 mm) in Diameter: Flanged.
- D. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, 1995 edition, Figure 3-2, 2005 edition, "Seams - Round Duct and Fittings," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 1. Fabricate round ducts larger than 90 inches (2286 mm) in diameter with butt-welded longitudinal seams.
 - 2. Fabricate flat-oval ducts larger than 72 inches (1830 mm) in width (major dimension) with butt-welded longitudinal seams.
- E. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," 90 Degree Tees and Laterals," and "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.4 DOUBLE-WALL ROUND DUCTS AND FITTINGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Lindab Inc.
 - 2. McGill AirFlow LLC.
 - 3. SEMCO Incorporated.
 - 4. Sheet Metal Connectors, Inc.
- B. Provide spiral seams for all ducts and fittings
- C. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on static-pressure class unless otherwise indicated.
 - 1. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," "Transverse Joints - Round Duct," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

- a. Transverse Joints in Ducts Larger Than 60 Inches (1524 mm) in Diameter: Flanged.
 2. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Seams - Round Duct and Fittings," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - a. Fabricate round ducts larger than 90 inches (2286 mm) in diameter with butt-welded longitudinal seams.
 - b. Fabricate flat-oval ducts larger than 72 inches (1830 mm) in width (major dimension) with butt-welded longitudinal seams.
 3. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible, 90 Degree Tees and Laterals," and "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - D. Inner Duct: Minimum 0.028-inch (0.7-mm) perforated galvanized sheet steel having 3/32-inch- (2.4-mm-) diameter perforations, with overall open area of 23 percent.
 - E. Interstitial Insulation: Fibrous-glass liner complying with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
 1. Maximum Thermal Conductivity: 0.25 Btu x in./h x sq. ft. x deg F (0.034 W/m x K) at 75 deg F (24 deg C) mean temperature.
 2. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.
 3. Coat insulation with antimicrobial coating.
 4. Cover insulation with polyester film complying with UL 181, Class 1.
- 2.5 SHEET METAL MATERIALS
- A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible", latest edition for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
 - B. Exposed Ductwork
 1. Where ductwork is indicated to be exposed to view in occupied spaces, provide materials which are free from visual imperfections, including pittings, seam marks, stains, discolorations, and other imperfections. Provide finishes which will allow painting. Provide flat type seams and joints for all exposed duct construction

- C. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
 - 1. Galvanized Coating Designation: G60 (Z180).
 - 2. Finishes for Surfaces Exposed to View: Mill phosphatized.
- D. Carbon-Steel Sheets: Comply with ASTM A 1008/A 1008M, with oiled, matte finish for exposed ducts.
- E. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304 or 316, as indicated in the "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in the "Duct Schedule" Article.
- F. Aluminum Sheets: Comply with ASTM B 209 (ASTM B 209M) Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.
- G. Factory- or Shop-Applied Antimicrobial Coating:
 - 1. Apply to the interior surface of sheet metal that serve Air Handling Unit's AHU-146 and AHU 147's supply ductwork system an antimicrobial coating that shall form the interior surface of the duct.
 - 2. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
 - 3. Coating containing the antimicrobial compound shall have a hardness of 2H, minimum, when tested according to ASTM D 3363.
 - 4. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
 - 5. Shop-Applied Coating Color: Black.
- H. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
 - 1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.
- I. Tie Rods: Galvanized steel, 1/4-inch (6-mm) minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch (10-mm) minimum diameter for lengths longer than 36 inches (900 mm).
- J. Watertight construction where noted with edges bent 1/2 inch for watertight seal. Longitudinal seam sealant shall be similar to 3M Brand No. 800; Alcoa, aluminastic Type C, or solder. Stiffeners shall be plug or spot welded. Transverse joints shall be bolted companion angles with 1/4 inch cadmium plated bolts with 6 inch minimum on centers and gasket.
- K. Air tight construction where noted with longitudinal seams soldered. Stiffeners shall be plug or spot welded. Transverse joints shall be bolted companion angle with 1/4 inch cadmium plated bolts with 6 inch minimum on centers and gasket.

Exposed, uninsulated ductwork shall be flush flat seam. Provide airtight concrete, masonry and other construction materials for plenums and shafts only where noted

- L. Flush flat seam ductwork: Provide for all exposed uninsulated ducts and transverse joint detail shall be as indicated. Provide sheet metal 2 gauge numbers heavier than required for pressure classification with normal (standing) seam construction. Provide all joints and seams, smooth and aligned with no projections. For internal reinforcing, at transverse joints and on 2 ft centers, provide on ducts 31 inch to 60 inch wide, single vertical stay at duct midpoint, on ducts 61 inch to 90 inch wide provide 2 vertical stays on duct third (1/3) points and for ducts over 90 inch wide provide 3 vertical stays at ducts quarter (1/4) points. For vertical stays: provide 10 USSG galvanized steel, free of burrs and rough edges with both ends bent and fastened to top and bottom of duct.

2.6 DUCT LINER

- A. Comply with requirements specified in Division 23 Section "NOISE CONTROL" .
- B. Shop Application of Duct Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," "Flexible Duct Liner Installation."
 - 1. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.
 - 2. Apply adhesive to transverse edges of liner facing upstream. .
 - 3. Butt transverse joints without gaps, and coat joint with adhesive.
 - 4. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.
 - 5. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and dimensions of standard liner make longitudinal joints necessary.
 - 6. Apply adhesive coating on longitudinal seams in ducts with air velocity of 2500 fpm (12.7 m/s).
 - 7. Secure liner with mechanical fasteners 4 inches (100 mm) from corners and at intervals not exceeding 12 inches (300 mm) transversely; at 3 inches (75 mm) from transverse joints and at intervals not exceeding 18 inches (450 mm) longitudinally.
 - 8. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:
 - a. Fan discharges.
 - b. Intervals of lined duct preceding unlined duct.
 - c. Upstream edges of transverse joints in ducts or where indicated.
 - 9. Secure insulation between perforated sheet metal inner duct of same thickness as specified for outer shell. Use mechanical fasteners that maintain inner duct at uniform distance from outer shell without compressing insulation.

- a. Sheet Metal Inner Duct Perforations: 3/32-inch (2.4-mm) diameter, with an overall open area of 23 percent.
10. Terminate inner ducts with buildouts attached to fire-damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated buildouts (metal hat sections) or other buildout means are optional; when used, secure buildouts to duct walls with bolts, screws, rivets, or welds.

2.7 SEALANT AND GASKETS

- A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
- B. Indicate compliance with USGBC LEED rating criteria for Indoor environmental quality (IEQ)
- C. Two-Part Tape Sealing System:
 1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
 2. Tape Width: 3 inches (76 mm).
 3. Sealant: Modified styrene acrylic.
 4. Water resistant.
 5. Mold and mildew resistant.
 6. Maximum Static-Pressure Class: 10-inch wg (2500 Pa), positive and negative.
 7. Service: Indoor and outdoor.
 8. Service Temperature: Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).
 9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.
- D. Water-Based Joint and Seam Sealant:
 1. Application Method: Brush on.
 2. Solids Content: Minimum 65 percent.
 3. Shore A Hardness: Minimum 20.
 4. Water resistant.
 5. Mold and mildew resistant.
 6. VOC: Maximum 75 g/L (less water).
 7. Maximum Static-Pressure Class: 10-inch wg (2500 Pa), positive and negative.
 8. Service: Indoor or outdoor.
 9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.
- E. Flanged Joint Sealant: Comply with ASTM C 920.

1. General: Single-component, acid-curing, silicone, elastomeric.
 2. Type: S.
 3. Grade: NS.
 4. Class: 25.
 5. Use: O.
- F. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.
- G. Round Duct Joint O-Ring Seals:
1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg (0.14 L/s per sq. m at 250 Pa) and shall be rated for 10-inch wg (2500-Pa) static-pressure class, positive or negative.
 2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
 3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.8 HANGERS AND SUPPORTS

- A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.
- B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
- C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," "Rectangular Duct Hangers Minimum Size," and "Minimum Hanger Sizes for Round Duct."
- D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.
- E. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A 492.
- F. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.
- G. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
- H. Trapeze and Riser Supports:
1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
 2. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.
 3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

2.9 SEISMIC-RESTRAINT DEVICES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Cooper B-Line, Inc.; a division of Cooper Industries.
 2. Ductmate Industries, Inc.
 3. Hilti Corp.
 4. Kinetics Noise Control.
 5. Loos & Co.; Cableware Division.
 6. Mason Industries.
 7. TOLCO; a brand of NIBCO INC.
 8. Unistrut Corporation; Tyco International, Ltd.
- B. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an evaluation service member of the ICC Evaluation Service.
1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.
- C. Channel Support System: Shop- or field-fabricated support assembly made of slotted steel channels rated in tension, compression, and torsion forces and with accessories for attachment to braced component at one end and to building structure at the other end. Include matching components and corrosion-resistant coating.
- D. Restraint Cables: ASTM A 603, galvanized-steel cables with end connections made of cadmium-plated steel assemblies with brackets, swivel, and bolts designed for restraining cable service; and with an automatic-locking and clamping device or double-cable clips.
- E. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod.
- F. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

2.10 BACKDRAFT AND PRESSURE RELIEF DAMPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Greenheck Fan Corporation.
 2. Pottorff; a division of PCI Industries, Inc.
 3. Ruskin Company.
- B. Description: Gravity balanced.

- C. Maximum Air Velocity: 2000 fpm (10 m/s).
- D. Maximum System Pressure: 2-inch wg (0.5 kPa).
- E. Frame: 0.052-inch- (1.3-mm-) thick, galvanized sheet steel, with welded corners and mounting flange.
- F. Blades: Multiple single-piece blades, center-pivoted, maximum 6-inch (150-mm) width, 0.050-inch- (1.2-mm-) thick aluminum sheet with sealed edges.
- G. Blade Action: Parallel.
- H. Blade Seals: Extruded vinyl, mechanically locked.
- I. Blade Axles:
 - 1. Material: Non-metallic.
 - 2. Diameter: 0.20 inch (5 mm).
- J. Tie Bars and Brackets: Aluminum.
- K. Return Spring: Adjustable tension.
- L. Bearings: Synthetic pivot bushings.
- M. Accessories:
 - 1. Counterweights and spring-assist kits for vertical airflow installations.
- N. Sleeve: Minimum 16-gage thickness.

2.11 MANUAL VOLUME DAMPERS

- A. Dampers to be the same as duct construction.
- B. Standard, Steel, Manual Volume Dampers:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Pottorff; a division of PCI Industries, Inc.
 - b. Ruskin Company.
 - 2. Standard leakage rating, with linkage outside airstream.
 - 3. Suitable for horizontal or vertical applications.
 - 4. Frames:
 - a. Hat-shaped, galvanized -steel channels, 0.064-inch (1.62-mm) minimum thickness.
 - b. Mitered and welded corners.

- c. Flanges for attaching to walls and flangeless frames for installing in ducts.
 5. Blades:
 - a. Multiple or single blade.
 - b. Provide single blade dampers up to 6 inch width and opposed multiblade dampers above 6 inches in width.
 - c. Parallel- or opposed-blade design.
 - d. Stiffen damper blades for stability.
 - e. Galvanized-steel, 0.064 inch (1.62 mm) thick (16 ga.).
 6. Blade Axles: Galvanized steel.
 7. Bearings:
 - a. Molded synthetic.
 - b. Dampers in ducts with pressure classes of 3-inch wg (750 Pa) or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
 8. Tie Bars and Brackets: Galvanized steel.
- C. Standard, Aluminum, Manual Volume Dampers:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Pottorff; a division of PCI Industries, Inc.
 - b. Ruskin Company.
 2. Standard leakage rating, with linkage outside airstream.
 3. Suitable for horizontal or vertical applications.
 4. Frames: Hat-shaped, 0.10-inch- (2.5-mm-) thick, aluminum sheet channels; frames with flanges for attaching to walls and flangeless frames for installing in ducts.
 5. Blades:
 - a. Multiple or single blade.
 - b. Parallel- or opposed-blade design.
 - c. Stiffen damper blades for stability.
 - d. Roll-Formed Aluminum Blades: 0.10-inch- (2.5-mm-) thick aluminum sheet.
 - e. Extruded-Aluminum Blades: 0.050-inch- (1.2-mm-) thick extruded aluminum.
 6. Blade Axles: Nonferrous metal.
 7. Bearings:
 - a. Molded synthetic.

- b. Dampers in ducts with pressure classes of 3-inch wg (750 Pa) or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
 8. Tie Bars and Brackets: Aluminum.
- D. Low-Leakage, Steel, Manual Volume Dampers:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Pottorff; a division of PCI Industries, Inc.
 - b. Ruskin Company.
 2. Low-leakage rating, with linkage outside airstream, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.
 3. Suitable for horizontal or vertical applications.
 4. Frames:
 - a. Hat shaped.
 - b. Galvanized-steel channels, 0.064 inch (1.62 mm) thick.
 - c. Mitered and welded corners.
 - d. Flanges for attaching to walls and flangeless frames for installing in ducts.
 5. Blades:
 - a. Multiple or single blade.
 - b. Parallel- or opposed-blade design.
 - c. Stiffen damper blades for stability.
 - d. Galvanized, roll-formed steel, 0.064 inch (1.62 mm) thick. (16 ga.).
 6. Blade Axles: Galvanized steel.
 7. Bearings:
 - a. Molded synthetic.
 - b. Dampers in ducts with pressure classes of 3-inch wg (750 Pa) or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
 8. Blade Seals: Neoprene.
 9. Jamb Seals: Cambered aluminum.
 10. Tie Bars and Brackets: Galvanized steel.
 11. Accessories:
 - a. Include locking device to hold single-blade dampers in a fixed position without vibration.
- E. Low-Leakage, Aluminum, Manual Volume Dampers:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- a. Ruskin Company.
 - b. Trox USA Inc.
2. Low-leakage rating, with linkage outside airstream, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.
 3. Suitable for horizontal or vertical applications.
 4. Frames: Hat-shaped, 0.10-inch- (2.5-mm-) thick, aluminum sheet channels; frames with flanges for attaching to walls and flangeless frames for installing in ducts.
 5. Blades:
 - a. Multiple or single blade.
 - b. Parallel- or opposed-blade design.
 - c. Roll-Formed Aluminum Blades: 0.10-inch- (2.5-mm-) thick aluminum sheet.
 - d. Extruded-Aluminum Blades: 0.050-inch- (1.2-mm-) thick extruded aluminum.
 6. Blade Axles: Stainless steel.
 7. Bearings:
 - a. Molded synthetic.
 - b. Dampers in ducts with pressure classes of 3-inch wg (750 Pa) or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
 8. Blade Seals: Neoprene.
 9. Jamb Seals: Cambered aluminum.
 10. Tie Bars and Brackets: Aluminum.
 11. Accessories:
 - a. Include locking device to hold single-blade dampers in a fixed position without vibration.
- F. Jackshaft:
1. Size: 1-inch (25-mm) diameter.
 2. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
 3. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.
- G. Damper Hardware:
1. Zinc-plated, die-cast core with dial and handle made of 3/32-inch- (2.4-mm-) thick zinc-plated steel, and a 3/4-inch (19-mm) hexagon locking nut.
 2. Include center hole to suit damper operating-rod size.
 3. Include elevated platform for insulated duct mounting.

2.11 CONTROL DAMPERS

- H. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Greenheck Fan Corporation.
 - 2. Ruskin Company.
- I. Low-leakage rating, with linkage outside airstream, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage. All dampers serving outside air connections/service shall be internal insulated type.
- J. Dampers to be the same as duct construction.
- K. For internally lined ductwork: Provide 2 internal saddles to protect lining.
- L. Frames:
 - 1. Hat shaped.
 - 2. Galvanized-steel channels, 0.064 inch (1.62 mm) thick.
 - 3. Mitered and welded corners.
- M. Blades:
 - 1. Provide airfoil blades.
 - 2. Multiple blade with maximum blade width of 8 inches (200 mm).
 - 3. Provide dampers with parallel blades for 2 position control and opposed blades for modulating control.
 - 4. Parallel- and opposed-blade design.
 - 5. Galvanized steel.
 - 6. 0.064 inch (1.62 mm) thick.
 - 7. Blade Edging: Closed-cell neoprene edging.
 - 8. Blade Edging: Inflatable seal blade edging, or replaceable rubber seals.
- N. Blade Axles: 1/2-inch- (13-mm-) diameter; 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 200 deg F (minus 40 to plus 93 deg C).
- O. Bearings:
 - 1. Molded synthetic.
 - 2. Dampers in ducts with pressure classes of 3-inch wg (750 Pa) 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.

2.12 FIRE DAMPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Pottorff; a division of PCI Industries, Inc.
 - 2. Ruskin Company.
- B. Type: Dynamic; rated and labeled according to UL 555 by an NRTL.
- C. Closing rating in ducts up to 4-inch wg (1-kPa) static pressure class and minimum 4000-fpm (20-m/s) velocity.
- D. Fire Rating: 1-1/2 and 3 hours.
- E. Frame: Curtain type with blades outside airstream ("Type B"); fabricated with roll-formed, 0.034-inch- (0.85-mm-) thick galvanized steel; with mitered and interlocking corners.
- F. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.
 - 1. Minimum Thickness: 0.052 or 0.138 inch (1.3 or 3.5 mm) thick, as indicated, and of length to suit application.
 - 2. Exception: Omit sleeve where damper-frame width permits direct attachment of perimeter mounting angles on each side of wall or floor; thickness of damper frame must comply with sleeve requirements.
- G. Mounting Orientation: Vertical or horizontal as indicated.
- H. Blades: Roll-formed, interlocking, 0.034-inch- (0.85-mm-) thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch- (0.85-mm-) thick, galvanized-steel blade connectors.
- I. Horizontal Dampers: Include blade lock and stainless-steel closure spring.
- J. Heat-Responsive Device: Replaceable, 165 deg F (74 deg C) rated, fusible links.
- K. Provide fire dampers as noted on the plans and in ducts and openings in the following:
 - a. Floors.
 - b. Fire walls.
 - c. Fire-resistance partitions.
 - d. Fire rated ceilings.
 - e. Exit corridor walls.
- L. Provide access door in duct adjacent to each fire damper.

2.13 SMOKE DAMPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Ruskin Company.
 - 2. Pottorff; a division of PCI Industries, Inc.
- B. General Requirements: Label according to UL 555S by an NRTL.
- C. Frame: Multiple blade type; fabricated with roll-formed, 0.034-inch- (0.85-mm-) thick galvanized steel; with mitered and interlocking corners.
- D. Blades: Airfoil type Roll-formed, horizontal, interlocking, 0.034-inch- (0.85-mm-) thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch- (0.85-mm-) thick, galvanized-steel blade connectors.
- E. Leakage: Class I.
- F. Rated pressure and velocity to exceed design airflow conditions.
- G. Mounting Sleeve: Factory-installed, 0.052-inch- (1.3-mm-) thick, galvanized sheet steel; length to suit wall or floor application with factory-furnished silicone caulking.
- H. Provide motor mount bracket strengthener for dampers over 10" in height.
- I. Provide a 10 gauge welded vertical stiffener at each corner to prevent damper misalignment.
- J. Damper Motors: Two-position action, unless control sequence requires modulating. Coordinate with ATC contractor.
- K. Actuators mounted out of the air stream, with automatic reset.
- L. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."
 - 1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - 2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 23 Section "Instrumentation and Control for HVAC."
 - 3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
 - 4. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf (17 N x m) and breakaway torque rating of 150 in. x lbf (17 N x m).

5. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F (minus 40 deg C).
6. Electrical Connection: 115 V, single phase, 60 Hz.

M. Accessories:

1. Auxiliary switches for position indication.
2. Test and reset switches, remotemounted.

N. The HVAC contractor shall provide all devices, relays, end switches, e/p switches, control components, air piping, power wiring, control wiring and interlock wiring as required to accomplish the sequence of operation for these dampers.

O. Provide access door in duct adjacent to each combination fire / smoke damper.

2.14 COMBINATION FIRE AND SMOKE DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Pottorff; a division of PCI Industries, Inc., model FSD-151, FSD-341, 1-1/2 or 3 hours rated as applicable
2. Ruskin Company.model FSD-60, 1-1/2 or 3 hour rated as applicable

B. Type: Dynamic; rated and labeled according to UL 555 and UL 555S by an NRTL.

C. Closing rating in ducts up to 4-inch wg static pressure class and minimum 4000-fpm (20-m/s) velocity.

D. Fire Rating: 1-1/2 and 3 hours.

E. Frame: multiblade type fabricated with roll-formed, 0.034-inch- (0.85-mm-) thick galvanized steel; with mitered and interlocking corners.

F. Heat-Responsive Device: Replaceable, 165 deg F (74 deg C) rated, fusible links.

G. Blades: 14 gauge galvanized airfoil shaped double skin, single piece construction, maximum 6 inches wide..

H. Leakage: Class I.

I. Rated pressure and velocity to exceed design airflow conditions.

J. Mounting Sleeve: Factory-installed, 0.052-inch- (1.3-mm-) thick, galvanized sheet steel; length to suit wall or floor application with factory-furnished silicone calking.

K. Provide motor mount bracket strengthener for dampers over 10" in height.

L. Provide a 10 gauge welded vertical stiffener at each corner to prevent damper misalignment

- M. Master control panel for use in dynamic smoke-management systems.
 - N. Damper Motors: Two-position action unless control sequence requires modulating. Coordinate with ATC contractor.
 - O. Actuators mounted out of the air stream,
 - P. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."
 - 1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - 2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 23 Section "Instrumentation and Control for HVAC."
 - 3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
 - 4. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf (17 N x m) and breakaway torque rating of 150 in. x lbf (17 N x m).
 - 5. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F (minus 40 deg C).
 - 6. Electrical Connection: 115 V, single phase, 60 Hz.
 - Q. Accessories:
 - 1. Auxiliary switches for position indication.
 - 2. Test and reset switches, remote mounted.
 - R. The HVAC contractor shall provide all devices, relays, end switches, e/p switches, control components, air piping, power wiring, control wiring and interlock wiring as required to accomplish the sequence of operation for these dampers.
 - S. Provide combination fire / smoke dampers as noted on the plans.
 - T. Provide access door in duct adjacent to each combination fire / smoke damper.
- 2.15 TURNING VANES
- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Ductmate Industries, Inc.
 - 2. Duro Dyne Inc.
 - 3. METALAIRE, Inc.
 - 4. SEMCO Incorporated.

- B. 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.
 - 1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.
- C. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; "Vanes and Vane Runners," and "Vane Support in Elbows."
- D. Vane Construction: Double wall.
- E. The maximum unsupported vane length shall not exceed 48 inches.
- F. Single vane and short radius vanes are not acceptable.

2.16 REMOTE DAMPER OPERATORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Pottorff; a division of PCI Industries, Inc.
 - 2. Ventfabrics, Inc.
 - 3. Young Regulator Company.
- B. Description: Cable system designed for remote manual damper adjustment.
- C. Tubing: Brass.
- D. Cable: Stainless steel.
- E. Wall-Box Mounting: Recessed, 3/4 inches (19 mm) deep Surface.
- F. Wall-Box Cover-Plate Material: Steel.

2.17 DUCT-MOUNTED ACCESS DOORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Ductmate Industries, Inc.
 - 2. Greenheck Fan Corporation.
 - 3. McGill AirFlow LLC.
 - 4. Pottorff; a division of PCI Industries, Inc.
 - 5. Ventfabrics, Inc.

- B. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 2-10, "Duct Access Doors and Panels," and 2-11, "Access Panels - Round Duct."
1. Door:
 - a. Double wall, rectangular.
 - b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
 - c. Vision panel.
 - d. Hinges and Latches: 1-by-1-inch (25-by-25-mm) butt or piano hinge and cam latches.
 - e. 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 12 Inches (300 mm) Square: No hinges and two sash locks.
 - b. Access Doors up to 18 Inches (460 mm) Square: Two hinges and two sash locks.
 - c. Access Doors up to 24 by 48 Inches (600 by 1200 mm): Three hinges and two compression latches with outside and inside handles.
 - d. Access Doors Larger Than 24 by 48 Inches (600 by 1200 mm): Four hinges and two compression latches with outside and inside handles.
- C. Furnish and install gasketed grease tight access doors on the grease hood exhaust duct as required under NFPA 96.

2.18 FLEXIBLE CONNECTORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Ductmate Industries, Inc.
 2. Duro Dyne Inc.
 3. Ventfabrics, Inc.
- B. Materials: Flame-retardant or noncombustible fabrics.
- C. Coatings and Adhesives: Comply with UL 181, Class 1.
- D. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches (89 mm) wide attached to 2 strips of 2-3/4-inch- (70-mm-) wide, 0.028-inch- (0.7-mm-) thick, galvanized sheet steel or 0.032-inch- (0.8-mm-) thick aluminum sheets. Provide metal compatible with connected ducts.
- E. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.

1. Minimum Weight: 26 oz./sq. yd. (880 g/sq. m).
 2. Tensile Strength: 480 lbf/inch (84 N/mm) in the warp and 360 lbf/inch (63 N/mm) in the filling.
 3. Service Temperature: Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).
- F. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.
1. Minimum Weight: 24 oz./sq. yd. (810 g/sq. m).
 2. Tensile Strength: 530 lbf/inch (93 N/mm) in the warp and 440 lbf/inch (77 N/mm) in the filling.
 3. Service Temperature: Minus 50 to plus 250 deg F (Minus 45 to plus 121 deg C).
- G. High-Temperature System, Flexible Connectors: Glass fabric coated with silicone rubber.
1. Minimum Weight: 16 oz./sq. yd. (542 g/sq. m).
 2. Tensile Strength: 285 lbf/inch (50 N/mm) in the warp and 185 lbf/inch (32 N/mm) in the filling.
 3. Service Temperature: Minus 67 to plus 500 deg F (Minus 55 to plus 260 deg C).
- H. High-Corrosive-Environment System, Flexible Connectors: Glass fabric with chemical-resistant coating.
1. Minimum Weight: 14 oz./sq. yd. (474 g/sq. m).
 2. Tensile Strength: 450 lbf/inch (79 N/mm) in the warp and 340 lbf/inch (60 N/mm) in the filling.
 3. Service Temperature: Minus 67 to plus 500 deg F (Minus 55 to plus 260 deg C).
- I. Thrust Limits: Combination coil spring and elastomeric insert with spring and insert in compression, and with a load stop. Include rod and angle-iron brackets for attaching to fan discharge and duct.
1. Frame: Steel, fabricated for connection to threaded rods and to allow for a maximum of 30 degrees of angular rod misalignment without binding or reducing isolation efficiency.
 2. Outdoor Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
 7. Coil Spring: Factory set and field adjustable for a maximum of 1/4-inch (6-mm) movement at start and stop.

2.19 FLEXIBLE DUCTWORK

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Buckley Associates
 - 2. Novaflex
- B. Construction
 - 1. Flex duct shall comply with UL 181, Class 1.
 - 2. Flex duct shall be Type 4, with a heavy coated fiberglass cloth fabric liner, mechanically locked without adhesives. Helix shall be corrosive resistant galvanized steel formed and mechanically locked to fabric.
 - 3. For duct systems requiring insulation, the flex duct shall have 1 inch thick fiberglass insulation blanket encapsulated in a fire retardant polyethylene outer jacket with a flame spread less than 25 and smoke developed rating less than 50.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.
- B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.
- C. Install round and flat-oval ducts in maximum practical lengths.
- D. Install ducts with fewest possible joints.
- E. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.
- F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.
- G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
- H. Install ducts with a clearance of 1 inch (25 mm), plus allowance for insulation thickness.

- I. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.
- J. 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 1-1/2 inches (38 mm).
- K. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Division 23 Section "Air Duct Accessories" for fire and smoke dampers.
- L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "Duct Cleanliness for New Construction Guidelines."
- M. Flexible duct runouts to diffusers/registers/grilles shall not exceed six feet in length, fully extended.
- N. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.
- O. Install backdraft dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.
- P. 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. Provide manual balancing volume dampers as required properly balance the air distribution system. If the location of balancing dampers are not defined on the drawings, the following minimum standards shall govern:
 - a. Low Pressure: All supply main air branches from trunk, each split, and all sub branches from main shall be provided with balancing dampers.
 - b. Low Pressure: All exhaust main air branches from trunk, each split, and all sub branches from main shall be provided with balancing dampers.
 - c. Medium Pressure: All branches and takeoffs downstream of terminal boxes (CV, VAV and FPB) shall be provided with low leakage balancing dampers.
 - d. Ducts connecting to common plenums.
 - e. Ducts serving single outlet.
 - f. At open return duct in hung ceiling.
 - g. As noted on plans.
 2. For internally lined ductwork: Provide 2 internal saddles to protect lining.
 3. Install levers to be accessible through the insulation
- Q. Set dampers to fully open position before testing, adjusting, and balancing.

- R. Install test holes at fan inlets and outlets and elsewhere as indicated.
- S. Install, combination fire & smoke fire and smoke dampers according to UL listing.
- T. Connect ducts to duct silencers rigidly.
- U. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
 - 1. On both sides of duct coils.
 - 2. Downstream from manual volume dampers, control dampers, turning vanes, and equipment.
 - 3. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
 - 4. At each change in direction and at maximum 50-foot (15-m) spacing.
 - 5. Upstream of turning vanes.
 - 6. Elsewhere as indicated.
- V. Install access doors with swing against duct static pressure.
- W. Access Door Sizes:
 - 1. One-Hand or Inspection Access: 8 by 5 inches.
 - 2. Two-Hand Access: 12 by 6 inches.
 - 3. Head and Hand Access: 18 by 10 inches.
 - 4. Head and Shoulders Access: 21 by 14 inches.
 - 5. Body Access: 25 by 14 inches.
 - 6. Body plus Ladder Access: 25 by 17 inches.
- X. Label access doors according to Division 23 Section "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.
- Y. Install flexible connectors to connect ducts to equipment.
- Z. For fans developing static pressures of 5-inch wg and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.
- AA. Connect terminal units to supply ducts directly. Do not use flexible ducts provide flexible connections for all fan powered terminal boxes.
- BB. Connect diffusers to flexible ducts with draw bands.
- CC. Install duct test holes where required for testing and balancing purposes.
- DD. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch (6-mm) movement during start and stop of fans.

3.2 SEAM AND JOINT SEALING

- A. Seal duct seams and joints for duct static-pressure and leakage classes specified in "Performance Requirements" Article, according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Standard Duct Sealing Requirements," unless otherwise indicated..

3.3 HANGER AND SUPPORT INSTALLATION

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," "Hangers and Supports."
- B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
 - 1. Where practical, install concrete inserts before placing concrete.
 - 2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
 - 3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches (100 mm) thick.
 - 4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches (100 mm) thick.
 - 5. Do not use powder-actuated concrete fasteners for seismic restraints.
- C. Hanger Spacing: Comply with the requirements of this section, the BUILDING CODE and SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," "Rectangular Duct Hangers Minimum Size," and "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing whichever is more stringent. Install hangers and supports within 24 inches (610 mm) of each elbow and within 48 inches (1200 mm) of each branch intersection.
- D. Hangers Exposed to View: Threaded rod and angle or channel supports.
- E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.
- F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
- G. Hangers, horizontal ducts:
 - 1. To 2 sq ft in area: Provide galvanized steel strap hangers, minimum 1 inch x 1/8 inch, maximum 8 ft - 0 inch spacing.
 - 2. 2 to 4 sq ft in area: Galvanized steel strap hangers, minimum 1 inch x 1/8 inch, maximum 8 ft 0 inch spacing.
 - 3. Strap hangers shall be bent 2 inch under the bottom corner of rectangular ducts. One screw shall secure 2 inch portion of hanger to bottom of duct. Straps shall be secured to side of duct with a minimum of two screws and

more, as necessary, to provide a maximum screw spacing of 12 inch. Side-of-duct screws shall be located not more than 2 inch from top and bottom of duct.

4. 4 to 10 sq ft in area: Provide galvanized steel trapeze angles from steel threaded rods with a maximum 6 ft - 0 inch spacing.
 5. Over 10 sq ft in area: Provide galvanized steel trapeze angles from steel threaded rods with a maximum 4 ft - 0 inch spacing.
 6. Provide stronger support to match larger and heavier ducts; provide cross-bracing, angle iron hangers, as required for rigid and adequate supports.
 7. In mechanical rooms: Provide black steel painted or galvanized, vertical angles or rods and horizontal angles across ductwork.
 8. Kitchen exhaust in accordance with NFPA 96.
- H. Hangers Vertical ducts: At each floor, provide minimum 2 supports per duct fastened to duct and spanning shaft opening. Fasten supports to floor or structural construction. Maximum screw spacing shall be 12 inch on center and maximum shall be four screw per riser.
1. Angles and channels: Provide painted black steel or galvanized. Where angles are specified, channels of equivalent strength, material and protective coating will be permitted. Where more than one duct is supported by a common set of angles, support size shall be determined by sum of width dimensions.
 2. Supports: Provide as follows, except increase supports as required for load and span where span of angles exceed 6 ft or floor-to-floor height exceeds 14 ft.
 - a. Duct width to 30 inch: Provide angle size: 1-1/4 inch x 1-1/4 inch x 1/8 inch.
 - b. Duct width, 31 inch to 54 inch: Angle size shall be 2 inch x 2 inch x 3/16 inch.
 - c. Duct width, 55 inch to 90 inch: Angle size shall be 2 inch x 2 inch x 1/4 inch.
 3. Vertical kitchen exhaust, fireproofed and plastered ducts: Provide minimum 3 inch, 4.1 lb/ft, steel channels fastened to slab, welded to building structural steel or as acceptable. Supports shall be bolted or welded to ducts and in accordance with NFPA 96.

3.4 SEISMIC-RESTRAINT-DEVICE INSTALLATION

- A. Install ducts with hangers and braces designed to support the duct and to restrain against seismic forces required by applicable building codes. Comply with SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems." SEI/ASCE 7.
1. Space lateral supports a maximum of 40 feet (12 m) o.c., and longitudinal supports a maximum of 80 feet (24 m) o.c.
 2. Brace a change of direction longer than 12 feet (3.7 m).

- B. Select seismic-restraint devices with capacities adequate to carry present and future static and seismic loads.
- C. Install cables so they do not bend across edges of adjacent equipment or building structure.
- D. Install cable restraints on ducts that are suspended with vibration isolators.
- E. Install seismic-restraint devices using methods approved by an evaluation service member of the ICC Evaluation Service.
- F. Attachment to Structure: If specific attachment is not indicated, anchor bracing and restraints to structure, to flanges of beams, to upper truss chords of bar joists, or to concrete members.
- G. Drilling for and Setting Anchors:
 - 1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcement or embedded items during drilling. Notify the Architect if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
 - 2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
 - 3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
 - 4. Set anchors to manufacturer's recommended torque, using a torque wrench.
 - 5. Install zinc-coated steel anchors for interior applications and stainless-steel anchors for applications exposed to weather.

3.5 CONNECTIONS

- A. Make connections to equipment with flexible connectors.
- B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.6 PAINTING

- A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Division 09 painting Sections.

3.7 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Leakage Tests:

1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual."
2. All testing shall be done in the presence of the engineer or owner's representative. The contractor is responsible for providing all collars, caps, electric power, etc. necessary to perform the tests. The contractor is also responsible for scheduling the test no less than three (3) business days prior to its intended occurrence. Low pressure ductwork (2" class) shall be tested on an as needed basis at the engineer's direction. Leakage test procedure shall follow the outlines and classifications in the SMACNA HVAC duct leakage test manual. If specimen fails to meet allotted leakage level, the contractor shall modify to bring it into compliance and shall retest it until acceptable leakage is demonstrated. Tests and necessary repair shall be completed prior to concealment of ducts.
3. Test the following systems:
 - a. All ductwork greater than 2" class as defined within is to be tested. .
4. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
5. Test for leaks before insulation application.
6. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test entire system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure. Give seven days' advance notice for testing.

C. Duct System Cleanliness Tests:

1. Visually inspect duct system to ensure that no visible contaminants are present.
2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness according to "Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."
 - a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.

D. Duct system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.8 DUCT CLEANING

- A. Clean new duct system(s) before testing, adjusting, and balancing.
- B. Use service openings for entry and inspection.
 - 1. Create new openings and install access panels appropriate for duct static-pressure class if required for cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer.
 - 2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
 - 3. Remove and reinstall ceiling to gain access during the cleaning process.
- C. Particulate Collection and Odor Control:
 - 1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
 - 2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.
- D. Clean the following components by removing surface contaminants and deposits:
 - 1. Air outlets and inlets (registers, grilles, and diffusers).
 - 2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
 - 3. Air-handling unit internal surfaces and components including mixing box, coil section, condensate drain pans, humidifiers, filters and filter sections, and condensate collectors and drains.
 - 4. Coils and related components.
 - 5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
 - 6. Supply-air ducts, dampers, actuators, and turning vanes.
 - 7. Dedicated exhaust and ventilation components and makeup air systems.
- E. Mechanical Cleaning Methodology:
 - 1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
 - 2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
 - 3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
 - 4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.

5. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
6. Provide drainage and cleanup for wash-down procedures.
7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents according to manufacturer's written instructions after removal of surface deposits and debris.

3.9 DUCT SCHEDULE

- A. Fabricate ducts with galvanized sheet steel except as follows:
- B. Exposed ductwork:
 1. Where ductwork is indicated to be exposed to view in occupied spaces, provide materials which are free from visual imperfections, including pittings, seam marks, stains, discolorations, and other imperfections. Provide finishes which will allow painting. Provide flat type seams and joints for all exposed duct construction
 2. Watertight Ductwork exposed to weather, except as noted shall be as follows:
 - a. Aluminum.
 - b. Watertight.
 3. Outside air, exhaust and relief duct shall be as follows:
 - a. Aluminum.
 - b. Watertight.
 - c. Extent:
 - 1) Within 10 ft. of louvers.
 4. Ductwork at duct humidifiers shall be as follows:
 - a. Aluminum.
 - b. Watertight.
 - c. Minimum 2 ft. upstream.
 - d. Minimum 10 ft downstream.
 5. sub sterile exhaust ductwork, provide as follows:
 - a. 316 Stainless Steel.
 - b. Welded.
 - c. Construction shall be in accordance with SMACNA rectangular industrial duct construction standards.
 6. Canopy fume hoods shall be as follows:
 - a. ACGIH Industrial Ventilation Manual, unless noted otherwise.
 - b. Stainless steel No. 16 USSG.

- c. Internal angles and seams.
 - d. Bolts shall be countersunk.
 - e. Size, configuration and support shall be as indicated.
- C. Liner:
- 1. Comply with requirements specified in Division 23 Section 'NOISE CONTROL' .
- D. Double-Wall Duct Interstitial Insulation / acoustic lining:
- 1. Supply- and Return-Air Ducts, 1 inch thick.
- E. Elbow Configuration:
- 1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Rectangular Elbows."
 - 1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
 - 2) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Vanes and Vane Runners," and "Vane Support in Elbows."
 - 3) Provide splitter vanes on all short radius elbows.
 - 4) Provide double thickness turning vanes on all square elbows.
 - 2. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," "Round Duct Elbows."
 - a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments, conform to SMACNA.
 - 1) Velocity 1000 fpm or Lower: 0.6 radius-to-diameter ratio and three segments for 90-degree elbow.
 - 2) Velocity 1000 to 1500 fpm: 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
 - 3) Velocity 1500 fpm or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
 - b. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.
 - c. Round Elbows, 14 Inches and Larger in Diameter: Welded.
- F. Branch Configuration:
- 1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," "Branch Connections."
 - a. Rectangular Main to Rectangular Branch: 45-degree entry.
 - b. Rectangular Main to Round Branch: flanged spin in, conical.
 - c. Do not use "butt flange" straight taps.

- d. Divided flow branches
 - 1) Provide long radius takeoff or square elbow as per SMACNA.
- 2. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," "90 Degree Tees and Laterals," and "Conical Tees."
 - a. Velocity 1000 fpm or Lower: 90-degree tee fitting.
 - b. Velocity 1000 to 1500 fpm: Conical fitting.
 - c. Velocity 1500 fpm or Higher: 45-degree lateral fitting.
 - d. Saddle taps are NOT permitted.
 - e. No bull head tees
 - f. Divided flow branches, conical tees, y- branch or reducing Y-branch.or Tee's
- G. Obstructions
 - 1. Conform to SMACNA
- H. Offsets and transitions
 - 1. Conform to SMACNA

END OF SECTION