

## **SECTION 23 31 13 DUCTWORK**

### **PART 1 - GENERAL**

#### **1.1 STIPULATIONS**

- A. The specifications sections "General Conditions to the Construction Contract", "Special Conditions" and "Division 01 - General Requirements" form a part of this Section by this reference thereto, and shall have the same force and effect as if printed herewith in full.

#### **1.2 ADDITIONAL RELATED DOCUMENTS**

- A. Related Division 23 Sections include the following:
  - 1. "Vibration Controls for HVAC" for ductwork vibration isolators.
  - 2. "Air Duct Accessories" for dampers, sound-control devices, duct-mounted access doors and panels, turning vanes, flexible ducts, and other duct mounted specialties.
  - 3. "Diffusers, Registers, and Grilles" for air inlets and outlets.
  - 4. "Testing, Adjusting, and Balancing for HVAC" for air balancing and final adjusting of manual-volume dampers.

#### **1.3 SUMMARY**

- A. This Section includes rectangular and round metal ducts and plenums for heating, ventilating, and air-conditioning systems in pressure classes from minus 10- to plus 10-inch w.g. Products specified herein include the following:
  - 1. Single-wall, rectangular ducts and fittings.
  - 2. Single-wall round spiral-seam ducts and formed fittings.
  - 3. Sealants and gaskets.

#### **1.4 INTERPRETATION OF THE DRAWINGS**

- A. Duct system design, as indicated, has been used to select and size air-moving and -distribution equipment and other components of air system. Ductwork indicated on the Drawings is schematic; therefore, changes in ductwork sizes and/or location shall be made when necessary to conform to project conditions. Offsets, rises, drops, and duct profile changes shall be made at no additional cost to the Client Agency. The Architect / Engineer shall be consulted for approval of duct size changes which cannot maintain the same equivalent flow area and friction rate, require a duct aspect ratio exceeding 4 to 1, or represent a fundamental change to the configuration of duct system. Proposed changes must be specifically approved in writing by Architect / Engineer prior to being implemented. Accompany requests for layout modifications with calculations showing that proposed layout will provide original design results without increasing system total pressure.
- B. Duct dimensions indicated on Drawings are the required clear, inside dimensions. Adjust sheet metal dimensions to account for duct liner or double wall construction. Note that, typically, the

first dimension listed on the Drawings is that of the side visible in the particular 2D view (plan, section, etc.).

- C. The Drawings schematically indicate fitting types. All proposed changes in fitting types shown on the Drawing or specified in this Section shall be approved in writing by the Architect / Engineer prior to being implemented.
- D. Turning vanes not shown on the Drawings for mitered rectangular elbows have been omitted for clarity purposes only. The Contractor shall provide turning vanes as required by this Section regardless of drawing depiction.
  - 1. At the Contractor's option, radius type elbows with 1.5 or 1.0 centerline radius to duct width ratio may be provided in lieu of mitered elbows shown on the Drawings where the duct width in the plane of change in direction is less than 14", provided that the elbow fits in the space available.
  - 2. Mitered elbows shall not be substituted for a radius type elbows shown on the Drawings unless specifically approved by the Architect / Engineer.

## **1.5 PERFORMANCE REQUIREMENTS**

- A. Delegated Duct Design: 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" and performance requirements and design criteria indicated in this Section, and elsewhere in the Contract Documents.
  - 1. Where the requirements of this specification section exceed SMACNA requirements or where a prohibition of specific type of work contained in the SMACNA standard is made, the requirements of this specification section shall take precedence.
- B. Structural Performance: Duct hangers and supports shall withstand the effects of gravity and wind loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"
- C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

## **1.6 ACTION SUBMITTALS**

- A. Product Data: For prefabricated ductwork, duct components sealant and gasket materials.
- B. Shop Drawings: Show details of the following:
  - 1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
  - 2. Factory- and shop-fabricated ducts and fittings.
  - 3. Duct layout indicating sizes, configuration, and pressure classes.
  - 4. Elevations of top and bottom of ducts.
  - 5. Dimensions of main duct runs from building grid lines.
  - 6. Fittings.
  - 7. Reinforcement and spacing.
  - 8. Seam and joint construction.
  - 9. Penetrations through fire-rated and other partitions.
  - 10. Penetrations through the roof and exterior walls.

11. Equipment installation based on equipment being used on Project.
12. Duct accessories, including dampers and access doors.
13. Hangers and supports, including methods for duct and building attachment, and vibration isolation.
14. Control dampers, airflow measuring stations, temperature and pressure sensors, and all other control devices required. Coordinate with the work of the ATC Sub-contractor as described in Division 23 Section "Instrumentation and Control for HVAC".

C. Delegated-Design Submittal:

1. Sheet metal thicknesses.
2. Joint and seam construction and sealing.
3. Reinforcement details and spacing.
4. Materials, fabrication, assembly, and spacing of hangers and supports.
5. Design Calculations: Calculations for selecting hangers and supports.

## 1.7 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Reflected ceiling plans drawn to scale and coordinating penetrations and ceiling-mounted items. Refer to Division 23 Section "Common Work Results for HVAC" for additional coordination drawing requirements. Show the following:
1. Ceiling suspension assembly members.
  2. Other systems installed in same space as ducts.
  3. Ceiling- and wall-mounted access doors and panels required to provide access to dampers and other operating devices.
  4. Coordination with ceiling-mounted items, including lighting fixtures, diffusers, grilles, speakers, sprinkler heads, access panels, and special moldings.
  5. Other items required to be included as per the provisions of Division 23 Section "Common Work Results for HVAC".
- B. Welding Certificates: Copies of certificates indicating welding procedures and personnel comply with requirements in "Quality Assurance" Article.
- C. Field Test Reports: Indicate and interpret test results for compliance with performance requirements for the following:
1. Pressure and leakage tests.

## 1.8 CLOSEOUT SUBMITTALS

- A. Record Drawings: Indicate actual routing, fitting details, reinforcement, support, and installed accessories and devices.

## 1.9 QUALITY ASSURANCE

- A. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA): Generally, ductwork and ductwork supports shall meet the requirements of SMACNA's Publication "HVAC Duct Construction Standards--Metal and Flexible", 3rd Edition (2005), and various other SMACNA Publications referenced in this specification section. However, where the requirements of this specification section exceed SMACNA requirements or where a prohibition of specific type

of work contained within or permitted by the SMACNA standard is made, the requirements of this specification section shall take precedence.

- B. Welding Standards: Qualify welding procedures and welding personnel to perform welding processes for this Project according to latest editions of AWS D1.1, "Structural Welding Code--Steel," for hangers and supports; AWS D1.2, "Structural Welding Code--Aluminum," for aluminum supporting members; and AWS D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.
- C. Minimum Seal Class Requirements: Conform to requirements of 2018 International Energy Conservation Code , the referenced SMACNA standards and ASHRAE Standard 90.1-2016 except where these specifications exceed those requirements.

## **1.10 DELIVERY, STORAGE, AND HANDLING**

- A. Deliver sealant and firestopping materials to site in original unopened containers or bundles with labels indicating manufacturer, product name and designation, color, expiration period for use, pot life, curing time, and mixing instructions for multicomponent materials.
- B. Store and handle sealant and firestopping materials according to manufacturer's written recommendations.
- C. Deliver and store stainless-steel sheets with mill-applied adhesive protective paper maintained through fabrication and installation.
- D. Protect shop fabricated and factory fabricated ductwork, accessories and purchased products from damage during shipping, storage and handling. Prevent end damage and prevent dirt and moisture from entering ducts and fittings with a polyethylene film with a high-tack adhesive to attach to the ductwork and accessories. Where possible, store ductwork inside and protect from weather. Where necessary to store outside, store above grade and enclose with polyethylene waterproof wrapping.

## **PART 2 - PRODUCTS**

### **2.1 MANUFACTURERS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Fibrous-Glass Duct Liner:
    - a. CertainTeed Corp.; Insulation Group.
    - b. Johns Manville International, Inc.
    - c. Knauf Fiber Glass GmbH.
    - d. Owens Corning.
    - e. Or equal as approved by the Professional.
  - 2. Single Wall Round Prefabricated Ducts and Fittings:
    - a. Hranec Sheet Metal Inc.
    - b. Linx Industries Inc.
    - c. McGill AirFlow LLC

- d. MKT Metal Manufacturing
  - e. SEMCO LLC
  - f. Sheet Metal Connectors, Inc.
  - g. Spiral Manufacturing Co., Inc.
  - h. Or equal as approved by the Professional.
3. Round Prefabricated Connectors:
- a. Ductmate Industries, Inc.
  - b. Hranec Sheet Metal Inc.
  - c. Linx Industries Inc.
  - d. McGill AirFlow LLC
  - e. MKT Metal Manufacturing
  - f. SEMCO LLC
  - g. Sheet Metal Connectors, Inc.
  - h. Spiral Manufacturing Co., Inc.
  - i. Or equal as approved by the Professional.
4. Sealant and Gaskets:
- a. Ductmate Industries
  - b. Carlisle Hardcast
  - c. Childers; a Div. of HB Fuller Construction Products Inc.
  - d. McGill Airflow LLC
  - e. Foster; a Div. of HB Fuller Construction Products Inc.
  - f. Or equal as approved by the Professional.
5. Flanged Duct Connector Systems for Rectangular Duct:
- a. Ductmate '35' and '45' systems.
  - b. CL Ward "J" and "H" flange and corner systems.
  - c. Hardcast / Nexus "J" and "G" flange and corner systems.
  - d. Ward Industries / Hart and Cooley "FLGJ" and "FLGH" systems
  - e. Note: SMACNA joint types T-25a and T-25b (TDC and TDF type connectors, respectively) using corner pieces provided by the above listed manufacturers are also acceptable.
  - f. Or equal as approved by the Professional.
6. Flanged Duct Connector Systems for Round Duct:
- a. Ductmate 'Spiralmate'.
  - b. Or equal as approved by the Professional.
7. Steel Cable Hanger Systems:
- a. Ductmate 'Clutcher'
  - b. DuroDyne 'Dyna-Tite' Series
  - c. Gripple Inc. 'Standard Hanger' Series
  - d. Or equal as approved by the Professional.

## 2.2 SHEET METAL MATERIALS

- A. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods, except as otherwise indicated or modified by this Section. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
- B. Galvanized, Sheet Steel: Lock-forming quality; ASTM A 653 or ASTM A 924, G90 coating designation. Minimum thickness permitted shall be 24 gauge, except for round spiral seam ductwork which shall have a minimum thickness of 26 gauge.
- C. Stainless Steel: ASTM A 480 and A 276, Type 304L or 316L, sheet form with No. 2D or 2B finish for concealed ducts and for exposed ducts in non-finished spaces; No. 3 finish for exposed ducts in finished spaces. Minimum thickness permitted for welded construction shall be 18 gauge. Exposed ducts with welded joints in finished spaces shall have the joints ground smooth.
- D. Aluminum Sheets: ASTM B 209, Alloy 3003, Temper H14, sheet form with standard, one-side bright finish for ducts exposed to view and with mill finish for concealed ducts. Minimum thickness permitted shall be 22 gauge, except for round spiral seam ductwork which shall have a minimum thickness of 24 gauge.
- E. Reinforcement Shapes and Plates: Galvanized steel reinforcement where installed on galvanized, sheet metal ducts; matching materials for aluminum and stainless-steel ducts.
- F. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for 36-inch length or less; 3/8-inch minimum diameter for lengths longer than 36 inches. Maximum diameter permitted is 1/2".
  - 1. For stainless steel and aluminum ducts, provide matching materials.

## 2.3 SEALANT AND GASKETS

- A. Tapes: One-step (peel and stick) pressure-sensitive duct sealing tapes, two-part tape systems, and similar sealing tapes are not permitted for sealing metal duct joints and penetrations.
- B. 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. Sealants shall be UL-181B-M listed.
- C. Indoor Duct Water-Based Joint and Seam Sealant:
  - 1. Application Method: Brush-on or trowel-on to minimum 1/16" thickness to joints and seams. Application temperature range: 40 to 100 deg F.
  - 2. Solids Content: Minimum 68 percent.
  - 3. Shore A Hardness: Minimum 72.
  - 4. Shall be permanently flexible and water, mold, and mildew resistant after curing.
  - 5. Adhesion Strength per ASTM C794 to Bright Annealed Stainless Steel: 6.25 PLI
  - 6. VOC Content: Maximum 30 g/L (less water).
  - 7. UL 181B-M listed; UL 723 Classified.
  - 8. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
  - 9. Service Application: Indoor duct installations, except for unconditioned outdoor air ducts.
  - 10. Acceptable Products: Ductmate 'PROseal', Foster '32-19 Duct-Fas', or Childers 'Chil-Flex CP-146'.

- D. Outdoor Duct Joint and Seam Sealant: Polymeric rubber, resins, and fiber-reinforcing materials dispersed in solvent. Applied by brush or trowel, with a 24-hour cure time. Sealant shall be UV resistant, impervious to water, and shall be permanently flexible with an operational temperature range of -20 to +150 deg. F. Sealant shall be UL 181 A-M / B-M Listed and UL 723 Classified. Maximum VOC: 420 g/L.
1. Service Application: Ductwork unconditioned outdoor air ducts located indoors.
  2. Acceptable Products: McGill Airflow LLC 'Uni-Weather', Ductmate Industries 'SOLVseal', or Carlisle HVAC 'Sure-Grip 404'.
- 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.
1. Comply with UL 723 and meet Mil-C 18969B and TTS-S-001657. This material, in addition to the above, shall not contain vegetable oils, fish oils, or any other type vehicle that will support fungal and/or bacterial growth.
  2. The use of gaskets with adhesive properties on fitting and duct connections shall not substitute for fastening hardware.
- G. Round Duct Joint O-Ring Seals:
1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for 10-inch wg 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.

## **2.4 HANGERS AND SUPPORTS**

- A. Supports shall comply with Chapter 5 of the SMACNA Publication "HVAC Duct Construction Standards--Metal and Flexible, 3rd Edition, 2005, except as modified by this section.
- B. Building Attachments: Concrete inserts, mechanical-expansion fasteners , or structural-steel fasteners appropriate for building materials.
1. Do not use strap type attachments or friction type beam clips / clamps (e.g. hammer-on / slide-on flange clips and similar devices).
    - a. C-type beam clamps that incorporate a bolt for fastening, consistent with MSS Types 19 and 23, are acceptable.
- C. Hanger Materials: Galvanized, sheet steel straps, wire rope locking cable hanger system or round, threaded steel rod. Strap galvanizing shall be G90, or matching that of the supported duct, whichever is greater.

1. Exceptions to the Above:
    - a. Hangers and supports for aluminum duct shall be constructed of 6061- T6 aluminum or galvanized steel and isolated from the aluminum with an epoxy paint finish. Reinforcements shall be made of 6061-T6 aluminum.
  2. Straps and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards-- Metal and Flexible" for sheet steel width and thickness and for steel rod diameters.
  3. Do not use wirehangers unless explicitly specified elsewhere in this Section.
- D. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
1. Fasteners for interior galvanized ducts shall be zinc or cadmium coated.
  2. Fasteners for interior aluminum and stainless steel ducts shall be stainless steel.
  3. Blind rivets using pull-through mandrels are not permitted if they leave holes for air leakage. Fasteners shall not project into duct interiors more than 1/2".
  4. Do not use fasteners that penetrate the duct wall on clothes dryer ductwork or welded ductwork (all services).
- E. Trapeze and Riser Supports: Steel shapes shall comply with ASTM A 36.
1. Supports for Galvanized-Steel Ducts: Galvanized steel shapes and plates.
  2. Supports for Stainless-Steel Ducts: Stainless-steel support materials.
  3. Supports for Aluminum Ducts: Aluminum support materials Aluminum shapes shall comply with ASTM B 221.
- F. Steel Cable Hanger Systems: Factory-fabricated system of steel wire cables, locking cable anchors, and related accessories for the support of horizontal ducts which do not exhibit, or have been restrained from, lateral movement during system operation. All products shall be from a single manufacturer, and shall have been tested by SMACNA Testing and Research Institute and found to conform to the requirements of the "HVAC Duct Construction Standards, Metal and Flexible" for upper and lower attachments. Hangers shall be factory engineered for a 5 to 1 safety factor.
1. Steel Cables: Galvanized steel complying with ASTM A 603 or Stainless steel complying with ASTM A 492.
  2. Steel Cable Locks / End Connections: Cadmium or zinc-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.
  3. Stress Distribution Corner Guards: Used with uninsulated rectangular duct to prevent cable stress or deformation of the ductwork. Corner brackets are an acceptable alternative so long as the ductwork is not material handling or of fully welded construction.
  4. Acceptable Upper Attachments Are Limited to the Following:
    - a. Eyebolts, drilled concrete eyelets, ring anchors, studded cable ends in concrete structure buildings.
    - b. Cable loops around building structural steel and supplemental steel where the minimum required cable bending radius is ensured, and channel support system attachments in steel structure buildings.



## 2.5 RECTANGULAR DUCT FABRICATION – GENERAL REQUIREMENTS

- A. General: Fabricate ducts, elbows, transitions, offsets, branch connections, and other construction according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" (3rd Edition; 2005), except as modified by this Section. Comply with requirements for metal thickness, reinforcing types and intervals, tie-rod applications, and joint types and intervals.
  - 1. Transverse joint types are limited to the following:
    - a. T-1 through T-14 as shown in Figure 2-1, "Rectangular Duct/Transverse Joints" in the above referenced SMACNA standard, for ductwork in the 1/2" or 1" w.g. (positive or negative) pressure classes.
    - b. Flanged duct connector systems as elsewhere specified in this Section.
    - c. Joint types explicitly specified elsewhere in this Section.
  - 2. Longitudinal joint types are limited to joint types shown in Figure 2-2, "Rectangular Duct/Longitudinal Seams" in the above referenced SMACNA standard, except for L-2 (button punch snap lock) and L-3 (grooved seam), which are not permitted. Joint types explicitly specified elsewhere in this Section are also permitted.
- B. Lengths: Fabricate rectangular ducts in lengths appropriate to reinforcement and rigidity class required for pressure classification.
- C. Materials: Free from visual imperfections such as pitting, seam marks, roller marks, stains, and discolorations.
- D. Cross Breaking or Cross Beading: Cross break or cross bead duct sides 19 inches and larger and 0.0359-inch-thick or less, with more than 10 sq. ft. of unbraced panel area, unless ducts are lined.

## 2.6 FLANGED DUCT CONNECTOR SYSTEMS

- A. Except for ducts specified to be fully welded, a pre-fabricated flanged duct connector system is acceptable for forming transverse joints on rectangular and round ductwork where the specified pressure class can be met, and subject to other restrictions herein indicated.
- B. The system shall consist of factory-fabricated add-on flange connectors, gaskets, and related components and fasteners. Materials shall be galvanized steel, aluminum, or stainless steel to match the connecting ductwork. The system shall be suitable for ductwork having pressure ratings from +2 inches w.g. to +10 inches w.g. and from -2 inches w.g. to -10 inches w.g. The system flanges and corner pieces shall form a flange frame around the full perimeter of the duct, and shall be designed to produce a sealed fit onto a plain duct end using an integrated sealant pocket.
  - 1. 'Formed-on' style flanges, such as SMACNA joint types T-25a and T-25b (TDC and TDF type flanges, respectively) and similar joining methods using a flange that is formed directly from the duct end and secured in place with corner connectors, are also acceptable.
  - 2. Corners shall be jointed using corner clips or a bolted connection.
- C. The duct connector system shall be applied in full conformance with the system manufacturer's installation instructions and with all required screws, sealants, gasket tape, corner clips, bolts, nuts, washers, and spring clip / cleats. Systems that do not use spring clips are not acceptable.

1. Substitution of zip screws for the recommended galvanized steel spring clips (cleats) is not permitted. Spring clips shall be of the length, gauge, and quantity recommended by the system manufacturer.
- D. Flange Gaskets: Permanently flexible butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.
  1. Comply with UL 723 and meet Mil-C 18969B and TTS-S-001657. This material, in addition to the above, shall not contain vegetable oils, fish oils, or any other type vehicle that will support fungal and/or bacterial growth.

## **2.7 ROUND DUCT FABRICATION**

- A. Round Ducts: Fabricate ducts with standard spiral lock seams according to Figure 3-2 of SMACNA's "HVAC Duct Construction Standards--Metal and Flexible", 2005 (3rd Edition).
  1. Snap-lock, lapped and riveted, butt weld, and grooved type longitudinal seam construction is not acceptable.
- B. Transverse Joints Between Duct Sections and to Fittings: Fabricate according to Figure 3-1 of the above referenced SMACNA standard.
  1. Ducts up to 20 Inches in Diameter: Factory fabricated slip-on gasketed flange system or type 'RT-1' beaded sleeve joint consisting of an interior, center-beaded slip coupling, sealed before and after fastening, attached with sheet metal screws.
  2. Ducts 21 to 72 Inches in Diameter: Factory fabricated slip-on gasketed flange system or a type 'RT-2' Van Stone joint consisting of a gasketed, flanged joint with two internal flanges formed on the duct end, two exterior flanges, and flange hardware.
  3. Ducts Larger than 72 Inches in Diameter: Type 'RT-2A' companion angle flanged joints.
  4. Gasketed Push-On Joints (all sizes): Refer elsewhere in this Section for requirements for round duct joint O-ring seals:
    - a. Round Ducts: Factory-fabricated connection system consisting of double-lipped, EPDM rubber gasket. Manufacture ducts according to connection system manufacturer's tolerances.
  5. Draw-band, crimp joint sleeve, swedge bell, and outside sleeve joints are not acceptable.
    - a. Exception: Draw-band joints are acceptable for clothes dryer exhaust ducts not exceeding 16" diameter. For larger clothes dryer exhaust ducts, use Van Stone type joints.

## **2.8 ROUND FITTING FABRICATION**

- A. 90-Degree Tees and Laterals and Conical Tees: Fabricate to comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," 2005, with metal thicknesses specified for spiral lock seam straight duct.
- B. Diverging-Flow Fittings: Fabricate with a reduced entrance to branch taps with no excess material projecting from body onto branch tap entrance.
- C. Elbows: Fabricate in die-formed (stamped), gored (segmented), or pleated construction. Single-mitered and adjustable type elbows are not permitted on round ductwork. Fabricate with a centerline bend radius of at one and one-half times elbow diameter. Fabricate elbows as follows:

1. Round Elbows, 12 Inches and Smaller: Fabricate die-formed elbows for 45- and 90-degree elbows, and pleated elbows for 30, 45, 60, and 90 degrees only. Fabricate nonstandard bend-angle configuration or nonstandard diameter elbows with gored construction.
2. Round Elbows, Larger than 12 Inches: Fabricate gored (segmented) elbows. Maximum 22.5 degree change in direction per segment (e.g. this requires a 5-segment elbow for a 90 degree change in direction, and elbows with less than 90-degree change of direction shall have proportionately fewer segments.).
3. Die-Formed Elbows for Sizes through 8 Inches and All Pressures: 0.040-inch-thick with two-piece welded construction.
4. Round Gored (Segmented)-Elbow Metal Thickness: Same as non-elbow fittings specified above.
5. Pleated Elbows for Sizes through 12 Inches and Pressures through 10-Inch w.g: 0.028 inch.

## **2.9 STAINLESS STEEL DUCTWORK AT OUTDOOR AIR INTAKE PLENUMS**

- A. Outdoor air intake plenums shall be minimum 18 gauge, Type 304L stainless steel with continuously welded joint and seam construction. Reinforcing, and flange angles shall be Type 304 stainless steel. Hangers may be galvanized steel.
  1. All reinforcing shall be external. No internal reinforcing (e.g. tie-rods) shall be acceptable.
- B. Turning vanes, access doors, dampers, and other accessories exposed to the airstream shall be Type 304 stainless steel.
- C. Install ducts without dips or traps that may water. Duct shall be sloped a minimum of 2 percent (1/4" per foot) to drain water back to the trapped duct drain collection points.

## **PART 3 - EXECUTION**

### **3.1 DUCT APPLICATIONS**

- A. Refer to Division 23 Section "Common Work Results for HVAC" for definitions of 'conditioned' and 'unconditioned' spaces.
- B. Select and construct and seal duct systems components (ducts, fittings, and accessories) in accordance with the following SMACNA Static-Pressure and Seal Classes. The pressure ratings indicated are minimum values:
  1. Ducts Located in Interior Conditioned and Indirectly Conditioned Spaces: Unless otherwise indicated, construct ducts to the following:
    - a. Blower Coil and DOAS Supply Ducts: +2 -inch .wg., Seal Class "A".
      - 1) Exception: Where exposed in the space served, Seal Class "B" may be followed.
    - b. Blower Coil Return and DOAS Exhaust Air Ducts: -2-inch w.g., Seal Class "C".
    - c. Unconditioned Outside Air Ducts: -1-inch w.g., Seal Class "A".
    - d. Transfer Air Ducts: +1/2-inch w.g., Seal Class "C"
    - e. Other Exhaust Air Ducts: -2-inch w.g., Seal Class "B".
    - f. Clothes Dryer Exhaust Ducts: +1-inch w.g., Seal Class "A".

- g. All supply and relief air ducts not explicitly addressed by the above sub-paragraphs shall be +2" w.g., Seal Class "A".
  - h. All return and outdoor air ducts not explicitly addressed by the above sub-paragraphs shall be -2" w.g., Seal Class "A".
2. Ducts Located in Interior Unconditioned Spaces: Unless otherwise indicated, construct ducts to the following:
- a. As specified above for ducts located Interior Conditioned Spaces, except that all ducts listed above to receive Seal Class "C" shall be provided with Seal Class "B" instead, and all ducts listed above to receive Seal Class "B" shall be provided with Seal Class "A" instead.
- C. Material Application: All ducts shall be galvanized steel, except as follows:
- 1. Exhaust ducts serving Showers: Aluminum.
  - 2. Outdoor air intake plenums: Stainless steel, fully welded.
  - 3. Any ducts / duct systems specifically noted on the Drawings to be a material other than galvanized steel.
- D. All ducts shall be single wall.

### **3.2 CLOTHES DRYER EXHAUST DUCTS**

- A. Clothes dryer exhaust ductwork joints shall be made with a method that does not present any screw, rivet, etc. into the interior of the duct.
- B. Final connections to dryers shall be made with no more than 4 feet length of UL listed clothes dryer transition duct. Do not conceal, kink, or crush the flexible transition duct.
  - 1. 4" Diameter Clothes Dryer Transition Ducts for Domestic / Residential Size Clothes Dryers: UL 2158A listed, Class 0, semi-rigid and crush resistant, with a minimum of four (4) layers of 25 micron thick aluminum ribbon wound around a core of galvanized steel wire. Duct shall maintain its full cross-section whether compressed or stretched and through 90 deg. elbows. Duct shall be externally labeled with UL its listing. Transition ducts shall be DryerFlex 'UL 2158A Dryer Duct', or approved equal.
  - 2. Connections to Commercial Type II dryers shall be made with rigid ductwork (no semi-rigid transition duct) wherever possible.
- C. Individual 4" Round Dryer Connections (for Type I Domestic / Residential Dryers) Wall Boxes: Individual clothes dryer branch ducts shall be routed inside the wall located behind the planned location of installation of the dryer to a DryerBox Model 425 / 350 (by In-O-Vate Technologies Inc.), or approved equal by American Aldes Corp., installed flush into the wall construction. Flexible duct shall be used to connect the appliance to the DryerBox.
- D. Provide duct clean out doors at all changes in direction, at termination points at the building exterior, and before and after connections to fans, at the bottom of all duct risers, along straight lengths of duct at intervals not exceeding 20 feet, and where shown on the Drawings. Clean out doors shall be no smaller than 12" x H", where H = the duct height or diameter minus 1".
- E. Ductwork in vertical shafts shall not have any offsets or changes in direction.
- F. Do not provide a mesh bird screen in the clothes dryer exhaust duct termination to the exterior.

- G. Wall Termination: Terminate round dryer exhaust ducts at the exterior wall of the building with a stainless steel wall hood with integral backdraft damper. Backdraft dampers shall be of the single blade, top hinged type, with an aluminum blade and magnetic catch to prevent fluttering in windy conditions. The hood shall not incorporate a bird screen. The hood connection size shall match the duct size indicated on the Drawings. The hood shall be an American Aldes Corp. 'Dryer Wall Hood', or approved equal.

### 3.3 DUCT FITTING APPLICATIONS

- A. Elbow Configuration: Unless explicitly noted otherwise on the Drawings, use the following elbow types:
1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows", as modified below. NOTE: All radii listed below are to the centerline of the duct, in the plane of change of direction.
    - a. Supply ducts downstream of terminal units, exhaust and return ducts upstream of terminal units, and constant volume ducts, and duct systems lacking in terminal units and air valves:
      - 1) Radius Type RE 1 with minimum 1.5 centerline radius-to-duct width (r-to-dw) ratio.
      - 2) Radius Type RE 1 with minimum 1.0 r-to-dw ratio.
        - a) These are only permitted where a 1.5 r-to-dw elbow is demonstrated to not possibly fit in the available space by way of the ductwork shop drawing and coordination drawing review and approval process.
      - 3) Mitered Type RE 2 with small single-wall vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible, 2005" Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
    - b. Supply ducts upstream of terminal units, return and exhaust ducts downstream of terminal units and air valves:
      - 1) Radius Type RE 1 with minimum 1.5 centerline radius-to-duct width (r-to-dw) ratio.
      - 2) Radius Type RE 3 with minimum 1.0 r-to-dw ratio and splitter vane(s) complying with Chart 4-1 and Figure 4-9 of SMACNA's "HVAC Duct Construction Standards - Metal and Flexible, 3rd Edition (2005)".
        - a) Ducts less than 12" wide: Provide 1 splitter vane.
        - b) Ducts from 12" to 36" wide: Provide two (2) splitter vanes.
        - c) Ducts wider than 36": Provide three (3) splitter vanes.
      - 3) Mitered Type RE 2 with small single-wall vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible, 3rd Edition (2005)" Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
    - c. All other elbow types (e.g. RE 4 un-vaned square/mitered ells, RE 5, 6, 7, 8, 9, or 10 ells, and square throat / radius heel, etc.) are not permitted, except where explicitly shown on the Drawings.

- 1) Exception: Type RE 4 (un-vaned and mitered) ells are permitted in transfer-air ducts, and in ducts where the peak / design velocity is less than 800 feet per minute.
2. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible, 2005" Figure 3-4, "Round Duct Elbows."
  - a. Minimum Radius-to-Diameter Ratio:
    - 1) 1.0 centerline radius-to-diameter ratio for 90-degree elbow. These are only permitted where a 1.5 centerline radius-to-diameter elbow is demonstrated to not possibly fit in the available space by way of the ductwork shop drawing and coordination drawing review and approval process.
    - 2) 1.5 centerline radius-to-diameter ratio 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: Segmented (gored) with standing seams or welded joints. Maximum 22.5 degree change in direction per segment (e.g. this requires a 5-segment elbow for a 90 degree change in direction, and elbows with less than 90-degree change of direction shall have proportionately fewer segments.)
- B. Branch Configuration: Unless explicitly noted otherwise on the Drawings, use the following branch-to-main connection types:
  1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connections."
    - a. Rectangular Main to Rectangular Branch: 45-degree entry, except as indicated on the Drawings.
    - b. Rectangular Main to Round Branch: Flanged or spin-in bellmouth or conical tap.
      - 1) Where the height of the duct main is insufficient to permit a bellmouth or conical tap, provide a round-to-rectangular transition on the branch duct so that a rectangular 45 degree entry connection to the main duct can be made. The transition shall be to a height equal to the main duct height, and to a width as required to maintain equal or greater total flow area as the connecting round branch duct.
      - 2) Plain, straight (e.g. constant diameter round) taps are not acceptable.
  2. Round: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90-Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are only permitted for new branches on existing ducts.
    - a. Conical tap, 90-degree tee with oval-to-round tap, or 45-degree lateral tap. Plain taps are not permitted.
- C. Rectangular Duct Divided Flow Branches: Type 1 or 2 of the referenced SMACNA Standard.
- D. Vertical and Horizontal Offsets: Full duct dimensions shall be maintained. Use a pair of elbows complying with the above provisions. Elbows with the smallest number of degrees of change in direction that will possibly fit in the available space shall be used. Offset types shown the referenced SMACNA Standard are not acceptable.

- E. Transitions: Changes in duct sizes shall be made with uniformly sloping transitions.
  - 1. Transitions from a larger to a smaller duct in the direction of flow in either duct depth or height shall have not more than a 45 degree angle parallel to the airflow for a one sided transition, or 22.5 degree angle for a two sided transition (i.e. 22.5 degrees on each side, for 45 degrees total).
  - 2. Transitions from a smaller duct to a larger duct in the direction of flow in either duct depth or height shall have not more than a 30 degree angle parallel to the airflow for a one sided transition, or 15 degree angle for a two sided transition (i.e. 15 degrees on each side, for 45 degrees total).

### **3.4 DUCT INSTALLATION, GENERAL**

- 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. Construct and install each duct system for the specific duct pressure classification specified.
- C. Install round ducts in lengths not less than 12 feet, unless interrupted by fittings.
- D. All ductwork shall be constructed to be free from vibration, chatter, objectionable pulsations and leakage under specified operating conditions. Provide additional external reinforcement to prevent visible or audible vibration of the duct walls.
- E. Install ducts with fewest possible joints.
- F. Install fabricated fittings for changes in directions, changes in size and shape, and connections.
- G. Provide SMACNA small type, single-wall turning vanes in all mitered duct elbows, except for transfer ducts and other clean air ducts with design velocities less than 750 feet per minute, and solid material-handling ducts (e.g. clothes dryer exhaust, dust collection ductwork). Note that vanes may not be explicitly shown on the Drawings for clarity purposes only.
- H. Install couplings tight to duct wall surface with a minimum of projections into duct.
- I. Install ducts, unless otherwise indicated, vertically and horizontally, parallel and perpendicular to building lines; avoid diagonal runs.
- J. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
- K. Successfully pressure and leak test ductwork before applying external insulation.
- L. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.
- M. Where ductwork is to be lined with insulation, sizes indicated on the Drawings shall be interpreted as indicating clear dimensions inside the insulation. Adjust actual sheet metal dimensions accordingly. Shape and location of ducts may be changed to suit building conditions but cross-sectional area shall be maintained.

- N. Conceal ducts from view in finished spaces with ceilings. Do not encase horizontal runs in solid partitions, unless specifically indicated.
- O. Coordinate layout with suspended ceiling, fire- and smoke-control dampers, lighting layouts, and similar finished work.
- P. Electrical Equipment Spaces: Route ductwork to avoid passing through electrical equipment spaces and enclosures. Ductwork not serving transformer vaults is prohibited in such spaces.
- Q. Non-Fire- or Smoke-Rated Partition Penetrations: Where ducts pass through interior partitions, conceal space between construction opening and duct or duct insulation with minimum 22 gauge galvanized steel sheet flanges/frames. Overlap opening on four sides by at least 1-1/2 inches and seal to wall with silicone caulk. Seal sheet metal frame to duct with duct sealant. Tightly pack the width and depth of the annular space between wall opening and duct with ASTM C 665 rock wool batt insulation, min 2.0 lbs./cu. ft. density.
- R. Fire-Rated Wall Penetrations: Where ducts pass through interior partitions and exterior walls, install an appropriately rated fire damper. Fire and smoke dampers are specified in Division 23 Section "Air Duct Accessories."
- S. Fire-Rated Slab / Floor Penetrations: Where ducts pass through discrete penetrations of fire rated slabs / floors and are not contained in a fire rated shaft enclosure, install an appropriately rated fire damper. Fire dampers are specified in Division 23 Section "Air Duct Accessories."
- T. Non-Fire-Rated Slab / Floor Penetrations: Where ducts pass through unrated floors, provide firestopping of the annular space between the duct and slab / floor opening if no rated shaft or fire damper is indicated.
- U. Fire-Rated Shaft Penetrations: Where ducts pass through a fire-rated shaft enclosure, install an appropriately rated combination fire and smoke damper. Fire and smoke dampers are specified in Division 23 Section "Air Duct Accessories."
- V. Finished Ceiling Penetrations:
  - 1. Where round ducts pass through finished ceilings, provide the duct with a 1"x1" aluminum ring angles, painted to match the finished ceiling or wall, to obscure the ceiling or wall rough opening. Secure ring angles to the duct.
  - 2. Where rectangular ducts pass through finished ceilings, provide a 1"x 1" plaster frame with mitered corners for the penetration to obscure the ceiling or wall rough opening. The frame shall be aluminum and painted to match the finished ceiling or wall. The plaster frame may be constructed of ceiling system wall angles for penetrations of lay-in tile ceilings.

### **3.5 WELDED STAINLESS STEEL DUCTWORK INSTALLATION (ALL SERVICES)**

- A. Weld seams, joints, etc., to provide a watertight seal. Welding process shall be suitable for stainless steel. Provide means to prevent warpage during and after welding.
  - 1. All welds shall conform to AWS D9.1M. Welds shall be Gas Tungsten Arc Weld (TIG) or Gas Metal Arc Weld (MIG) type. All filler metal shall conform to AWS A5.9 or A5.22 and be AWS Classification ER308L or ER308LSi with a carbon content of not over 0.03%.
- B. For exposed ductwork, remove weld discoloration and deposits on ductwork using cleaner intended for this purpose. Do not wire brush or steel wool. Grind and polish welds to provide a smooth appearance.



- C. Watertight bolted gasket connections shall be provided at connections to fans, hoods and other equipment (only). Flange gaskets shall be butyl rubber or EPDM polymer with polyisobutylene plasticizer.

### **3.6 INDOOR AIR QUALITY MANAGEMENT DURING CONSTRUCTION**

- A. Containment of Contaminants: The Contractor shall meet or exceed the control measures recommended by SMACNA "IAQ Guidelines for Occupied Buildings Under Construction", 2<sup>nd</sup> edition (2007) - ANSI/SMACNA 008-2008, in Chapters 3 and 4, to prevent construction dust and other contaminants from escaping the work area or contaminating new HVAC systems and equipment.
- B. Protect stored on-site and installed absorptive materials from moisture damage.
- C. The Contractor shall protect new duct and air system equipment (e.g. fans, AHUs, etc.) interiors from moisture, construction debris and dust, and other foreign materials. During ductwork system installation, keep open ends of ductwork and terminations at registers, grilles, VAV terminal units, and diffusers sealed off and closed with a polyethylene film to prevent entrance of dirt and debris. The film shall be Ductmate 'ProGuard', or approved equal. In addition, the Contractor shall take great care to thoroughly clean and wipe-down all HVAC system components and ductwork above prior and during installation.
  - 1. Comply with SMACNA "Duct Cleanliness for New Construction", 1st edition (2000), published as Appendix G of the SMACNA "IAQ Guidelines for Occupied Buildings Under Construction", 2<sup>nd</sup> edition (2007).
    - a. Comply with the requirements of "Advanced Level" cleanliness.
  - 2. Where duct systems have not been wiped down before and during installation or where visual contaminants are found from a duct wipe-down observation by the Client Agency, Architect/ Engineer, or Commissioning Agent after installation, the Contractor shall clean the entire ductwork system with a vacuum cleaning method in compliance with the requirements and recommendations found within NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems", 2013.
- D. HVAC System Start-Up: Delay the start-up of permanent ductwork systems until construction activities that generate large amounts of indoor or exterior airborne particulates have been completed. System startup shall be considered to be a process that involves operating the equipment and systems only as long as it necessary to verify proper operation and installation of the equipment, verification of connections, making adjustments and settings, testing controls, and conducting similar field quality control and commissioning efforts. Successful start-up does not grant the Contractor license to use the permanent systems for construction phase heating and cooling.
  - 1. Start-up of the permanent HVAC systems shall not occur prior to all of the following being met:
    - a. The duct systems being pressure tested and fully insulated and sealed.
    - b. All filters installed, including temporary supplemental filters described below.
    - c. Completion of all drywall sanding and similar dust-generating construction activities performed inside the building, and subsequent clean-up.
    - d. Completed and functioning condensate drainage traps and piping installations.
    - e. Such time that the environmental conditions of the building under construction meet the factory warranty requirements /conditions of all installed HVAC equipment.

Factory warranties and their obligations to the Client Agency which have been violated by the Contractor's use of equipment during construction shall become the responsibility of the Contractor for the original factory warranty duration and coverage.

2. Temporary Supplemental Filters: Operation of the permanent systems for any purpose prior to completion of final cleaning of the building by the General Contractor shall only occur with minimum ASHRAE 52.2 - MERV 10 filter media secured and sealed to each return or exhaust air grille, register, and open ended duct inlet. Filters shall be changed weekly, or more often as needed.
  - a. Outdoor air intakes require an equivalent treatment if outdoor construction activities involve site work generating airborne dust and dirt.
- E. Temporary / Construction-Phase HVAC Services: Do NOT utilize the permanent HVAC systems, or any portion thereof, to provide construction-phase heating, cooling, ventilation, exhaust, or dehumidification required by the construction process until the permanent systems are permitted to operate continuously, and outside of the start-up process, as defined below. Temporary systems shall be provided to meet all HVAC needs prior to that time. Temporary / construction-phase HVAC shall be provided by the General Contractor, unless Division 01 indicates otherwise.
  1. Changeover from temporary systems to the use of permanent HVAC system shall not occur prior to system start-up has been completed, subject to the conditions and restrictions placed on system start-up, as described above. The permanent system may not be capable of accommodating special conditions or loads created by ongoing construction processes (e.g. high latent loads created by painting), so supplemental temporary HVAC equipment shall be provided to meet those special needs and conditions.

### **3.7 SEAM AND JOINT SEALING**

- A. General: Seal duct seams and joints according to the duct pressure classes and seal classes specified and as described in SMACNA's "HVAC Duct Construction Standards--Metal and Flexible", unless more restrictive requirements are indicated in this Section.
- B. Seal and successfully pressure test externally insulated ducts before insulation installation.
- C. Seal duct seams and joints according to the referenced SMACNA standard, this Section, whichever is most restrictive / demanding:
  1. For ducts where Seal Class A is indicated, seal transverse joints, longitudinal seams and wall penetrations (except for damper rod penetrations).
  2. For ducts where Seal Class B is indicated, seal transverse joints and longitudinal seams.
  3. For ducts where Seal Class C is indicated, seal transverse joints only.
  4. Regardless of the Seal Class specified, any joint, seam, or wall penetration through which air leakage makes an audible noise at a distance of 4 feet shall be sealed till the leakage is no longer audible.
- D. All seams and joints in outside air intake ducts and plenums shall be sealed water-tight with and outdoor-grade duct joint and seam sealant.

### 3.8 HANGING AND SUPPORTING

- A. Unless otherwise indicated or specified, install rigid round and rectangular metal duct with support systems indicated in SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."
1. Supporting ductwork and associated equipment from metal roof and floor decking is prohibited. All ductwork and associated equipment shall be supported from the building structural system.
  2. Ductwork shall be supported directly from the building's steel beams or from miscellaneous structural steel provided by the Division 23 Contractor bearing on steel beams.
  3. Loads supported by steel bar joists exceeding 100 lbs. shall be located at the joist panel points, and shall not impose an eccentric load (twisting moment). Provide supplemental steel and align direct hanger connections to the joists with the joist centerline. Connect to the upper chord of the joist wherever it is possible to do so.
  4. Do not drill or cut building structural steel.
- B. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.
- C. Support vertical ducts with steel or aluminum 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 interval of 16 feet. Angles bearing on floors shall overlap the floor opening by no less than 3".
- D. Refer to Division 23 Section "Vibration Controls for HVAC" for ductwork systems requiring vibration isolation hangers and supports. Vibration isolated ductwork shall be installed such that it does not contact building structure, walls, or other building elements or work that fixed in place.
- E. Hanging ductwork from roof and floor decking in steel framed buildings is prohibited. All equipment shall be hung from building steel structural system (e.g. steel beams and joists).
1. Ductwork shall be supported directly from the building's steel beams or from miscellaneous structural steel provided by the Division 23 Contractor bearing on steel beams.
  2. Loads supported by steel bar joists exceeding 100 lbs. shall be located at the joist panel points, and shall not impose an eccentric load (twisting moment). Provide supplemental steel and align direct hanger connections to the joists with the joist centerline. Connect to the upper chord of the joist wherever it is possible to do so.
  3. Supplemental steel deflections shall be limited to length/180 of the span.
- F. Fastener System Installation in Concrete Slab Construction:
1. Install drilled-in mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.
  2. Anchor capacity used in design shall be based on the technical data published by the manufacturer or such other method as approved by the Architect and Structural Engineer of Record.
  3. Anchor capacity is dependent upon spacing between adjacent anchors and proximity of anchors to edge of concrete. Install anchors in accordance with the manufacturer's recommended spacing and edge clearances.
  4. Reinforcing bars in the concrete structure may conflict with specific anchor locations. Exercise care to avoid damaging existing reinforcing or embedded items. The Contractor shall review the structural drawings and shall undertake to locate the position of the reinforcing bars near the locations of the concrete anchors, by Hilti 'Ferrosan, GPR', X-

rays, or other non-invasive means approved by the Architect and Structural Engineer of Record. Notify the Architect and Structural Engineer of Record if reinforcing steel or other embedded items are encountered during drilling.

5. Install concrete inserts before placing/pouring concrete.

G. Steel Cable Hanger Systems Applications and Installation: Comply with all recommendations of the cable system manufacturer. Comply with all restrictions on the use of the system imposed by the SMACNA Testing and Research Institute to ensure full conformance with SMACNA standards and recommendations. System installers shall be site-trained in the use of the materials and tools by a manufacturer's representative prior to installing materials.

1. Use only on ducts with bare metal as the exterior, finished surface (e.g. uninsulated ducts, double wall ducts, and lined ducts).
  - a. Exception: Cable hanger systems may be used on ducts with exterior insulation when used as hangers for a channel trapeze support.
2. Select cables and end connectors so that actual loads do not exceed 1/4 of the hanger system failure load. For cables hung at angles other than vertical, apply the required derating factor. Space hangers no more than 12 feet apart. Confirm engagement of cable locks prior to apply the load.
3. Apply stress distribution corner guards on rectangular duct to prevent excessive cable stress and kinking or deformation of the ductwork.
4. Material Applications:
  - a. Use galvanized steel cables on galvanized steel ducts.
  - b. Use stainless steel cables on aluminum and stainless steel ducts.
5. Do not kink or deform cables or expose to sharp edges. Do not subject cables to a bending radius smaller than 1/4". Keep cables free of dirt, grease, and other lubricants.
6. Do not use where the ducts are subject to dynamic loading either due to the presence of vibration or thrust force inducing equipment or asymmetrical outlet arrangements. Only use on static ducts. Restrain ducts from lateral movements using rigid hangers or by using multiple cables installed in opposing angles at a given support location (i.e. horseshoe or spread horseshoe hanger configuration). Do not use single point support methods.
7. Do not paint cable hangers. Any hangers that have been painted shall be replaced.

### **3.9 CONNECTIONS**

- A. Connect equipment with flexible connectors according to Division 23 Section "Air Duct Accessories."
- B. For branch, outlet and inlet, and terminal unit connections, comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible", 2005, unless detailed otherwise on the Drawings.
- C. Make ductwork connections to curb-mounted rooftop equipment by extending ductwork to the top of the roof curb. Provide a duct transition as required to terminate the duct at the top of the curb with a size matching that of the mating duct connection opening on the curb and on the equipment. Provide neoprene gasket on the mating surfaces between the duct end or curb and the equipment.

### **3.10 PRESSURE AND LEAKAGE TESTS**

- A. Disassemble, reassemble, and seal segments of systems as required to accommodate pressure and leakage testing and as required for compliance with test requirements.
- B. Conduct tests, in presence of the Architect / Engineer, at static pressures equal to maximum design pressure of system or section being tested. Do not pressurize systems above maximum design operating pressure. Give a minimum of seven (7) days' advance notice for testing. Test for leaks before applying external insulation. Where less than 100% of duct systems are specified below to be pressure tested, the Architect / Engineer reserves the right to select the particular portions of the duct systems to be tested. Pressure-test the following:
  - 1. Indoor Ducts:
    - a. No less than 25% of the total duct wall area of indoor positive pressure ductwork located in the attic and basement.
    - b. No less than 25% of the total duct wall area of indoor negative-pressure ductwork located in the attic and basement.
    - c. Indoor ductwork with a pressure rating between -2" w.g. and +2" w.g. located outside of the attic or basement does not require pressure testing.
- C. Determine leakage from entire system or section of system by relating leakage to surface area of test section.
- D. Inspect the pressurized ductwork for distortion or other physical damage that resulted from pressurizing the ductwork to the test level, and for audible leakage points. Repair and reinforce areas where physical damage occurred and seal all audible leaks, then perform a retest.
- E. Maximum Allowable Leakage:
  - 1. Round Ducts: Comply with requirements for Leakage Classification 4 for indoor ducts in pressure classification of 2-inch w.g. and lower, and Leakage Classification 2 for all outdoor ducts, and indoor ducts in pressure classification 3-inch w.g. and higher.
  - 2. Rectangular Ducts: Comply with Leakage Classification 8 for indoor ducts in pressure classification of 2-inch w.g. and lower, and Leakage Classification 4 for all outdoor ducts and indoor ducts in pressure classifications from 3-inch w.g. and higher.
  - 3. If a given duct test section fails, the Contractor shall:
    - a. Remake leaking joints and retest until leakage is less than maximum allowable for that test section.
    - b. Pressure-test an additional, previously untested section of ductwork that is of equal or greater surface area as the section that failed the initial pressure test. The Architect / Engineer shall select the additional duct test section(s).
- F. Leakage Test Method: Perform tests and report results according to Chapters 4 through 7 of the 2nd Edition (2012) of SMACNA's "HVAC Air Duct Leakage Test Manual" except where these specifications exceed or modify SMACNA requirements.

### **3.11 ADJUSTING**

- A. Adjust volume-control dampers in ducts, outlets, and inlets to achieve design airflow.

- B. Refer to Division 23 Section "Testing, Adjusting, and Balancing for HVAC" for detailed procedures.

**END OF SECTION**