

## SECTION 23 31 00 - HVAC DUCTS

### PART I - 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 REFERENCE STANDARDS

- A. Material, construction and installation shall meet requirements of the most recent editions of the following standards and references, except for more stringent requirements specified or shown on the Drawings:
  1. SMACNA 1035 – HVAC Duct Construction Standards – Metal and Flexible.
  2. SMACNA – HVAC Air Duct Leakage Test Manual.
  3. SMACNA – IAQ Guidelines for Occupied Buildings Under Construction.
  4. SMACNA – Rectangular Industrial Duct Construction Standards.
  5. SMACNA – Round Industrial Duct Construction Standards.
  6. SMACNA – Sheet Metal Welding Guide.
  7. ACGIH – Industrial Ventilation.
  8. NFPA 90A – Standard for the Installation of Air-Conditioning and Ventilating Systems.
  9. NFPA 90B – Standard for the Installation of Warm Air Heating and Air-Conditioning Systems.
  10. NFPA 96 – Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations.
  11. NFPA 45 – Standard on Fire Protection for Laboratories Using Chemicals.
  12. National Air Duct Cleaners Association (NADCA).

#### 1.3 SUBMITTALS

- A. Submit shop drawings per Section 01 33 23 – Shop Drawings, Product Data, and Samples.
- B. Provide manufacturer's data and/or contractor data for the following:
  1. Fabrication and installation drawings.
  2. Schedule of duct systems including material of construction, gauge, pressure class, system class, seal class, leakage class, method of reinforcement, joint construction, fitting construction, and support methods, all with details as appropriate.
  3. Manufactured duct (i.e. double wall duct, flexible duct).
  4. Turning vanes.
  5. Duct sealant and gasket materials.
  6. Duct leakage testing methods, apparatus, and apparatus certification signifying meter is in conformance with ASME requirements for fluid meters.
  7. Upon completion of duct leakage testing, submit a minimum of six (6) copies of the signed report to the A/E, indicating test apparatus used, results of the leakage test,

and any remedial work required to bring duct systems into compliance with approved leakage rates.

8. Submit shop drawings of ductwork for the entire facility. Drawings shall be to scale, double line, with duct sizes, locations, fittings, equipment, accessories and structural clearances shown. Do not install ductwork prior to approval of shop drawings by A/E.

#### 1.4 DELIVERY, STORAGE AND HANDLING

- A. Promptly inspect shipments to ensure that ductwork is undamaged and complies with the specification.
- B. Protect ductwork against damage.
- C. Protect ductwork by storing inside or by storing in durable, waterproof, above ground packaging. Do not store material on grade. Protect ductwork from dirt, dust, construction debris and foreign material. Where end caps/packaging are provided, take precautions so caps/packaging remain in place and free from damage.
- D. Offsite storage agreements do not relieve the contractor from using proper storage techniques.

### PART 2 - PRODUCTS

#### 2.1 GENERAL DUCTWORK FABRICATION REQUIREMENTS

- A. All ductwork shall be constructed to be free from vibration, chatter, objectionable pulsations and leakage under specified operating conditions.
- B. Use material, weight, thickness, gauge, construction, and support and installation methods as outlined in the above-listed SMACNA publications. Minimum gauge of galvanized steel rectangular supply, return and exhaust ductwork shall be 24.
- C. Duct board is **not** allowed.
- D. Mixed Air Ductwork Requirements: Ductwork carrying mixed air shall be of sufficient length prior to entering heating coils to prevent stratification. *[Note to AE: Factory-fabricated air blenders may be used in air handling units where space is allowed and designed, but proper duct design is the preferred method of stratification control.]*
- E. Use products which conform to NFPA 90A, possessing a flame spread rating of not over 25 and a smoke developed rating of not over 50.
- F. Duct liner: Liners shall not be used. *[Note to AE: With written permission from the owner, fiber-free duct liner or duct liner with a protective coating can be installed in ductwork serving spaces with low allowable sound levels where adequate sound attenuation cannot be achieved by the application of standard noise control measures.]*
- G. Duct Velocities and Pressure Class Requirements: Sizing and pressure classes of ductwork for comfort heating and cooling systems, fume hood exhaust systems, toilet exhaust systems and grease exhaust systems shall be based on the following table. Sizing and pressure classes of ductwork for other types of systems shall be based on SMACNA and engineering "best practices". *[Note to AE: Consideration should be given to showing and specifying round duct for medium and high pressure supply air ductwork between air handling units and terminal air boxes.]*

Description	High Pressure SP > 6 inches w.c.	Medium Pressure 2 inches w.c. < SP ≤ 6 inches w.c.	Low Pressure SP ≤ 2 inches w.c.
Heating and Cooling - fpm	2400 < Velocity < 3500	1500 < Velocity < 2400	Mains < 1500 Branches < 1200 After Term. < 1200 Branch to Individual Grille/Diffuser < 600

Fume Hood Exhausts - fpm	2000 < Velocity < 3000	1000 < Velocity < 2000	
Toilet Exhausts - fpm		1000 < Velocity < 1500	Velocity < 900
Kitchen Hood Exhausts - fpm		1500 < Velocity < 2500	

- H. Duct sizes indicated on drawings are net inside dimensions.
- I. Duct Sizes Not Indicated: Where size for a duct segment is not indicated:
1. The duct segment size shall be equal to the largest duct segment to which it is connected.
  2. Transition to a smaller size shall occur on the side of the fitting where the smaller size is indicated.
- J. Takeoffs: Takeoffs shall be designed and constructed as follows:
1. Rectangular to rectangular: Use 150 percent to 200 percent free area take off from main to branch duct.
  2. Round to 45 degree conical wye or round to 90 degree conical wye: Use a typical branch coefficient of 0.45 or less.
  3. Round to 45 degree "T" or Wye: Use a typical branch coefficient of 0.45 or less.
  4. Round to 60 degree "T" or Wye: Use a typical branch coefficient of 0.65 or less.
  5. 90 degree "T" or Wye is not allowed.
- K. Elbows:
1. Elbows for Rectangular Ducts:
    - a. Use radius throat, radius heel elbows with a minimum centerline radius to width ratio of 1.5. Where 1.5 radius elbows will not fit, use 1.0 radius elbows with "radius proportional" splitter vanes permanently installed within. Splitter vanes shall be installed per SMACNA and manufacturer's recommendations.
    - b. Where radius elbows will not fit, provide square elbows with turning vanes. Turning vanes shall be installed per SMACNA and manufacturer's recommendations.
    - c. Square throat, radius heel elbows are not allowed.
  2. Elbows for Round Ducts:
    - a. Use radius elbows with a minimum centerline radius to diameter ratio of 1.5. Where 1.5 radius elbows do not fit, use 1.0 radius elbows.
- L. Transitions: Limit transition angles (for each side) to 15 degrees diverging and 30 degrees converging.
- M. Flex Connections:
1. Connections to inlet and discharge openings of fans shall be made with a section of at least 1/16 inch thick neoprene coated fiberglass fabric. Flex connections shall not be less than 4 inch long and shall have at least 1 inch of slack. Connections shall have angle frames at each end for rectangular ducts, and metal tension bands at each end for round ducts. Flex connections shall be installed to allow for easy replacement and shall be installed on straight duct sections, not on transitional fittings or tapers.
  2. Connections to units that have fans internally isolated within the unit housing do not require flex connections.
- N. Additional Pressure Class Requirements:
1. VAV: For coordination purposes, unless otherwise indicated, the pressure class for VAV system ductwork upstream of the air terminal devices shall be equal to or greater than

the static pressure at the fan outlet but not less than 4 inches w.c. for the fan discharge side ductwork.

2. Constant Volume: For coordination purposes, unless otherwise indicated, pressure class for Constant Volume system ductwork shall be equal to the external static pressure (fan outlet or discharge pressure minus associated unit internal component pressure drop), but no less than 2" w.c.
3. Minimum allowable pressure class for all low pressure ductwork is 2" w.c.
- O. Seal Class: All ductwork, including low pressure ductwork, shall be SMACNA Seal Class A with all joints, seams and wall penetrations sealed.
- P. Leakage Class: All rectangular ductwork shall be SMACNA Leakage Class 6 and all round ductwork shall be SMACNA Leakage Class 3.
- Q. Seams: All longitudinal seams shall be "Pittsburgh" style. Snap-lock seams are not allowed.
- R. Crossbreak or bead rectangular ductwork. Crossbreaks shall be "out" on positive pressure duct and "in" on negative pressure ducts.
- S. Bolts and Fasteners: Carbon steel, zinc coated per ASTM A153 for galvanized steel ducts and stainless steel for aluminum and stainless steel ducts.
- T. Welding Materials: Refer to SMACNA – Sheet Metal Welding Guide.

## 2.2 DUCTWORK MATERIALS

### A. Flexible Duct:

1. Shall be factory fabricated, listed and labeled as a UL 181 Class 1 air duct, and shall comply with NFPA 90A and NFPA 90B.
2. Flame spread shall be 25 or less and smoke developed shall be 50 or less.
3. Minimum Service Temperatures and Pressures: -20 to 250 Degrees F; 10" w.c. positive; 10" w.c. negative thru 12" dia., 5" w.c. negative - 14" and 16" dia., 1" w.c. negative - 18" and 20" dia.
4. Rated Velocity: 5500 fpm.
5. Inner Liner: Liner shall be nonmetallic type composed of polyester film, polyethylene film, nylon film or woven and coated fiberglass fabric liner mechanically locked without adhesives to corrosion resistant galvanized steel wire helix.
6. Insulation: Fiberglass blanket – ¾ pound, factory wrapped, minimum 1-1/2" thick.
7. Vapor Barrier: Barrier shall have a permeance of not over 0.1 perm and shall be fiberglass reinforced aluminum material or polyethylene.
8. Usage: Connections to air inlets and outlets. Maximum allowable length is 6'-0". Flexible duct is **not** permitted in medium and high pressure duct systems.
9. Installation:
  - a. Shorten and reinstall all sagging or loose flexible duct. Avoid sharp elbows. Elbows shall maintain centerline radius to diameter ratio of 1.5.
  - b. Support flexible duct with pre-manufactured hangers.
  - c. To attach flexible duct to hard duct, tape the inner liner to the hard duct, then attach with two nylon tie wraps, one for the inner liner and one for the vapor barrier. Fold the vapor barrier inside itself so it has neat edges prior to tie wrapping.

### B. Galvanized Steel Rectangular Duct – Single Wall:

1. Material: Ductwork and reinforcements shall be ASTM A653, A924 mill galvanized steel. Galvanized coating to be 1.25 ounces per square foot, both sides of sheet, G90 in accordance with ASTM A90. Provide "Paint Grip" finish or galvanneal sheet metal for ductwork that will be painted.

2. Reinforcement: All reinforcement shall be external to the duct except that tie rods may be used with the following limitations:
    - a. Conform to SMACNA requirements.
    - b. Ducts must be over 18" wide and duct dimensions must be increased 2" in one dimension (height or width) for each row of tie rods installed.
    - c. Tie rods must not exceed ½" in diameter.
    - d. Manufacturer of tie rod systems must certify pressure classifications of various arrangements. This information shall be included in the shop drawings.
  3. Joints: All transverse joint systems shall be a manufactured product that has been tested for conformance with Section VII of SMACNA 1035 – HVAC Duct Construction Standards – Metal and Flexible for sheet and joint deflection at the required pressure class:
    - a. General: Apply sealant to all inside corners. Holes at corners are unacceptable.
    - b. Slide-On Flanged Transverse Joint Systems: Acceptable Manufacturers are Ductmate '25'/35'/45', Nexus, MEZ, WDCI.
    - c. Formed-On Flanged Transverse Joint Systems: Acceptable Manufacturers are Lockformer TDC, Lockformer TDF, United McGill, Sheet Metal Connectors TDC.
    - d. Manufacturers other than those specified above must submit test data and fabrication standards and receive A/E's approval before any fabrication begins.
  4. Exception: Galvanized steel round duct may be substituted for galvanized steel rectangular duct where approved by A/E. The round duct shall meet the standards set forth in this specification. The round duct shall meet or exceed the specified cross-sectional area and insulation requirements. The substitution shall be coordinated with all other trades prior to installation.
- C. Galvanized Steel Round Duct:
1. Material: Ductwork and reinforcements shall be ASTM A653, A924 mill galvanized steel. Galvanized coating to be 1.25 ounces per square foot, both sides of sheet, G90 in accordance with ASTM A90. Provide "Paint Grip" finish or galvanneal sheet metal for ductwork that will be painted.
  2. Reinforcement: All reinforcement shall be external to the duct. Internal reinforcement is not allowed. Flat oval duct shall be reinforced the same as rectangular duct of similar size.
  3. Construction: Machine-formed, round and/or flat oval spiral lock seam duct. Longitudinal or snap lock seams are not allowed. Duct shall be single wall or double wall type. Liner in double wall duct shall be solid and annular space between inner liner and outer duct shall be filled with 1" thick fiberglass insulation. *[Note to AE: Determine if double wall ductwork is necessary.]*
  4. Acceptable Manufacturers: Ajax, Lindab, Semco, Inc., United McGill, Sheet Metal Connectors, United Sheet Metal.
  5. Joints: Slip type connection with a 2" minimum insertion length and a stop bead. Use inside slip couplings for duct-to-duct joints, and outside slip couplings for fitting-to-fitting joints.
  6. Secure all joints with at least three (3) sheet metal screws before sealing.
  7. Ducts and fittings larger than 36" dia. shall have flanged connections.
- D. Stainless Steel Welded Duct:
1. Material: Ductwork and reinforcements shall be 316L stainless steel, 18 gauge minimum.

2. Reinforcement: All reinforcement shall be external to the duct. Internal reinforcement is not allowed. External reinforcement for rectangular stainless steel duct of width greater than 24" can be galvanized steel.
3. Construction and Joints: All ductwork shall have continuously welded joints and seams (Joints shall also be liquid tight.). Note: All round duct joints shall be butt-welded. Exposed duct shall have a #3 finish. Wire brush and polish exposed joints and seams to a #3 finish. Concealed duct shall have a #2 or #2D mill finish.
4. Supports shall not penetrate duct surfaces.
5. Note: Turning vanes and dampers are not allowed in kitchen hood exhaust duct.
6. 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%.

E. Black Steel Welded Duct:

1. Material: Ductwork and reinforcements shall be black steel, 16 gauge minimum.
2. Reinforcement: All reinforcement shall be external to the duct. Internal reinforcement is not allowed.
3. Construction and Joints: All ductwork shall have continuously welded joints and seams (Joints shall also be liquid tight.).
4. Supports shall not penetrate duct surfaces.
5. Note: Turning vanes and dampers are not allowed in kitchen hood exhaust duct.

## 2.3 DUCTWORK SEALANTS AND GASKETS

A. Sealant:

1. UL Classified sealant as compounded specifically for sealing joint and seam in ductwork shall be used. Acceptable manufacturers are Hardcast, United McGill, Mon-Eco Industries or H. B. Fuller/Foster.
2. Duct tapes are not allowed.
3. Select sealants as recommended by manufacturer for specific application.
4. Submit sealant manufacturer's data sheets including performance data, pressure ratings, surface burning characteristics data, and manufacturer's detailed installation instructions.
5. Install sealants in strict accordance with manufacturer's recommendations, paying special attention to temperature limitations. Allow sealant to fully cure before pressure testing of ductwork and before startup of air handling systems.

B. Gaskets:

1. Use Butyl or polymer based tape similar to Ductmate 440, Ventfabrics Ventlok No. 797 or 799 in flanged joints.
2. Gasket material shall be FDA or USDA approved.

C. Exterior Sealants and Gaskets:

1. Same as for interior ducts, but use only products rated from -20 to 200 Degrees F and 2000 hour minimum UV resistance per ASTM G53.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Ductwork and equipment shall be free of kinks, dents and defects before and after installation.
- B. Cleaning: Properly clean all components internally and externally prior to assembly.

- C. Verify dimensions on site, making field measurements and drawings necessary for fabrication and erection. Check plans showing work of other trades and consult with A/E in the event of any interference.
- D. During construction, provide temporary closures of metal or taped polyethylene on open ducts to prevent dust from entering duct system.
- E. Provide openings in ducts for thermometers and controllers.
- F. Provide openings in ducts for test and balance work.
- G. Do not install ducts and other equipment above electrical switchboards or panelboards.
- H. Where two (2) dissimilar metals meet, the joint shall be installed in such a manner that ducts do not contact each other by using a proper seal or compound.
- I. Repair all tears in duct insulation.
- J. Install manual volume dampers in branch supply, return and exhaust ducts so all air devices can be adjusted.
- K. At all manual volume dampers, provide 1" stand-offs on operators when ductwork is insulated.
- L. Insulate terminal air box reheat coils. Seal insulation tight in order to form a tight vapor barrier.
- M. Exterior Ducts: Seal all exterior ducts watertight. All exterior ductwork shall be round. *[Note to AE: If it is not possible to fit round ducts in the space allotted, rectangular ducts will be considered. All rectangular ducts shall be pitched to shed water.]*
- N. Duct Support: Support all duct systems in accordance with SMACNA 1035 – HVAC Duct Construction Standards – Metal and Flexible.
- O. Stainless Steel Duct Hangers: Hangers for stainless steel duct shall be 304 stainless or galvanized steel. Painted or plain steel supports are not allowed.
- P. Cable or Strap Hangers: Main runs of ductwork shall not be supported by cable or strap hangers. Only 12" dia. and less dedicated branch runs can be supported by cable or strap hangers.
- Q. Riser Support: Vertical duct risers shall be supported at each floor.
- R. Sleeves: At duct penetrations thru mechanical room floors, provide metal sleeves that are 6" high above floor in order to prevent moisture from dripping to floors below.
- S. Where supply diffusers are located with backs exposed to unconditioned plenums, ventilated attics, etc., insulate backs with ¾" thick, flexible fiberglass wrap with FSK jacket.

### 3.2 FUME HOOD AND DISHWASHER HOOD /CAGE WASHER EXHAUST DUCT INSTALLATION

- A. Ducts shall maintain the maximum possible pitch toward their inlets unless a different drainage location is indicated on the drawings. If at least 1/8" per foot pitch cannot be maintained, notify A/E before installing duct or other items with which duct may conflict.

### 3.3 KITCHEN HOOD EXHAUST DUCT INSTALLATION

- A. Install ductwork, including access doors in accordance with NFPA 96.
- B. Provide rated insulation or rated enclosure as required by code. *[Note to AE: Review applicable codes and consult with UIUC F&S to determine best course of action.]*
- C. Rated insulation or rated enclosure shall be removable at each access door.
- D. Construct grease tight access doors of the same material and thickness as the duct and as large as possible, up to 24 inches in any dimension. Locate on sides of duct for ease of inspection and cleaning at each change in direction, every 8 to 10 lineal feet of horizontal duct, and not less than 1-1/2 inches from the bottom of the duct. *[Note to AE: Review locations of access doors with UIUC F&S.]*
- E. Install duct without forming dips or traps which might collect residue.

### 3.4 CLEANING

- A. Remove all dirt and foreign matter from the entire duct system and clean diffusers, registers, grilles and the inside of air handling units before operating fans.
- B. Cleaning Agents: Use only non-hazardous, non-toxic cleaning agents and materials. Provide MSDS sheets.
- C. Clean in accordance with National Air Duct Cleaners Association (NADCA).

### 3.5 LEAKAGE TESTING

- A. Test all medium and high pressure and select sections of low pressure (described below) ductwork in accordance with test methods described in Section 5 of the SMACNA HVAC Air Duct Leakage Test Manual. Test all low pressure supply air and return air ductwork located in attics and other unconditioned spaces; all outside air and relief air ductwork; and all ductwork to and from energy/heat recovery equipment. Do not insulate ductwork until it has been successfully tested. Test pressure shall be equal to the duct pressure class. *[Note to AE: Specify pressure class of each duct system shown on the drawings (i.e. 2", 3", 4", 6", etc.). Furthermore, provide a table in this specification that lists each duct system, pressure class of that duct system and testing requirements for that duct system.]* Testing at reduced pressures and converting the results mathematically is not acceptable.
- B. Ductwork that is not required to be tested shall still meet the seal and leakage class requirements of this specification. *[Note to AE: Review leakage testing requirements with UIUC F&S.]*
- C. Maximum allowable leakage shall be calculated by the contractor based on Fig. 4-1 in the SMACNA HVAC Air Duct Leakage Test Manual. Contractor is responsible for all duct square footage calculations and other calculations necessary to establish maximum allowable leakage.
- D. All test methods and calculations shall comply with the requirements set forth in the SMACNA HVAC Air Duct Leakage Test Manual.
- E. All testing shall be witnessed by UIUC F&S and the A/E.
- F. UIUC F&S and the A/E reserve the right to review the contractor's calculations.
- G. If excessive air leakage is found, locate leaks, repair the duct in the area of the leak, seal the duct, and retest.
- H. Totalling leakage from several sections and comparing them to the allowable leakage for the entire system is not acceptable. Each section must pass the test individually.
- I. If any leak causes discernible noise at a distance of 3 feet, that leak shall be eliminated, regardless of whether that section of duct passed the leakage test.
- J. Submit a signed report to the A/E, indicating test apparatus used, results of the leakage test, and any remedial work required to bring duct systems into compliance with specified leakage rates.

### 3.6 DUCTWORK APPLICATION SCHEDULE

USAGE	MATERIAL
Supply Air Duct	Galvanized Steel
Return Air Duct	Galvanized Steel
Relief Air Duct	Galvanized Steel
General Exhaust Air Duct	Galvanized Steel
Toilet Exhaust Air Duct	Galvanized Steel
Fume Hood Exhaust Duct	316L Stainless Steel-Welded
Kitchen Hood Exhaust Duct-Concealed	Black Steel-Welded



Kitchen Hood Exhaust Duct-Exposed	304 Stainless Steel-Welded
Dishwasher Hood and Cage Washer Exhaust Duct-Concealed&Exposed	304 Stainless Steel-Welded

*[Note to AE: In some cases, extremely strong acids will attack 316L stainless steel fume hood exhaust duct. Review alternative materials with UIUC F&S for approval.]*

END OF SECTION **23** 31 00

This section of the *U of I Facilities Standards* establishes minimum requirements only. It should not be used as a complete specification.