

**SECTION 23 30 00****HVAC AIR DISTRIBUTION****PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

- A. Comply with Division 1 - General Requirements and referenced documents.
- B. Comply with all other Division 23 Sections as applicable. Refer to other Divisions for coordination of work with other portions of work.

**1.2 SYSTEM DESCRIPTION**

- A. The scope shall include the furnishing and installation of all ductwork as shown on the Drawings; acoustical and thermal linings; flexible ducts and connections; combination smoke and fire dampers, smoke dampers, and fire dampers; duct access doors; air diffusers, grilles and registers; air volume control devices; hangers and supports; plenums and casings; turning vanes; air filters; installation of temperature control dampers, and other appurtenances necessary for a complete and operational system.
- B. All work shall be preceded by taking measurements at the job site, fully coordinating all work with other trades, verifying available spaces for ductwork, and developing Shop Drawings illustrating such.

**1.3 QUALITY ASSURANCE**

- A. All equipment and materials shall be new and of the quality as specified herein. All work shall comply with the most recent Local Building Code, Mechanical Code, Fire Code, and all other applicable National, State and Local Codes or ordinances.
- B. All equipment and materials shall be installed in a workmanlike manner by trained and experienced sheet metal technicians and mechanics as recommended by the manufacturers of the products installed.
- C. Where the standards and requirements of this specification exceed those of the Sheet Metal and Air Conditioning Contractors National Association (SMACNA) the requirements herein shall govern. As a minimum all ductwork shall be constructed to meet all functional criteria defined in Section 11 of the 2005 SMACNA "HVAC Duct Construction Standards, Metal and Flexible," Third Edition. However, all ductwork shall comply with all code requirements noted above to include meeting deflection limits established in the local Mechanical code.

- D. The work shall be guaranteed for a period of one (1) year from and after the date of acceptance of the job, "Substantial Completion", against noise, chatter, whistling, or vibration, and free from pulsation under all conditions of operation. After the system is in operation, should these defects occur, they shall either be removed and replaced or reinforced as directed by the Owner's Representative.
- E. Air quantities shown on the Drawings, or specified, are based on air at 75 Deg.F. dry bulb, 50 percent relative humidity, and 29.92 inches H.G. barometric pressure.
- F. Except where specified otherwise, all sheet metal used shall be constructed from prime galvanized steel sheets or coils up to 60 inches in width. Each sheet shall be stenciled with manufacturer's name and gauge. Coils of sheet steel shall be stenciled throughout on 10 foot centers (fabricate with stencils to the outside of the ductwork so they are visible when installed) with manufacturer's name and gauge tolerances in inches:

Gauge No.	Nominal Thickness	Minimum Thickness
26	0.0217	0.0187
24	0.0276	0.0236
22	0.0336	0.0296
20	0.0396	0.0356
18	0.0516	0.0466

- G. Contractor shall comply with this specification section in its entirety. If during a field observation, the engineer of record finds changes have been made without prior written approval, the contractor shall make the applicable changes to comply with this specification at the contractor's expense.
- H. At the discretion of the Engineer of Record, sheet metal gauges and reinforcing may be randomly checked to verify all duct construction is in compliance with this is specification section.
- I. All ductwork and fittings shall have a computer generated label affixed to each section detailing all applicable information including the duct dimensions, gage, reinforcement type/class, and connector type of the systems manufacturer. In addition, galvanizing thickness and country of origin shall be clearly stenciled on each duct section.

## 1.4 SUBMITTALS

- A. Product Data: Submit manufacturer's descriptive literature and installation instructions in all items specified herein in accordance with Section 23 05 00.
- B. Shop Drawings shall be submitted on all items of sheet metal work specified herein. Shop drawings of ductwork shall be submitted at a minimum scale of 1/4" equal to one foot except that the Congested Areas and all Air Handling Unit Mechanical Rooms shall be submitted at a minimum scale of 1/2" = 1'-0". Provide sections for all Congested Areas and Mechanical Room Plans.
- C. Shop Drawings shall include the reflected ceiling plan, screened back, overlaid onto the floor plan indicating the proposed installation of all light fixtures; ductwork layout; duct fittings; duct connection details; offsets; bottom of duct elevations; all sheet metal dimensions (sizes); overall air device sizes, air device neck sizes, air device air flow quantities, and device type; duct pressure classifications; all mechanical piping; any conflicts discovered and unresolved through the use of transitions and offsets in the available space; turning vanes; manual volume dampers; automatic control dampers; smoke and fire dampers; duct access doors; flexible connections; and all mechanical fans and equipment.
- D. Sheet metal shop drawings shall be overlaid on piping shop drawings and other shop drawings for other portions of work specified in other sections of these specifications for complete coordination of all work prior to commencing with any installation. These Shop Drawings shall not be prepared directly on the Shop Drawings of other trades; they will be separate from all other shop drawings. Coordination Drawings shall be prepared in accordance with Specification Sections 01 30 00.
- E. Shop Drawings shall be based on actual field measurements taken at the job site and shall take into consideration all obstacles and be fully coordinated with all piping, conduits, structure, equipment, and general construction features.
- F. Shop Drawings shall be generated by a computer aided design and drafting (CADD) system as a CADD drawing. CADD files with Architectural Backgrounds and Mechanical design drawing files will only be provided when requested, if this privilege has not been previously abused, after a Release of Liability Form has been completed.
- G. Include a brochure, with individually assembled cut sheets, and details of all sheet metal fittings, duct construction standards proposed for each system, air volume control devices, and other accessories proposed to be used for job duct construction standards. This shall be done prior to submission or preparation of any sheet metal shop drawings.
- H. Should any ductwork installation commence without approved ductwork shop drawings or written approval by the Engineer of Record, the Contractor assumes all liability, to

include all costs, in revising any portion of the sheet metal work that is deemed unacceptable by the Owner's Representative to include any conflicts discovered in installation that could have been resolved through the Shop Drawing process.

## **1.5 GUARANTEE**

- A. The work shall be guaranteed for a period of one (1) year from and after the date of acceptance of the job, "Substantial Completion", against noise, chatter, whistling, or vibration, and be free from pulsation under all conditions of operation. This guarantee shall include defects in material, equipment and workmanship.
- B. After the system is in operation, should these defects occur, they shall either be removed and replaced or reinforced as directed by the Owner's Representative. This shall include repair of damages to building materials related to these deficiencies.

## **1.6 PRODUCT HANDLING**

- A. Cover and protect material in transit and at site. Material not properly protected and stored, which has been damaged or defaced, or which has gotten wet during storage or construction shall be rejected.
- B. Prior to ductwork being installed the roof system, or floor above the ductwork, must be sufficiently installed to protect ductwork from rain water entering ductwork. All openings in the ductwork shall be covered with minimum three (3) MIL thick plastic during construction. All open ends shall be covered in plastic at the end of each construction day. Whenever the system is operated with the ducts open the open ends must be covered with a pleated media fabric fastened to the open end (use MERV11 for these filters and only remove the filters to make final tie-ins).
- C. Storage and protection of materials shall be in accordance with Section 23 05 00.

## **PART 2 - PRODUCTS**

### **2.1 DUCTWORK**

- A. General:
  - 1. All ductwork shown on the Drawings, specified or required for the heating, ventilating, and air conditioning systems, shall be constructed and erected in a first-class workmanlike manner by trained and skilled sheet metal workers.
  - 2. All ducts shall be erected in the general locations shown on the Drawings, but must conform to all structural and finish conditions of the building. Before fabricating any ductwork, Contractor shall check the physical conditions of the job site, and shall make all necessary changes in cross sections, offsets, etc., whether they are specifically indicated or not.

3. Before starting shop drawings or fabrication of any ductwork, the Contractor must have an approved reflected ceiling plan with which he can coordinate location of air outlets, lights, tile patterns, etc.
4. The sizes of ducts indicated on the Drawings are the required net internal air stream dimensions, and where ducts are lined, the sheet metal sizes shall be increased three inches (3") in both dimensions to accommodate the linings (1-1/2" thick lining, unless indicated otherwise). Assume all rectangular ducts are lined (one inch (1") thick) unless noted otherwise.
5. Ductwork shall be classified, for construction standards, as follows:
  - a. All exhaust ductwork, except grease or other special exhaust systems specified elsewhere herein, all constant volume ductwork (supply, return relief and outside air) served by packaged roof mounted heat pumps, and all transfer air ducts shall be constructed to meet one inch (1") W.G. standards.
6. Except as noted otherwise, ducts, plenums, and casings shall be constructed of new lock forming quality galvanized prime grade steel sheets. The gauges of metal to be used, duct construction details, and the construction and bracing of joints shall be in accordance with the latest edition of the published standards of the ASHRAE Handbook or in accordance with the latest editions of Sheet Metal and Air Conditioning Contractors' National Association (SMACNA) "Duct Construction Standards Manual, Metal and Flexible".
7. Plenum chambers shall be constructed of 18 gauge sheets thoroughly braced with 1-1/2 inch angle irons. All duct panels in rectangular galvanized steel ducts which are 12 inches and wider and which are not lined shall be crossbroken.
8. Make square elbows where shown or required, with factory fabricated double thickness turning vanes. Job fabricated vanes will not be acceptable. Except as otherwise specified or indicated on the drawings, make all other changes in direction with rounded elbows having a centerline radius equal to 1-1/2 times the width of the duct in the plane of the bend.
9. Make transformations in duct shape or dimension with gradual slopes on all sides. Normally, make increases in dimension in the direction of air flow, with a maximum slope of one inch (1") in seven inches (7") on any side. Where conditions prevent the normal slope specified above, a maximum slope of one inch (1") in four inches (4") will be allowed only where conditions necessitate.
10. Where a transition must be made with less slope than that noted above, install single thickness guide vanes to insure proper air flow, and to minimize air pressure drop. Transitions that require less slope than that noted above shall be noted on Shop Drawings, and require review and approval by the Engineer prior to installation.
11. Ducts shall be routed in conjunction with all types of pipes, electrical conduits, ceiling hangers, etc., so as to avoid interferences insofar as possible. When duct penetrations are unavoidable, provide streamline-shaped sleeves around such material penetrations, made airtight at duct surfaces, except that such sleeves are not required at tie rods. When the Contractor believes such penetrations are unavoidable, notify the Owner's Representative for approval prior to commencing with such work. Otherwise all such penetrations are not expected to occur and are

not allowed. Such penetrations will not be allowed for the convenience of, or lack of coordination by, the Contractor. Where obstructions necessitate, are approved by the Owner's Representative, and are of a size exceeding 10% of the total duct area, the duct shall be transformed to maintain the same original duct area.

12. Where each duct passes through a fan room wall, it shall be wrapped with not less than 1/2" thick closed cell neoprene tightly fitted to the outer surface of the duct all around and sealed. In lieu of this method, completely fill the annular space between the duct and penetration by packing with fibrous insulation and seal the perimeter of the penetration around the duct, on both sides of the penetration, with a flexible non-hardening sealant, to be fire rated when applicable.
13. All outlets or grilles in ceilings shall be supported rigidly from ceiling construction with suitable adapters or bucks installed as necessary and as shown to insure outlets and grilles will be accurately trued up with ceiling.
14. Ductwork shall be fabricated in a manner to prevent the seam or joints being cut for the installation of grilles or diffusers.
15. All sheet metal ductwork shall be securely hung from the building construction. All ducts shall be hung adjacent to the seam in the duct and shall be secured in a suitable manner to both the duct and the building construction. All vertical riser ducts shall be supported at each floor with angle iron secured to the ducts and set on the structure members. These angles shall be the same size as specified for bracing.
16. All holes in ducts for damper rods and other necessary devices shall be either drilled or machine punched (not pin punched), and shall not be any larger than necessary. All duct openings shall be provided with sheet metal caps if the openings are to be left unconnected for any length of time. All panels of uninsulated ducts twelve inches (12") and larger shall be cross broken. In general, sheet metal screws shall not be used in duct construction unless the point of the screw is in the air stream unless specifically indicated otherwise elsewhere herein.
17. Manual dampers shall be installed as shown and as required to afford complete control of the air flow in the various duct systems. In rectangular supply ducts, a splitter damper shall be installed at each point where a branch is taken off and additional volume dampers shall be installed where shown or required to achieve the final air balance. No splitter dampers shall be installed in medium pressure ductwork, unless specifically shown on Drawings.
18. Splitter dampers and volume dampers of the "butterfly" type, installed in rectangular ducts, shall be constructed of 16 gauge galvanized steel riveted or welded to square operating rods. Dampers shall have brass, bronze, or approved plastic bearings. The length of any splitter damper blade shall be 1-1/2 times the width of the smaller split in the duct, but shall be not less than twelve inches (12"). Where splitter dampers exceed 12 inches in height two (2) pull rods shall be used. Splitter dampers 12 inches (12") in height or less shall have one (1) pull rod.
19. Butterfly damper blades in round ducts shall be the full width of the duct in which they are installed. Dampers shall be constructed of a minimum 22 gauge metal. Dampers over twelve inches (12") in diameter shall be constructed of 20 gauge metal, have a continuous rod with end bearings opposite the damper handle, and a quadrant type locking handle.

20. The operating rods of all dampers shall be fitted with Young Regulators and the operating head shall be securely fastened in place so as to be accessible in the finished building unless shown otherwise. Operators shall be attached to duct where regulator occurs above a lay-in ceiling. Use a Ventlock No. 555 locking quadrant on accessible concealed splitter dampers. Where dampers occur above or behind plaster or other inaccessible ceilings, walls, chases or furrings, the regulator shall be the concealed type with adjustable cover plate equal to Young Regulator Company Type 315 with maximum 2-1/2" diameter cover plate and required accessories. Young Regulator bearings shall also be provided on the opposite end of each operating rod.
21. Behind each ceiling supply outlet, provide and install a turning vane or approved equalizing grid, where noted or scheduled. Where adjustable air pick-ups are indicated at points branch ducts meet trunk ducts, they shall be Titus AG-45 or approved equal with operator adjustable from the duct exterior.
22. Rectangular opposed blade volume dampers shall be as manufactured by American Warming and Ventilating or Ruskin. Blades shall not exceed 48 inches in length or twelve inches (12") in width, and shall be the opposed interlocking blade type. The blades shall be of not less than No. 16 gauge steel supported on one-half inch (1/2") diameter rustproofed axles. Axle bearings shall be the self-lubricating ferrule type.

**B. Low Pressure Ductwork:**

1. Rectangular low pressure ducts, systems designated to be operating at up to two (2) inches W.G., shall be constructed of the following gauges:

Largest Dimension of Duct	U.S. Gauge of Metal	Maximum Reinforcement Spacing
Up to 26"	26	5'-0"
27" to 42"	24	4'-0"
43" to 48"	22	4'-0"
49" to 60"	20	4'-0"
61" to 84"	18	4'-0"
85" to 96"	18	3'-0"
97" and Over	18	2'-6"

The above rectangular ducts shall be constructed in accordance with Section 1 the latest edition of the "Duct Manual" published by the Sheet Metal and Air Conditioning Contractors National Association. However, the gauge thickness of the ductwork shall meet that as scheduled above.

2. Rectangular low pressure ducts, for systems designated to be operating at up to one (1) inches W.G., shall be constructed of the following gauges:

Largest Dimension of Duct	U.S. Gauge of Metal	Maximum Reinforcement Spacing
Up to 36"	26	5'-0"
37" to 48"	24	5'-0"
49" to 60"	24	4'-0"
61" to 72"	22	4'-0"
73" to 84"	20	4'-0"
85" to 96"	18	4'-0"
Over 96"	18	2'-6"

The above rectangular ducts shall be constructed in accordance with Section 1 the latest edition of the "Duct Manual" published by the Sheet Metal and Air Conditioning Contractors National Association. However, the gauge thickness of the ductwork shall meet that as scheduled above.

3. Round low pressure ducts shall be spiral wound as manufactured by United Sheet Metal Company or have grooved seams with flat snaplock longitudinal seams. Spiral seam round duct gauge thicknesses shall be that standard by the manufacturer for the pressure rating of the system. Gauges for snaplock shop fabricated ducts shall be as follows, without exception:

Largest Dimension of Duct	Gauge of Metal	Gauge of Longitudinal Seams and Fittings
Up thru 8" in Diameter	26	26
9" to 14"	26	24
15" to 26"	24	22
27" to 36"	22	20
37" to 50"	20	18
51" to 60"	18	16

Elbows shall have a centerline radius of 1-1/2 times duct diameter or width and for round ducts may be smooth elbows or 5 piece 90 degree elbows and 3 piece 45 degree elbows. Joints of round ducts shall be slip type with a minimum of three (3) sheet metal screws.



4. All low pressure ductwork shall be externally sealed using water based products to include, United McGill Corporation United Duct Sealer, Hardcast "Iron-Grip 601", Foster 32-19 or Polymer Adhesive Sealant Systems, Inc. "Air Seal No. 11" duct sealer installed in the joints after closure. All sealants shall be U.L. rated. Externally seal all transverse and longitudinal joints, all fitting connections, and all accessories. Do not seal control or manual balance damper control rods. All systems shall meet a Class "A" Seal.
5. Low Pressure Duct Supports:
  - a. All horizontal ducts up to and including 40 inches in their greater dimension shall be supported by means of No. 18 U.S. gauge band iron hangers attached to the ducts by means of screws, rivets or clamps, and fastened above to inserts, toggle bolts, beam clamps or other approved means. Duct shall have at least one pair of supports 8'-0" on centers. Clamps shall be used to fasten hangers to reinforcing on sealed ducts.
  - b. Horizontal ducts larger than 40 inches in their greatest dimension shall be supported by means of hanger rods bolted to angle iron trapeze hangers. Duct shall have at least one pair of supports 8'-0" on centers according to the following:

Angle Length	Angle	Rod Diameter
4'-0"	1-1/2" x 1-1/2" x 1/8"	1/4"
6'-0"	1-1/2" x 1-1/2" x 1/8"	1/4"
8'-0"	2" x 2" x 1/8"	5/16"
10'-0"	3" x 3" x 1/8"	3/8"

- c. Vertical ducts shall be supported where they pass through the floor line with 1-1/2" X 1-1/2" X 1/4" angles for ducts up to 60". Above 60" the angles must be increased in strength and sized on an individual basis considering space requirements.
6. All low pressure ductwork shall be reinforced to maintain a maximum reinforcement spacing as scheduled with the rigidity classification as needed to meet the specification construction standard. Reinforcement spacing shall be reduced as required to meet the construction standard specified using the gauge thickness scheduled.

C. Round Flexible Insulated Ductwork:

1. All round flexible insulated ducts, low and high pressure type, shall be factory fabricated and insulated as manufactured. All round flexible insulated ducts, low and high pressure type, shall be factory fabricated and insulated as manufactured by Thermaflex or Flexmaster USA, Inc. Flexible ducts shall be equal to Thermaflex factory insulated type "M-KC" or Flexmaster "Type 3M".
2. Flexible duct thermal conductance shall be based on a 75 Deg.F. mean temperature and an aged condition (not out of the box value). Flexible duct insulation shall be a minimum nominal two inches (2.0") in thickness with a minimum 0.75 lb. density. The completed duct assembly shall have a minimum R-value of 6.0. To verify compliance with the Energy Conservation Code in effect, the minimum R-value of 6.0 will need to be documented on the outside of the jacket to allow field verification of compliance with this requirement.
3. The core liner of the flexible duct system shall be a tri-laminate aluminum foil, made with fiberglass and aluminized polyester, or a PVC coated fiberglass cloth. The outer liner shall be a polyester reinforced aluminized foil jacket.
4. Flexible ducts shall be U.L. Listed in accordance with U.L. 181 as a Class I insulated air duct, and shall comply with NFPA Standard 90A and 90B. Flexible ducts shall have a maximum flame spread of 25 and maximum smoke developed rating of 50.
5. Flexible ducts shall be suitable for operating temperatures of -20 up to 250 Deg.F.
6. Flexible ducts shall be suitable for negative pressures of minus one inch W.G. in sizes up to 16" in diameter; and positive pressures up to 10 inches W.G. for sizes up to 16" in diameter. Maximum operating duct velocity rating shall be a minimum of 4,500-5,500 feet per minute.
7. Maximum vapor transmission rating shall be 0.05 Perms as rated in accordance with ASTM-E-96.
8. Unless otherwise noted, the maximum length of flexible duct shall be limited to five feet (5').
9. Securement of flexible ducts to air devices shall consist of sliding the duct onto the air device collar or connector and securing it with plenum rated nylon or teflon panduit band on the inner liner which shall be U.L. rated for the application. Fold insulated outer vapor barrier jacket liner over the first band and secure with a second plenum rated panduit band. Make connection vaportight with a vapor barrier seal using polyester reinforced aluminized duct tape that is two inches (2") wide, wrapped 2 times around the duct, or by the use of a fiberglass mesh wrapped in a similar fashion and coated with a vapor barrier coating, Foster's Vapor Safe 95-90 or 95-96 mastic or Childers CP-38. Coating must adhere to MIL-PRF-19565C with a permeance rating of less than 0.02 perms per ASTM-E-96, procedure B. No cloth backed duct tape is allowed. All duct tapes used shall be acrylic based. All fasteners, adhesives, and duct tape used shall be U.L.rated for the application.

## 2.2 ROUND LOW PRESSURE DUCT TAPS

- A. Provide round low pressure, systems operating at a maximum of two inches (2" inches) water gauge (W.G.) static pressure, duct taps to serve air devices where shown on the drawings and in accordance with details for these taps
- B. Duct taps shall consist of spin-in, or spin on, collar type manufactured fittings specifically made for commercial ductwork systems. Spin-in fittings shall be the conical type as shown and detailed on the drawings to include integral manual balance damper with locking device. Fittings shall be fabricated using continuous weld longitudinal seams. No riveted construction allowed.
- C. All spin-in fittings shall be made with hot dipped, G-60 or G-90, galvanized steel (per ASTM A 653) and be a minimum of 26 gauge in thickness for all sizes from 4" to 12" round. All sizes 14" to 20" round shall be a minimum of 24 gauge in thickness. Thicker gauges shall be provided on larger fittings as required per SMACNA and the Mechanical Code, where required.
- D. Provide plain or beaded ends for connection of duct work as required for the application. Crimped ends are not allowed.
- E. All ductwork systems are called out elsewhere in these specifications to be externally sealed to limit air leakage. These fittings may either be factory sealed (all seams sealed) or be sealed by the contractor in the field.
- F. All spin-in fittings shall also include integral manual balance dampers unless indicated otherwise. Damper options shall be as follows:
  - 1. All manual volume dampers shall be the butterfly type, using a single round damper blade and positive locking regulator damper hardware.
  - 2. Sizes 4"-12" round shall have a reinforced damper axis (not a continuous damper shaft) with 1/4" regulator and spring loaded, retractable bearings.
  - 3. Sizes 14" through 20" round shall have a minimum 3/8" continuous damper rod axis with nylon grommets installed at damper sleeve penetrations
  - 4. Provide dampers, which shall include an extended threaded shaft that aligns with a sheet metal stand-off bracket (spot welded to the fitting) with the stand-off distance to be 2" to clear the thickness of any external duct wrap insulation. Coordinate stand-off dimensions with specified duct insulation thickness (only when thicker than 2"). Damper handle and wing nut to be fastened at the outside of the stand-off bracket.
  - 5. Provide premium optional balance dampers to include a 2" stand-off bracket, spot welded to the fitting, to include a 3/8" square shaft extended to the stand-off bracket, with U-bolt, nylon bushings, locking quadrant and handle.
- G. Acceptable Manufacturers:
  - 1. Flexmaster or equals by,
  - 2. Crown Company Products,
  - 3. Ductmate,
  - 4. Hercules Industries.

## 2.3 FIRE, SMOKE, AND COMBINATION SMOKE-FIRE DAMPERS

- A. Contractor shall furnish and install fire, smoke, and combination smoke-fire dampers in air passages, openings, and ductwork wherever shown on the Drawings, and as required by the local authorities having jurisdiction. Installations shall be in accordance with all

applicable NFPA standards and the SMACNA Duct Manual. All dampers shall carry the U.L. Label and shall be installed such as to conform to conditions under which the U.L. Label was granted. All dampers shall be constructed and tested in accordance with the latest edition of U.L. Safety Standards 555 or 555S, as applicable. Provide sleeves, typically 12" in length minimum, for all dampers as required for the installation conditions encountered.

- B. Fire dampers shall be constructed in accordance with the recommendations of the NFPA and shall be of metal gauges required by the class of separation in each case.
  - 1. Interlocking curtain blade type fire dampers carrying the Underwriters' Label will be acceptable, except at locations where an operating type damper is required to meet local requirements, to meet sequence of operations indicated in Temperature Control Specifications, Section 23 09 00, or to meet the limited spaces available.
  - 2. Use Style "B" rectangular and style "CR" for round dampers such that blades are out of the air stream.
  - 3. For grille installations at fire rated partitions, use Style "B" thin line fire dampers or Style "G" integral sleeve type for grilles.
- C. Smoke dampers shall be designed for vertical or horizontal applications as encountered in accordance with NFPA 90A and meet the latest requirements of UL 555 S. Smoke dampers shall be installed in, or adjacent to, the smoke barrier; but in no case, more than 24 inches from the smoke barrier. Smoke dampers shall be a Ruskin Model SD35, 36, 37, or SDRS25 as applicable for the application. Frames shall be made of 16 gauge single piece galvanized steel hat shaped channel frames. Blades shall be 6" wide galvanized steel and be the triple V-groove or air foil type. Provide stainless steel jamb seals, silicone edge type blade seals where required for the classification, stainless steel sleeve bearings and linkages concealed in the frame. Leakage Class shall be Class 1, 2, or 3, as required, to meet the requirements specified elsewhere herein. Provide compatible electric actuator on all dampers, factory installed.
- D. Combination fire-smoke dampers shall be Leakage Class 1 dampers with electric, manually resettable, fuse link operated by 120 volt electric actuator furnished with the damper. Fire-smoke dampers shall be Ruskin FSD-60, or equal, with minimum 16 gauge galvanized steel hat channel shaped frames. Fire-smoke dampers shall be increased in size to maintain a minimum of 90 percent free area of the ductwork size indicated on the Drawings thru each fire-smoke damper. Leakage shall be Class 1, 2, or 3, as required, to meet the requirements specified elsewhere herein. Provide compatible electric actuator on all dampers, factory installed.
- E. Insulated all metal access panels, secured with sash locks, shall be installed to service all fire, smoke, and combination smoke-fire dampers. Access panels shall be identified with "FIRE DAMPER", "SMOKE DAMPER", or "SMOKE-FIRE DAMPER" stenciled thereon in a visible or conspicuous location. Removable flexible duct shall not be

permitted as a means of damper access. Access shall be direct and shall not be obstructed by turning vanes or other duct accessories.

F. General Requirements:

1. For ductmate connections at fire, smoke, or combination smoke-fire dampers, do not use screw fasteners.
2. Use four inch (4") draw band connections at round duct fire damper connections.
3. Use blade dampers when the blade width exceeds 12 inches.
4. Install vertical or horizontal mount dampers suitable for the application.
5. Dampers shall be suitable for the maximum air system operating pressures expected to be encountered. Medium pressure ductwork is expected to operate at up to six inches (6") W.G.
6. Use multi-section dampers where damper size openings are larger than single section maximum sizes.
7. Fire, smoke and combination smoke-fire dampers shall be sized to provide for 100 percent of the ductwork size (minimum 95% free area) indicated on the Drawings through each damper.
8. Provide 165 Deg.F. rated fusible links for fire dampers.

G. Acceptable Manufacturers:

1. Ruskin, or approved equals by:
2. Greenheck, or
3. Nailor, or
4. Prefco, or
5. National Controlled Air (N.C.A.), or
6. Air Balance, or
7. Pottoroff.

## 2.4 FLEXIBLE CONNECTIONS

- A. Where ducts connect to fans, including roof exhausters, flexible connectors shall be made that are fire-resistant, (up to 200 Deg. F.), waterproof, mildew-resistant and essentially airtight, and shall weigh approximately thirty ounces (30 oz.) per square yard.
- B. There shall be a minimum of one-half inch (1/2") slack in these connections, and a minimum of two and one-half inches (2-1/2") distance between the edges of the ducts for a total of three inches (3"). There shall also be a minimum of one inch (1") of slack for each inch of external static pressure on the fan system for medium pressure systems.
- C. Acceptable Manufacturers:
  1. Vent Fabrics "Ventglas", or approved equals by:
  2. Duro-Dyne.

## 2.5 ACCESS DOORS

- A. Furnish and install hinged, low leakage access doors in ductwork or plenums to provide access to all fire, smoke and combination fire - smoke dampers, mixed air plenums, automatic dampers, coils, filters, and elsewhere as detailed on the Drawings.
- B. Where the ducts are insulated, the access doors shall be double skin doors with a minimum one inch (1") of insulation in the door. The insulation shall have a minimum R-value of 5.0. Increase the thickness of the insulation as needed to comply. Where the access door is installed in non-insulated ductwork the access door shall be unlined sheet metal of the same gauge thickness as the duct.
- C. In no case shall access doors be smaller than eight (8") by eight inches (8"). Access doors shall be sized to permit testing or servicing of duct mounted components, such as, for coil cleaning, installation of control devices, resetting of fusible links, filter replacement, etc., as applicable and suitable for the application.
- D. Where duct access doors are above a suspended, normally non-readily accessible ceiling, such as plaster, gypboard or spline type ceilings, Contractor, under this Section of Specifications, shall be responsible for the proper location, and furnishing of, ceiling access doors, or panels, to make duct access doors easily accessed through the ceiling system. Ceiling access doors, or panels, shall be rated, where applicable, to match the fire rating of the ceiling system penetrated. Ceiling access doors, or panels, shall be installed under other Sections of these Specifications. Ceiling access doors, or panels, shall be centered directly beneath duct access doors or immediately adjacent thereto when duct access is through the side of the duct.
- E. In rectangular grease exhaust ducts, install access doors every twenty feet (20') maximum, center to center, and at all 90 degree elbows, when the total developed length exceeds forty feet (40'). Install access doors at every other floor level for vertical grease exhaust duct risers.
- F. All access doors shall be fully double gasketed, door to frame and frame to duct, and include a sash type or compression latches for sizes under eighteen inches (18") by eighteen inches (18"). Use one (1) sash type latch per twelve inches (12") of height or width. Access doors 18" x 18" and larger shall have quarter turn handle latches; Provide one handle per 24" section, height or width, of door. As an example, provide two (2) handle type latches for a 48" tall access door.
- G. Provide a minimum of two (2) heavy loose pin hinges for each access door unless indicated otherwise herein. Piano style hinges will be an allowed substitute.

- H. Where the installation conditions prohibit suitable access with hinged access doors, then non-hinged access doors may be used in conjunction with a corrosion resistant cable or chain, of suitable length, attached to the access door and duct.
- I. For duct systems constructed to 2 inches W.G standards, or less, provide standard access doors meeting all requirements specified herein, which have a tested air leakage rating of less than 4.0 CFM at a test pressure of 2 inches W.G., and as manufactured by:
  - 1. Ventlok with hinges and No. 90 or No. 99 latches (less than 18" x 18"), or No. 100 or No. 140 latches (18" x 18" and larger), as applicable, or approved equals by:
  - 2. Ductmate, or
  - 3. Duro Dyne DDIAD-0806, or
  - 4. NCA Manufacturing ADH-T-1, or
  - 5. Pottorff HAD or CAD, or
  - 6. Nailor 08SH with HP Seal, or 0890, or
  - 7. Cesco Products HDG, or
  - 8. Ward Sandwich Style Access Doors, DSA or DDA, for round ductwork.

## 2.6 DUCT LINER

- A. Where indicated on the Drawings or specified herein, all rectangular transfer ducts; except kitchen grease hood, kitchen dishwasher and fume hood exhaust ducts; shall be lined with Fiberglass mat faced duct liner in the thicknesses, type, and locations as indicated elsewhere herein.
- B. Kitchen grease hood exhaust, kitchen dishwasher exhaust, kitchen hood make-up air, and fume hood make-up air and other industrial type exhaust air ducts shall not be lined. Line all other general building exhaust air ducts within 10'-0" on each side of each in-line exhaust fan with one inch (1") thick liner. Roof mounted exhaust fan ductwork shall also be lined, one inch (1") thickness, but only for the first 10'-0" of ductwork from the roof curb toward the occupied space.
- C. All transfer air ducts shall be lined with one inch (1") thick duct liner.
- D. The liner insulation system shall be one and one-half inches (1.5") in thickness on all conditioned air, heated or cooled, as well as outside air intake ducts, and mixed air plenums to obtain a minimum R-value of 6.0 thereon.
- E. All ductwork systems are required to meet the most recent version of the International Energy Conservation Code.
- F. All duct liners shall comply with NFPA 90A and 90B and ASTM C 1071, Type I, for ducts and Type II for plenums (rigid liner). Liner shall consist of flexible, matt faced insulation made of inorganic glass fibers bonded by a thermosetting resin with an encapsulant edge coating, and shall be a rotary style duct liner product with a water

repellant ingredient on the mat face to help keep moisture from penetrating the air stream surface. Other technical requirements shall include:

1. Be suitable for temperatures up to 250 Deg.F. per ASTM C 411.
  2. Be suitable for air velocities up to 6,000 FPM per ASTM C 1071 for Type I products and 5000 FPM for Type II products.
  3. Water vapor sorption shall be less than 3% by weight per ASTM C 1104.
  4. Air stream surface mat facing shall be tested with an EPA registered anti-microbial agent to aid in the prevention of fungal and bacterial growth. Mat face, as treated, shall not support the growth of mold, fungi, or bacteria per ASTM C 1338, ASTM G 21 and ASTM G 22.
  5. Does not exceed a Flame Spread of 25 and Smoke Developed and Fuel Contributed of 50 per ASTM E 84, NFPA 225, and UL 723.
  6. Conductance of 0.24 (R-value of 4.2) for a 1.5 PCF or 2.0 PCF duct liner at a 75 Deg.F. mean temperature per ASTM C177 for a one inch (1") thick product.
  7. Greenguard Compliant (Greenguard Environmental Institute).
  8. Noise Reduction Coefficient (NRC) of 0.70 or higher for a one inch (1") thick product and 0.80 for a two inch (2") thick product per ASTM C 423, type A mounting.
- G. All duct liners shall be able to be cleaned in accordance with the North American Insulation Manufacturers Association (NAIMA) "Cleaning Fibrous Glass Insulated Air Duct Systems Recommended Practices".
- H. Liner shall be applied to the inside of rectangular ducts and plenums with fire-resistant adhesive, Fosters 85-60, or 85-65, or Childers CP-127, Hardcast "Seal-Tack" or Ward "Premium Duct Liner Adhesive", or equal, complying with ASTM C 916, completely coating the clean sheet metal. All joints in the insulation shall be "buttered" and firmly butted tightly to the adjoining liner using fire resistant adhesive. Where a cut is made for duct taps, etc., the "raw" edge shall be accurately and evenly cut and shall be thoroughly coated with this same fire resistant adhesive.
- I. On ducts over twenty-four inches (24") in width or depth, the liner shall further be secured with mechanical fasteners. Fasteners shall be Graham or Gemco weld pins. "Stick Clips", "Sheet Metal Clips", or other fasteners secured to the ducts by adhesive are not allowed. Fasteners shall be placed on a maximum spacing of eighteen inches (18") and shall be pointed up with fire-resistant adhesive. Fasteners shall not compress the insulation more than 1/8".
- J. Liner shall be accurately cut and ends thoroughly coated with adhesive so that when the duct section is installed, the liner shall make a firmly butted and tightly sealed joint. Provide metal nosings securely installed over transversely oriented liner edges facing the air stream at all fan discharges, at access doors, and at any interval of lined duct preceded by unlined duct.



- K. Where rectangular ducts are lined and adjoins externally insulated rectangular ducts, the two insulations shall be overlapped not less than twenty-four inches (24").
- L. Dimensions given on the Drawings are inside air stream, free area, dimensions only and sheet metal sizes shall be increased in size to maintain these free area dimensions when liner is installed.
- M. All exposed ductwork shall be internally lined unless specifically indicated otherwise.
- N. Refer to Section 23 07 00, Insulation, for further related requirements.
- O. Acceptable liner manufacturer shall be:
  - 1. Certainteed, Tough Gard R with enhanced surface.
  - 2. Knauf, Rotary Duct Liner E-M with Hydroshield.
  - 3. Owens Corning, Quiet R Acoustic Duct Liner, Type 150 or equivalent Duct Liner Board.
  - 4. Johns Manville, Linacoustic RC or R-300.

## **2.7 GRILLES, REGISTERS, AND DIFFUSERS**

- A. Grilles, registers, ceiling outlets, diffusers and other air devices shall be as scheduled on the Drawings and shall be suitable for the intended use.
- B. Provide air devices with sponge rubber or soft felt gaskets at flanges where the devices mate up to a ceiling or wall surface.
- C. If a manufacturer other than the one scheduled is used, the sizes shown on the Drawings shall be checked for performance, noise level or criteria, face velocity, throw, drop, pressure drop, air diffusion, etc., before the submittal is made. Selections shall meet the manufacturers' own published data for the above performance criteria. The throw shall be such that the terminal velocity will be not more than 50 FPM or less than 25 FPM at the point of penetrating the occupancy zone. The occupancy zone is defined as six feet (6') above the finished floor and six inches (6"), or farther, from the walls.
- D. Noise levels shall not exceed those published in current ASHRAE Standards and Guidelines for the type of space being served (N.C. level) or that scheduled.
- E. Locations of outlets on Drawings are approximate and shall be coordinated with other trades to make symmetrical patterns and shall be governed by the established pattern of the lighting fixtures, structure and Architectural Reflected Ceiling Plan (RCP). Air devices shall have margins, frames, and sizes to be compatible with the ceiling and wall systems installed. All color and finishes are subject to final approval by the Architect.
- F. Where called for on the schedule, grilles, registers, ceiling outlets, diffusers and other air devices shall be provided with deflecting devices and manual dampers.

- G. Where indicated on the Drawings, provide a fire rated blanket on the back side of steel ceiling mounted air devices (supply, return, exhaust, etc.).
- H. Where indicated on the Drawings, provide an insulation blanket on the back side (all surface area) of ceiling mounted supply air devices to prevent condensation.
- I. All air devices shall be the standard product of the manufacturer, subject to review by the Architect. Acceptable manufacturers are:
  - 1. Titus, or approved equals only by:
  - 2. Krueger.
  - 3. Nailor.
  - 4. Metal-Aire.
  - 5. Carnes.
  - 6. Price Industries.

## **2.8 LINED SPIRAL DUCT**

- A. Lined spiral duct shall be United McGill Acoustic-K27 duct or equivalent. Utilize duct-duct slip joint connector, conical reducing tees, and 5 gore elbows (60 Deg. and 90 Deg.) for offsets and end runs.
- B. Inner duct liner shall be perforated 28 gauge galvanized steel with 1.5" thick 1.0" thick allowed if ductwork is exposed in a conditioned space, 1.5 pound density, fiberglass insulation sandwiched between it and the outer duct. The outer duct shall be spiral seam construction, and be a minimum of 24 gauge galvanized steel.
- C. In lieu of the perforated steel and factory installed insulation liner, an extra heavy density liner, field installed, may be used as an equivalent to the 1.5" thick Johns Manville Spiracoustic Plus. This system shall have a minimum R-value of 5.0 at 75 Deg.F Mean Temperature, with a noise reduction coefficient of 0.80. The airstream surface shall be coated and be suitable for mechanical cleaning.
- D. Externally seal all duct connections, transverse and longitudinal, with a sealant being listed and labeled in accordance the requirements of U.L. 181A or U.L. 181B such as Foster 32-19 duct sealant.

## **2.9 KITCHEN HOOD EXHAUST DUCTS**

- A. The kitchen hood exhaust duct system shall be constructed of 16 gauge carbon steel with liquid tight continuous external welds at all seams and joints in accordance with NFPA 96 and local codes.
- B. The ductwork shall be installed with access doors at every 20 feet on center, as applicable, and at each elbow to facilitate cleaning, as required by code, and as required

to provide access to fire protection devices in the duct. Access doors shall be grease tight construction with suitable hinges and latches.

- C. The duct shall slope 1/4 inch per foot from the discharge point toward the hood.
- D. All changes in direction shall be made with 1-1/2 times the duct width to centerline radius elbows; no turning vanes or mitered fittings will be allowed.
- E. The ductwork shall be enclosed in a fire-rated duct enclosure, refer to Architectural Drawings, from the point of ceiling penetration to the outside air. The duct enclosure shall be sealed around the duct at the point of penetration to the outside air. The duct enclosure shall be sealed around the duct at the point of penetration and vented to the exterior through weather-protected openings.
- F. Make rigid connections to the hood and fans, transitioning as required, for connection at each piece of equipment. Seal duct connections to fan and hood.
- G. Do not internally line grease exhaust ductwork.

## **2.10 AIR FILTERS**

- A. Provide appropriately sized and number of air filters for each piece of individual air handling equipment to include, but not be limited to, the following:
  - 1. Split DX AC Units.
  - 2. Roof-top AC Units.
  - 3. Elsewhere as required to protect air type heat exchangers, such as warm air furnaces, or coil surfaces, such as duct mounted direct expansion coils.
- B. High performance, extended area, 2" or 4" nominal depth, mini-pleated, disposable filters shall be provided where scheduled or as indicated in other Sections of these Specifications. These filters shall have the following characteristics:
  - 1. Filter media shall be assembled in compact secure enclosures.
  - 2. Filter media shall consist of 100% melt-blown, polypropylene joined with fire retardant bonding agents. Polypropylene separators shall be bonded to the media that are designed to maintain pleat configuration and stability. Media shall have a progressive denier of fibers with coarse fibers on the air entering side and finer fibers on the air exiting side.
  - 3. The media pack, or filter frame, shall be completely enclosed and bonded around the perimeter to a high wet-strength "beverage" board enclosing frame. This frame shall include diagonal support members on the air entering and air exiting sides to maintain pleat spacing and to provide adequate support to maintain the filter pack shape under operating conditions.
  - 4. Filters shall be capable of withstanding 10 inches W.G. without distortion of the media pack or filter frame.
  - 5. Sizes shall be standard sizes that are readily available by multiple sources and be as indicated elsewhere herein.

6. These filters shall have an efficiency of 80-85% when tested in accordance with the most recent version of ASHRAE Standard 52.1. The filters shall have a MERV rating of 13 when tested in accordance with the latest version of ASHRAE Standard 52.2. Initial pressure drop of clean filters at 500 FPM shall not exceed 0.45" W.G.
  7. Provide product test data and related details in accordance with ASHRAE Standards 52.1 and 52.2 for each efficiency specified.
  8. Acceptable Manufacturers:
    - a. Camfil Farr, Inc., Model "AP-Thirteen", or approved equals by:
    - b. Environmental Filter Corporation.
    - c. Eco-Air.
- C. Medium efficiency air filters shall generally be one (1") or two inches (2") thick, unless indicated otherwise and shall be the pleated media, disposable type, listed by Underwriters Laboratories as Class 2, with the following features:
1. Air filters shall be rated in accordance with the most recent version of ASHRAE Standards 52.1 and 52.2, test methods as indicated herein, and shall conform to Section 7.4 of ARI Standard 850.
  2. Filter media enclosing frame shall be constructed of rigid, heavy duty, high wet-strength resistant, "beverage" board with diagonal support members on the air entering and air exiting sides. Expanded diamond grid media support, integral with frame, shall be chemically bonded to filter media at each pleat, to insure pleat spacing and stability. Pleated media shall be bonded to the inside of the frame to eliminate air bypass.
  3. Filter media shall be high performance, non-woven, reinforced cotton-poly, synthetic blend fabric formed in a V-shape.
  4. Filters shall have the following performance data:

<b>THICKNESS</b>	<b>SQUARE FEET MEDIA AREA TO ONE SQUARE FOOT FACE AREA</b>	<b>MINIMUM PLEATS PER LINEAL FOOT</b>	<b>INITIAL AIR RESISTANCE (INCHES W.G.)</b>	<b>RESISTAN CE BASED ON AIR FLOW OF</b>
One Inch (1")	2.4	16	0.25 (350 FPM)	1400 CFM
Two Inch (2")	4.3	15	0.28 (500 FPM)	1500 CFM
Four Inch (4")	6.9	11	0.27 (500 FPM)	1500 CFM

5. Filters shall be suitable for operation with varying velocities of up to 500 feet per minute (FPM) for 2" and 4" filters and 350 FPM for 1" filters.
6. Filters shall have a minimum efficiency of 20% for particles in the 0.3 to 1.0 micro range, 65% for particles in the 1.0 to 3.0 range, and 85% for particles in the 3.0 to 10.0 micron range as tested in accordance with ASHRAE Standard 52.1. Filters

shall also have a MERV rating of 11 as tested in accordance with ASHRAE Standard 52.2.

7. Refer to equipment schedules for more specific filter MERV rating requirements.
8. Acceptable Manufacturers:

- a. Camfil Farr, Inc., Model AP-Eleven, or approved equals by:
- b. Environmental Filter Corporation.
- c. Eco-Air.

- D. All filters shall be standard sizes that are readily and locally available, in stock, through multiple over the counter sources without requiring special order. Standard acceptable sizes shall be 16" x 20" and 16" x 25".

## **2.11 ADHESIVES AND SEALANTS**

- A. All adhesives and sealants used on this project must have a Volatile Organic Compound (VOC) content less than that listed in the current South Coast Air Quality Management District (SCAQMD) Rule 1168, and all sealants and fillers must meet or exceed the requirements of the Bay Area Air Quality Management District Regulation 8, Rule 51.
- B. All adhesives and sealants shall meet the most current Leadership in Energy and Environmental Design (LEED™) requirements.

## **2.12 TURNING VANES**

- A. Turning vanes shall be Harper double wall turning vanes fabricated from the same material as the duct.
- B. Turning vane front and back panels shall be securely locked together with adequate crimping to prevent twisting of vane. Vanes shall be capable of withstanding 250 pounds of tensile load when secured according to the manufacturer's instructions.
- C. Rails for mounting vanes shall have self locking, friction fit tabs designed to facilitate proper alignment of vanes. Tab spacing shall be as specified in Figure 4-3 of the 2005 SMACNA Manual, "HVAC Duct Construction Standards, Metal & Flexible", Third Edition standard. Rail systems with non-compliant tab spacing shall not be accepted.
- D. Acoustical Turning Vanes shall be used in applications that require quiet operating systems. Mounting rails shall have friction insert tabs that align the vanes automatically. These shall only be required where designated on the Drawings.
- E. Approved Manufacturers:
  1. Ductmate Industries PRO-Rail Turning Vane or approved equals.

## **2.13 FIBERGLASS DUCTBOARD**

- A. Fiberglass duct board of any type is not allowed on this project without exception.

## **PART 3 - EXECUTION**

### **3.1 INSTALLATION**

- A. Install all ductwork and equipment as indicated on the Drawings in full accordance with these specifications including foundations, hangers, supports, etc.
- B. Seal all ductwork as specified, pressure test and repair leaks.
- C. Should defects or installation deficiencies become apparent, or are observed, after the systems have been in operation, the deficient components shall be removed and replaced or reinforced as directed by the Owner's Representative.

### **3.2 CLEANING OF DUCT SYSTEMS**

- A. Before the grilles or diffusers are installed, all fans and air conditioning units shall be operated and all debris and foreign matter shall be removed from the ducts.
- B. The air conditioning units shall be thoroughly cleaned, and the drain pans shall be thoroughly cleaned and flushed out with a hose; the filters shall be thoroughly cleaned and the grilles shall then be installed.
- C. Insure all duct openings are capped and sealed during construction when additions are not being made.

### **3.3 AUTOMATIC CONTROL DAMPERS**

- A. Refer to Section 23 09 00, Controls and Instrumentation.
- B. Install all temperature control modulating dampers under this section of the specifications, furnished in Section 23 09 00.

### **3.4 FILTERS**

- A. No air moving equipment may be operated at any time without filters being fully installed in equipment.
- B. Provide a minimum of three (3) spare sets of two inch (2") thick, medium efficiency, pleated media filters for all air handling and fan coil units, as well as for filter return air grilles where scheduled, in addition to manufacturer furnished filters specified elsewhere herein. Where other sections of these specifications require one inch (1") or four inch (4") thick filters, or other types of filters, provide spare sets of matching thickness and type.
- C. Additionally replace filters during construction as directed by the Owner's Representative.

- D. Install one (1) new complete set of filters, as directed by the Test and Balance (TAB) Firm, just prior to performance of TAB work.
- E. Install one (1) new set of filters at "Substantial Completion" of the project.
- F. Where the minimum number of filter sets are not used for the aforementioned purposes, provide the left over filters to the Owner for maintenance stock.
- G. Document, in writing, when each filter change-out occurs.

### **3.5 STATIC PRESSURE DUCT TESTING - LOW PRESSURE SYSTEMS**

- A. All designated low pressure duct systems (ERV exhaust and outdoor duct work shall be pressure tested by the Contractor, witnessed by the Testing, Adjusting, and Balancing (TAB) firm, according to the most current version of the SMACNA HVAC Air Duct Leakage Test Manual test procedures.
- B. Design pressure for testing low pressure duct work shall be two inches (2") of water gauge, unless indicated otherwise herein. All pressure tests shall be conducted under a positive pressure, even for systems intended to operate at negative air pressures such as exhaust systems.
- C. Test duct work from fan connection up to and including the hard sheet metal tap just prior to the final connection at each air device. Test in sections as required based on the Leakage Test Kit utilized. Use a United McGill Corporation LTK-S (small) or LTK-L (large) Leakage Test Kit with accessories as required to perform the test. This shall include a calibrated orifice tube with certified calibration chart, fan, and two U-tube manometers with connecting tubing.
- D. Tests shall be performed as soon as possible after the first section of duct work to be tested is installed to evaluate the quality of the installation early in the process to allow corrective actions to be taken before the entire installation is completed.
- E. Cap all open ends of duct systems to be tested for testing purposes. Make temporary openings for test equipment as required. Patch these to match new installation conditions when tests are complete and accepted per criteria stated herein. Generally, follow United McGill's procedures as published in their document titled "System Pressure Testing for Leaks", or the SMACNA Manual referred to herein.
- F. All ducts shall have been sealed as specified, during installation, and shall be sealed as a Seal Class "A" per SMACNA.
- G. Leaks that whistle or are excessive, as determined by the Owner's Representative, shall be repaired and the test repeated until such are eliminated.

- H. Maximum leakage rate of each system shall not exceed 5% of the design operating air volume; or, whichever is most restrictive, be equal to 6.0, or less, in accordance with the following equation (from International Energy Conservation Code, 2009);

$$\text{Leakage Rate} \leq 6.0 = R \times P^{0.65}$$

F = Measured Leakage Rate in CFM per 100 square feet of duct surface

P = Test Static Pressure, In W.G.

- I. Provide duct leakage test report summary for submission and review by the Owner's Representative. At least one test, preferably the first to occur, shall be witnessed by the Testing, Adjusting, and Balancing (TAB) Agent. Test Report Summaries shall include the following:
1. Cut sheets on test equipment used along with calibration sheet for orifice tubes used.
  2. Drawing or diagram depicting portion of duct system tested. Indicate square footage of duct work in test section.
  3. Indicate test pressure used in test, versus, construction class of duct installed.
  4. Note allowed leakage in CFM for test section.
  5. Indicate actual leakage recorded during the test.
- J. All tests shall be repeated until the sections tested all pass the test per the criteria stated herein.

### **3.6 KITCHEN HOOD EXHAUST DUCTS**

- A. Prior to the concealment of any portion of the grease duct system, an air leakage test shall be performed as noted in Paragraph 3.3.
- B. Prior to the concealment of any portion of the grease duct system a light test shall also be performed on all field or shop welded or brazed joints in the system to include hood-to-duct connections. The light test shall involve passing a lamp with a power rating of no less than 100 watts through the entire length of duct work. The lamp shall be exposed and fully open to allow light to emit equally in all directions. Systems may be tested in Sections, if necessary, provided that all joints are tested. Provide duct light test report summary (suitable video tape confirmation is acceptable) for submission and review by Owners Representative. Testing shall comply with Section 5.06.3.2.5 of the 2009 International Mechanical Code (IMC) or later.

**END OF SECTION**