

SECTION 233100 - DUCTWORK

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-01 Specification sections, apply to work of this section.

1.2 SCOPE

- A. Provide complete duct systems as indicated. Systems shall include, but not be limited to, the following: outside air, exhaust air, and air conditioning supply and return air duct systems as shown on drawings. Drawing scales prohibit the indication of all offsets, fittings, and like items; however, these items shall be installed as required for the actual project conditions at no change in contract price.
- B. Items Included: This section generally includes, but is not limited to, the following major items:
 - 1. Low pressure sheet metal ductwork.
 - 2. Acoustical thermal duct liner.
 - 3. Low pressure flexible ducts.

1.3 RELATION TO OTHER WORK

- A. Refer to the section, "General Mechanical Provisions" for related requirements. Refer to other sections of Division 23 and to other applicable portions of the Drawings and Specifications.
- B. This section is directly related in particular to sections (which may or may not be included in this division) which describe the following:
 - 1. Sections describing air handling equipment and fans.
 - 2. Air distribution devices.
 - 3. Terminal units.
 - 4. Duct system accessories.
 - 5. Insulation.
- C. Coordinate shop drawings, ordering, delivery, and placement of all items affecting the duct systems including, but not limited to, the following items: air handling units, exhaust fans, supply fans, sound attenuators, duct mounted coils, access panels, air distribution devices, fire dampers, outside air louvers, hoods, filters, roof curbs, structural framing, roof construction, roofing, and the work of all trades to insure an orderly and timely progression of the work. Refer to the requirements of Section entitled "General Mechanical Provisions".
- D. Refer to other sections which may describe additional sound attenuation measures which may relate to this section.

1.4 SHOP DRAWINGS

- A. Refer to Section entitled "General Mechanical Provisions". Include complete data as applicable to this project on: all prefabricated duct and fittings; duct liner including mechanical fasteners and adhesives; duct sealing materials; duct joining and seaming methods; and all other items.

1.5 OTHER REQUIREMENTS

- A. Provide all ductwork and components thereof in accord with manufacturer's recommendations. All ductwork dimensions indicated are nominal free clearance internal dimensions which do not include insulation thickness.

1.6 DEFINITIONS

- A. "SMACNA" means "Sheet Metal and Air Conditioning Contractors National Association, Inc."
- B. Low Pressure Ductwork: Any and all ductwork conveying air or other gases at velocities less than 2500 fpm and static pressure less than 2.0 inches wg. This ductwork may also be referred to in these specifications as "Low Velocity Ductwork". SMACNA "HVAC Duct Construction Standards, Metal and Flexible", latest Edition, shall govern construction of this ductwork unless otherwise specified.
- C. High Pressure Ductwork: Any and all ductwork conveying air or other gases at velocities equal to or greater than 2500 fpm or static pressure equal to or greater than 2.0 inches wg. This ductwork may also be referred to in these specifications as "High Velocity Ductwork" or "Medium Pressure Ductwork", but shall be considered, in either terminology, to fall within pressure/velocity class (PV/C designation) 3 to 10. SMACNA "HVAC Duct Construction Standards, Metal and Flexible", latest Edition, shall govern construction of this ductwork unless otherwise specified.

1.7 PRESSURE/VELOCITY CLASSIFICATIONS

- A. Pressure and velocity classifications (hereinafter called "P/VC") for ducts are defined as follows:

<u>P/VC Desig.</u>	<u>SMACNA Pressure Class</u>	<u>Static Pressure Rating</u>	<u>Positive or Negative Pressure</u>	<u>SMACNA Seal Class</u>	<u>Maximum Velocity (fpm)</u>
10	High	10"	+	A	2000 up
6	Medium	6"	+	A	2000 up
4	Medium	4"	+	A	4000 dn
3	Medium	3"	+ or -	B	4000 dn
2	Low	2"	+ or -	C	2500 dn
1	Low	1"	+ or -	C	2500 dn
½	Low	1/2"	+ or -	C	2000 dn

- B. See Part 3, EXECUTION, of this section for duct sealing requirements.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Materials shall comply with current SMACNA standards.
- B. ASTM: Unless otherwise specified, ASTM material specifications applicable are:

<u>Material</u>	<u>Type</u>	<u>ASTM Number</u>
Galvanized steel	G90	A635
Stainless steel	304,316	A240
Cold rolled steel	20-28 ga.	A366
Cold rolled steel	18 ga.	A619
Aluminum	3003 H-14	B609

- C. Special Materials, Gauges and Construction:
 - 1. Special Materials: Where special duct material other than galvanized steel is required, such duct material (e.g., fiberglass, stainless steel, plastic such as polyvinylchloride, etc.) shall be specifically indicated.
 - 2. Gauges: Gauges indicated in this section are for galvanized steel. Where greater or lesser gauges are specifically indicated for a sheet metal material other than galvanized steel, provide the indicated gauge. Comply with the SMACNA construction standard covering the required material if no gauge is given.
 - 3. Construction: Comply with indicated special requirements (i.e., such as welding, soldering, etc.) where application requires.

2.2 LOW PRESSURE SHEET METAL DUCTWORK

- A. Material: Prime quality forty-eight inch wide resquare tight coat galvanized steel conforming to the requirements of ASTM A-635 and/or A-527 as applicable to the intended use.
- B. Construction:
 - 1. Construct to comply with the pressure/velocity classification(s) indicated.
 - 2. Use rectangular or round as indicated on drawings.
 - 3. Reinforcing, Cross Breaking, Seams, Joints: Be in accord with latest SMACNA construction standard for low pressure sheet metal duct.
 - 4. Gauge: As required by SMACNA for the dimensions and pressure/velocity classification involved.
- C. Insulation:
 - 1. Rigid sheet metal ductwork: Where low pressure ductwork is designated to have internal acoustical/thermal liner, provide factory fabricated double wall ductwork as specified for high pressure round acoustically lined sound attenuating duct (i.e., factory fabricated double wall duct with perforated inner wall).

2.3 ACOUSTICAL THERMAL DUCT LINER

- A. Line ductwork where indicated. Dimensions indicated are net inside dimensions. Liner shall be one inch thick, three pound density fiberglass duct liner with the surface in contact with moving air stream stabilized with black pigmented neoprene. Duct liner shall comply with

requirements of NFPA 90A as to flame spread and smoke developed ratings. Duct liner shall be factory treated with antimicrobial/antibacterial treatment to prevent formation & growth of bacteria.

- B. Acceptable Manufacturers: Johns-Manville, Microtex; PPG Industries, Testrafine; or Certain-Teed/Saint Gobain, Coated Ultralite.
- C. Attachment: Attach to the interior of sheet metal ducts using a full coverage coat of Foster's 85-20 adhesive and mechanical fasteners applied as follows:
 - 1. Horizontal Ducts: Install mechanical fasteners on underside of the tops of ducts over twelve inches in width and on the insides of ducts over sixteen inches in height.
 - 2. Vertical Ducts: Install mechanical fasteners on all duct surfaces exceeding twelve inches.
 - 3. Fastener Spacing: Install fasteners within two inches of the leading edge of each duct section and within three inches of the leading edge of cross joints in insulation within any given duct section. Pins shall thereafter be spaced at not more than fifteen inches on centers. Pins shall be installed in strict accordance with manufacturer's instructions.
- D. Edge Stabilization: All exposed edges and the leading edge of all cross joints of liner shall be coated with Foster's 30-36.

2.4 LOW PRESSURE FLEXIBLE DUCTS

- A. General:
 - 1. The inclusion of flexible ducts in this specification shall not be construed as approval of use on the project unless specifically shown on the Drawings.
 - 2. Where used, provide in factory finished lengths not in excess of lengths required to make kink-free connections with minimum air pressure drop.
- B. Insulated flexible ducts: Flexible duct shall be factory-fabricated preinsulated type with seamless vapor barrier. Duct shall bear UL 181 Class 1 Air Duct label and shall comply with NFPA 90A and 90B. Fiberglass insulation nominal 1" thickness with thermal conductance of 0.23 BTU/hr-ft²-°F maximum at 75°F mean temperature. Flexible duct shall have an operating range of minus 0.5" w.g. to plus 2" w.g. Core shall be continuous and consist of aluminized mylar laminated to corrosion resistant steel wire helix. Vapor barrier perm rating shall be 0.17 maximum per ASTM E96-A. Maximum working velocity shall be 4000 FPM. Flexible duct shall be Genflex SLR-25, Clevaflex Type KQ, Wire Mold type WG, Flexmaster Type 5B, or approved equal.
- C. Un-insulated flexible ducts, steel: Flexible ductwork shall be constructed of all metal one ply hot-dipped galvanized steel, closely corrugated for strength and flexibility, with seams interlocked, folded flat, and knurled to insure tightness. Duct shall be listed as #UL181 "Flexible Air Duct", Class 1, and NFPA 90A. Products shall be Flexmaster Type NI-TL, Clevaform Type GS or approved equal.
- D. Round branch take-off fittings for flexible duct:
 - 1. Round duct branch take-off fitting shall be made of galvanized sheet metal designed for twist-in installation and to assure minimum air loss at the take-off. The fittings shall be of the conical converging type to reduce the pressure drop through the fittings. Provide a raised bead on the throat of the fitting to assure a tight positive connection. Products shall be Flexmaster Model CB-DE-BO3 or approved equal.

2. Provide each fitting with the following:
 - a. Lockable quadrant damper.
 - b. 45-degree extractor scoop.
 - c. Insulation guard where used with internally lined ductwork.
3. Provide these "spin-in" type fittings at all connections between rigid sheet metal duct and flexible duct at the upstream end of the flexible duct.

PART 3 - EXECUTION

3.1 GENERAL

- A. All duct systems shall be free of noise, chatter, vibration and pulsation under all conditions of operation. Remove, replace or reinforce as directed by the Architect/Engineer if necessary to correct such conditions.
- B. If field conditions are determined to exist which would limit the guarantee of air delivery or system performance, due notice in writing shall be submitted to the Architect/Engineer of such conditions prior to starting fabrication.
- C. Properly support and align ductwork. Ducts to be free of sag and bulge. Hang ductwork below concrete floors or roof deck with hangers set prior to pouring concrete, or from self drilling screw anchors. GUN POWDER SET ANCHORS ARE NOT PERMITTED.
- D. Where it is necessary that ducts be divided due to pipes or other obstructions which must pass through these ducts, the Contractor shall, at locations as noted or directed, provide air-stream deflectors in the duct and the duct shall be increased in size to maintain equivalent area around deflectors. Such changes shall be in accord with standard SMACNA details and shall be shown on Contractor's As-Built Drawings.
- E. Interior of ductwork visible through registers, grilles, or diffusers shall be painted flat black.
- F. Do not route ductwork through transformer vaults and electrical equipment spaces and enclosures.
- G. Construct all ductwork and accessories in accord with the latest indicated editions of applicable SMACNA construction standards. Sheet Metal and Air Conditioning Contractors' National Association.
- H. Streamline all ductwork to the full extent practical and equip with proper and adequate devices to assure proper balance and quiet draftless distribution of indicated air quantities.
- I. Protect all ductwork and system accessories from damage during construction until Architect/Engineer's final acceptance of project.
- J. Prior to ductwork fabrication, verify if all ductwork as dimensioned and generally shown will satisfactorily fit allocated spaces. Take precautions to avoid space interferences with beams, columns, joists, pipes, lights, conduit, other ducts, equipment, etc. Notify Architect/Engineer if any spatial conflicts exist, and then obtain Architect/Engineer's approval of necessary routing. Make any such necessary revisions which are minor at no additional cost.

- K. Carefully correlate all duct connections to air handling units and fans to provide proper connections, elbows and bends which minimize noise and pressure drop.
- L. Provide all curved elbows with radius ratios of not less than 1.5 unless otherwise shown or approved by Architect/Engineer. Provide all mitered elbows with turning vanes.
- M. Properly suspend all ductwork so that no objectionable conditions result (such as vibration, sagging, etc.).
- N. Coordinate any and all dimensions at interfaces of dissimilar type of ductwork and at interfaces of ductwork with equipment so that proper overlaps, interfaces, etc., of insulation and continuity of vapor barriers are maintained.
- O. If necessary where ducts interface and have different types of insulation, provide transitions so that internal free-clear dimensions of duct remain unchanged.
- P. Install horizontal low pressure ductwork at a level which maximizes length of any vertical, rectangular or round rigid duct connections to rectangular diffuser necks; however, such vertical duct connections are not required to be over 24 inches in length.
- Q. Make connections from any low pressure ductwork to terminal units (fan terminal units, variable volume boxes, etc.) with appropriate lengths of flexible duct unless other type of connection is indicated.
- R. Install all flexible round duct without kinks or similar obstructions so that pressure drop is minimized. Cut and remove excess lengths as necessary.
- S. Install horizontal rigid ductwork as high as practical above suspended ceilings so that movable light fixtures may be relocated without interference to meet any future partition relocation requirements.
- T. Insulated Duct: Where ducts will be insulated, make provision for neat insulation finish around damper operating quadrants, splitter adjusting clamps, access doors, and similar operating devices. A metal collar equivalent in depth to insulation thickness and of suitable size to which insulation may be finished shall be mounted on duct.

3.2 LOW PRESSURE SHEET METAL DUCTS

- A. If width or height of rectangular duct exceeds 12 inches, cross break or roll a cross bead in panels to increase stiffness; otherwise, use two gages heavier steel.
- B. Provide corner closures. Longitudinal seams and transverse joints shall be flat and smooth inside. Make slip joints in direction of air flow. See governing SMACNA manual for transition requirements.
- C. Fabricate offsets, turns and elbows with centerline radius equal to 1-1/2 times diameter when possible. No mitered offsets will be allowed. Provide double thickness turning vanes to assist in smooth flow of air in square elbows or elbows with centerline radius less than duct width or diameter.

3.3 LOW PRESSURE FLEXIBLE DUCTS

- A. Flexible ducts shall not be used unless specifically indicated on drawings.

B. If flexible duct is indicated for use on this project, it must comply with the following requirements.

1. The extent of the use of flexible ductwork shall be limited to that shown on the drawings.
2. Flexible duct installation shall be per SMACNA Flexible Duct Installation Standards, and manufacturers latest printed instructions, whichever is stricter. In addition the following shall apply:
 - a. Flexible duct between rigid duct and diffusers shall be a MAXIMUM of 8 feet in length and shall be fully extended with a maximum equivalent of (2) 90 degree bends (no bend shall be made with centerline radius of less than one duct diameter). No additional flexible duct shall be provided for future terminal device relocation unless otherwise specified.
 - b. Flexible duct shall be supported at ends and at each 90 degree bend. Maximum permissible sag is 1/2 inch per foot of spacing between supports.
 - c. Hanger or saddle material in contact with the flexible duct shall be of sufficient width to prevent any restriction of the internal diameter of the duct when the weight of the supported section rests on the hanger or saddle material. In no case will the material contacting the flexible duct be less than 1 inch wide. Narrower hanger material may be used in conjunction with a sheet metal saddle which meets the foregoing specifications. This saddle must be formed to cover one-half the circumference of the outside diameter of the flexible duct and must be rolled to fit neatly around the lower half of the duct's outer circumference.
 - d. Factory installed suspension systems integral to the flexible duct are an acceptable alternative hanging method when manufacturers recommended procedures are followed.
 - e. Hangers shall be adequately attached to the building structure (not pipe, conduit, etc.).
 - f. To prevent tearing of vapor barrier, do not support entire weight of flexible duct on any one hanger during installation. Avoid contact of flexible duct with sharp edges of hanger material. Damage to vapor barrier may be repaired with approved tape. If internal core is penetrated, replace flexible duct or treat as a connection.
3. Terminal devices connected by flexible duct shall be supported independently of the flexible duct.

3.4 RIGID STAINLESS STEEL DUCT

A. In addition to SMACNA recommendations and other requirements, rigid stainless steel duct systems shall comply with the following:

1. All joints and seams shall be made with continuous welds. Ductwork shall be liquid tight and gas tight.
2. Hangers and supports in finished areas shall be of same material as ductwork.
3. Food Service Equipment Exhaust Ductwork:
 - a. Kitchen exhaust ductwork of stainless steel or black steel shall be installed in accordance with NFPA 96 Standard for removal of smoke and grease laden vapors from commercial cooking equipment.
 - b. Install horizontal stainless steel or black steel kitchen exhaust ductwork with a minimum slope of 1-inch per foot.
 - c. Provide access panels of suitable size, minimum 12"x12", at 10'-0" centers minimum and at each change of direction for cleaning purposes.
 - d. Changes in Shape and Direction: Construct all changes in shape or direction in such a manner as to prevent the formation of any traps or pockets which might collect grease.

- e. Cleanout Openings: Provide an opening in each exhaust duct at each change in direction of duct for the purposes of inspection and cleaning. Openings shall be at the sides and large enough to permit cleaning. In horizontal sections the lower edge of the opening shall be not less than one and one-half inches from bottom of the duct. Covers shall be constructed of the same material and thickness as the duct and shall be grease tight when in place.
- f. Standards: Comply with latest SMACNA HVAC Duct Construction Standards – Metal and Flexible, 3rd Edition.

3.5 MISCELLANEOUS DUCT SYSTEM COMPONENTS

- A. Spin-In Take-Off Fittings: Install around duct branch takeoff fittings according to manufacturer's installation instruction. Additionally seal fitting to rectangular duct with a thin bead of mastic sealant.

3.6 HANGERS AND SUPPORTS

- A. General: Comply with latest applicable SMACNA construction standard. Where sprayed fireproofing occurs, install hangers before application of such treatment and withhold installation of ducts until after application.
- B. Supports: Vertical risers and other duct runs where the method of support specified above is not applicable shall be supported by substantial angle brackets designed to meet field conditions and installed to allow for duct expansion.
- C. Fasteners: Secure hangers to steel beams or metal deck with beam clamps or drop through connections from the metal or concrete deck.

3.7 CHANGES IN SHAPE OR DIMENSION

- A. Where duct size or shape is changed to effect a change in area, the following shall apply:
 - 1. Where the area at the end of the transformation results in an increase in area over that at the beginning, the slope of the transformation shall not exceed one inch in seven inches.
 - 2. Where the area at the end of the transformation results in a decrease in area from that at the beginning, the slope of the transformation may be one inch in four inches, but one inch in seven inches is preferable, space permitting.
 - 3. The angle of transformation at connections to heating coils or other equipment shall not exceed thirty degrees from a line parallel to the air flow on the entering side of the equipment, nor fifteen degrees on the leaving side. The angle of approach may be increased to suit limited space conditions when the transformation is provided with vanes approved by the Architect/Engineer.

3.8 CHANGES IN DIRECTION

- A. Changes in direction shall be basically as indicated on the drawings and the following shall apply:
 - 1. Supply duct turns of ninety degrees in low pressure duct shall be made with mitered elbows fitted with closely spaced turning vanes designed for maintaining a constant velocity through the elbow.

2. Return and exhaust duct turns of ninety degrees in low pressure duct shall be made with mitered elbows, as specified hereinbefore for supply ducts, unless radius elbows are indicated in which case they shall be constructed with a turning radius one and one-half (1-1/2) times the width (with width considered as the dimension in the plane of the turn) as measured to the duct centerline.
3. Tees in low pressure duct shall conform to the design requirements specified hereinbefore for elbows.
4. Branch take-offs in low pressure supply duct shall be made with extractors or splitter dampers, as indicated, in square take-offs.
5. In high pressure duct, branch take-offs and connections to flexible duct supplying air to terminal units shall be made with conical taps.

3.9 IMPROPER MATERIALS OR CONFIGURATION

- A. If ductwork materials or ductwork configurations are installed which do not meet these specifications, Contractor shall remove such ductwork and replace with materials or configurations which are acceptable. Any delay in job progress will be the responsibility of the Contractor.

3.10 OTHER REQUIREMENTS

- A. Insulated Duct: Where ducts will be insulated, make provision for neat insulation finish around damper operating quadrants, splitter adjusting clamps, access doors, and similar operating devices. A metal collar equivalent in depth to insulation thickness and of suitable size to which insulation may be finished shall be mounted on duct.
- B. Control Devices: Properly install all control related devices which are part of the duct systems. See Section(s) describing control systems.

3.11 SEALING OF DUCTS

- A. Duct seal classes are as follows:
 1. Seal class "A": Seal all transverse joints, longitudinal seams and duct wall penetrations. Use for P/VC-4 (4" w.g.) and greater unless otherwise indicated.
 2. Seal class "B": Seal all transverse joints and longitudinal seams. Use for P/VC-3 (3" w.g.) unless otherwise indicated.
 3. Seal class "C": Seal all transverse joints. Use for P/VC-2 (2" w.g.) and lower unless otherwise indicated.
- B. Where sealing is required, it shall mean the following:
 1. The use of adhesives, gaskets, tape systems or combinations thereof to close openings in the surface of the ductwork and field-erected plenums and casings through which air leakage would occur; or
 2. The use of continuous welds;
 3. The prudent selection and application of sealing methods by fabricators and installers, giving due consideration to the designated pressure class, pressure mode (positive or negative), chemical compatibility of the closure system, potential movement of mating parts, workmanship, amount and type of handling; cleanliness of surfaces, product shelf life, curing time and manufacturer-identified exposure limitations;
 4. That these provisions are applicable to duct connections to equipment and to apparatus but are not for equipment and apparatus;

5. That where distinctions between seams and joints are made herein, a seam is defined as joining of two longitudinally (in the direction of air-flow) oriented edges of duct surface material occurring between two joints. Helical (spiral) lock seams are exempt from sealant requirements. All other duct surface connections made on the perimeter are deemed to be joints. Joints are inclusive of but not limited to girth joints; branch and sub-branch intersections; so-called duct collar tap-ins; fitting subsections; louver and air terminal connections to ducts; access door and access panel frames and jambs; duct, plenum and casing abutments to building structures; that sealing requirements herein do not contain provisions to:
 - a. Resist chemical attack.
 - b. Be dielectrically isolated.
 - c. Be waterproof, weatherproof or ultraviolet ray resistant.
 - d. Withstand temperatures higher than 120°F or lower than 40°F.
 - e. Contain atomic radiation or serve in other safety-related construction.
 - f. Be electrically grounded.
 - g. Maintain leakage integrity at pressures in excess of the duct classification herein.
 - h. Be underground below the water table.
 - i. Be submerged in liquid.
 - j. Withstand continuous vibration visible to the naked eye.
 - k. Be totally leak-free within an encapsulating vapor barrier.
 - l. Create closure in portions of the building structure used as ducts, e.g., ceiling plenums, shafts, pressurized compartments.
6. The requirements to seal apply to both positive pressure and negative pressure of operation.
7. Externally insulated ducts located outside of buildings shall be sealed prior to being insulated as though they were inside. If metal surfaces of ducts located on the exterior of buildings are exposed to weather, they shall receive exterior duct sealant. An exterior duct sealant is defined as a sealant that is marketed specifically as forming a positive air and water tight seal, bonding well to the metal involved, remaining flexible with metal movement and having a service temperature range of -30°F to 175°F. If exposed to direct sunlight it shall also be ultraviolet ray and ozone resistant or shall, after curing, be painted with a compatible coating that provides such resistance. The term sealant herein is not limited to materials of adhesive or mastic nature but is inclusive of tapes and combinations of open weave fabric strips and mastics.

C. Materials and applications for sealing ducts:

1. General:
 - a. Complete product data on all materials used for sealing ducts must be submitted for approval prior to any duct fabrication.
 - b. All sealants must be specifically recommended by their manufacturer for the purpose of sealing ducts.
2. Liquid Sealant:
 - a. Use only for slip type joints where sealant is to fill small space between overlapping pieces of metal. Do not use where metal clearances exceed 1/32-inch.
 - b. Sealant must be specifically manufactured for the purpose of sealing ducts.
3. Mastics:
 - a. Use in lieu of liquid sealant at Contractor's option.
 - b. Use as a fillet, in grooves and between flanges.

- c. Do not use oil base caulking or glazing compounds.
- 4. Gaskets:
 - a. Use soft elastomer butyl or neoprene rubber or extruded forms of sealants in flanged joints in addition to mastic.
- 5. Tape:
 - a. Tape is not allowed on sheet metal ducts.
- 6. Combination of mastic and embedded fabric:
 - a. Use mastic/mesh/mastic as a sealant where pressure/velocity classification equals and exceeds P/VC-3 and where any spaces between metal surfaces at transverse joints or longitudinal seams or duct wall penetrations exceeds 1/16-inch.
 - b. Apply glove coat of mastic, then embed a continuous or overlapping strip of not less than 4-inch wide 10 x 10 fiberglass cloth into the mastic, then apply a final glove coat of mastic over the glass cloth.
- 7. Surface preparation:
 - a. Surfaces to receive sealant should be adequately clean (free from oil, dust, dirt, rust, moisture, ice crystals and other substances that inhibit or prevent bonding). Use solvent and/or apply a face primer if necessary to obtain adequately clean surface for adhesion.

3.12 LEAKAGE TESTING

A. General:

- 1. Test the following duct systems:
 - a. All ducts which are (1) under positive or negative pressure and (2) which are directly connected to air moving device (air handling unit, exhaust fan, supply fan or similar air moving equipment) and (3) which convey 1000-cfm or greater through their largest portion.
 - b. All ducts which are (1) under positive or negative pressure and (2) which are part of a supply, return, outside and/or exhaust air system and (3) which are equal to or greater than 25 feet in length and (4) which may or may not be directly connected to an air moving device.
- 2. Portions of duct to be tested shall consist of all portions from the largest cross sectional area to the air distribution device connection or to the smallest inlet or outlet point, whichever is applicable.
- 3. Duct systems shall be constructed so that leakage does not exceed 5.00% of the air quantity handled by the respective fan.

B. Allowable Leakage:

- 1. Leakage shall be measured during leakage test at a test pressure which is equal to the pressure/velocity classification of the duct system (e.g., a P/VC-2 duct shall be tested at 2.0 in. w.g.s.p., a P/VC-1/2 duct at 0.5 in. w.g.s.p., etc.).

C. Test Procedure:

1. Test at time of duct installation and prior to installation of any field applied insulation and prior to any concealment in chases or similar enclosures.
2. Duct openings (both entry openings and outlet openings) shall be capped or sealed by taping or banding a flexible plastic sheet over each opening prior to pressurizing duct. The plastic sheet shall be of adequate strength and thickness to withstand the test pressures. Use other method of sealing duct openings providing objective of test is obtained and if method of sealing is approved by Architect/Engineer.
3. Use a fan having a minimum capacity of 300-cfm or 5% of the particular duct system design capacity, whichever is greater and which is capable of producing a duct test pressure of 150% of the duct test pressure.
4. Test fan shall be connected to a flow measuring assembly consisting of straightening vanes and an orifice plate mounted in a straight tube with appropriately located pressure taps. Orifice assembly shall be accurately calibrated with its own calibration curve. Pressures shall be measured with U-tube manometers and corresponding flow rates obtained from the orifice performance curve.
5. Connect test fan and orifice flow measuring assembly to the duct to be tested with a section of flexible duct.
6. Test for audible leaks as follows:
 - a. Close off and seal all openings in the duct section to be tested. Connect the test apparatus to the duct by means of a section of flexible duct.
 - b. Start the blower with its control damper closed (some small blowers popularly used for testing ducts may damage the duct because they can develop pressures up to 25 inches (W.G.).
 - c. Gradually open the inlet damper until the duct pressure reaches 50% in excess of designed duct operating pressure.
 - d. Survey all joints for audible leaks. Mark each leak and repair after shutting down blower. Do not apply a retest until sealing has been repaired if and where necessary.
7. After all audible leaks have been sealed, the leakage should be measured with the orifice section of the test apparatus as follows:
 - a. Start blower and open damper until pressure in duct reaches 25% in excess of designed duct operating pressure.
 - b. Total allowable leakage shall not exceed five (5) percent of the total system design air flow rate. When partial sections (such as supply section, return section, etc.) of the duct system are tested, the summation of the leakage for all sections shall not exceed the total allowable leakage.
8. Correct any duct leaks which are detected either audibly or by touch regardless of whether leakage through duct system is less than allowable test leakage.

3.13 DEFINITIONS OF DUCT TYPES

A. Refer to the "Duct Construction Schedule" on the Drawings for:

1. The type of ductwork and where it is to be installed.
2. The pressure/velocity class at each location.
3. Indication of whether the ductwork is to be insulated externally or internally lined or not insulated.

END OF SECTION 233100