

**SECTION 23 31 00
HVAC DUCTS**

PART 1 – GENERAL

1. DESCRIPTION

- A. Ductwork and accessories for HVAC including the following:
 - 1. Supply air, return air, outside air, exhaust, make-up air, and relief systems.
- B. Definitions:
 - 1. SMACNA Standards as used in this specification means the HVAC Duct Construction Standards, Metal and Flexible.
 - 2. Seal or Sealing: Use of liquid or mastic sealant, with or without compatible tape overlay, or gasketing of flanged joints, to keep air leakage at duct joints, seams and connections to an acceptable minimum.
 - 3. Duct Pressure Classification: SMACNA HVAC Duct Construction Standards, Metal and Flexible.
 - 4. Exposed Duct: Exposed to view in a finished room, exposed to weather.

2. QUALITY ASSURANCE

- A. Fire Safety Code: Comply with NFPA 90A.
- B. Duct System Construction and Installation: Referenced SMACNA Standards are the minimum acceptable quality.
- C. Duct Sealing, Air Leakage Criteria, and Air Leakage Tests: Ducts shall be sealed as per duct sealing requirements of SMACNA HVAC Air Duct Leakage Test Manual for duct pressure classes unless mechanical and energy code requirements stipulate a higher sealing classification.
- D. Duct accessories exposed to the air stream, such as dampers of all types (except smoke dampers) and access openings, shall be of the same material as the duct or provide at least the same level of corrosion resistance.

3. SUBMITTALS

- A. Submit in accordance with section requirements. Provided detailed shop drawings of duct system coordinated with building structure and other trades. No work on the duct systems shall commence until duct system shop drawings have been submitted to Project Engineer for review. Any work completed prior to duct system shop drawing review shall be at the risk of the contractor and shall be subject to modification or removal as required by the Project Architect or Engineer.
- B. Manufacturer's Literature and Data:
 - 1. Rectangular ducts:
 - a. Schedules of duct systems, materials and selected SMACNA construction alternatives for joints, sealing, gage and reinforcement.
 - b. Duct liner.
 - c. Sealants and gaskets.
 - d. Access doors.

2. Round and flat oval duct construction details:
 - a. Manufacturer's details for duct fittings.
 - b. Duct liner.
 - c. Sealants and gaskets.
 - d. Access sections.
 - e. Installation instructions.
3. Volume dampers, back draft dampers.
4. Upper hanger attachments and duct support systems.
5. Fire dampers, fire doors, and smoke dampers with installation instructions.
6. Sound attenuators, including pressure drop and acoustic performance.
7. Flexible ducts and clamps, with manufacturer's installation instructions.
8. Flexible connections.
9. Instrument test fittings.
10. Details and design analysis of alternate or optional duct systems.

PART 2 - PRODUCTS

1. DUCT MATERIALS AND SEALANTS

- A. General: Except for systems specified otherwise, construct ducts, casings, and accessories of galvanized sheet steel, ASTM A653, G90 galvanizing. Duct sheet metal thickness shall be in accordance with the SMACNA Duct Construction Manual.
- B. Joint Sealing: Refer to SMACNA HVAC Duct Construction Standards for recommended seal class. If project codes enforce a higher degree of seal classification to meet mechanical and energy code requirements, then all HVAC ductwork shall be sealed to Class A. Wet, grease and special exhaust will have separate sealing requirements.
 1. Sealant: Elastomeric compound, gun or brush grade, maximum 25 flame spread and 50 smoke developed (dry state) compounded specifically for sealing ductwork as recommended by the manufacturer.
 2. Gaskets in Flanged Joints: Soft neoprene. Approved factory made joints may be used.
- C. Other Duct Materials:
 1. Grease Duct: Liquid tight, stainless steel grease duct system fabricated and installed in accordance with NFPA 96 and the relevant mechanical codes. All grease duct shall be either wrapped with Fire-Wrap or shall be constructed to allow for zero clearance to combustible materials. Grease duct may also be a factory built, stainless steel double wall system as manufactured by Metal-Fab. Pre-fabricated system shall be UL labeled and comply with NFPA 96. Installation and accessories shall comply with the manufacturers catalog data. Square and rectangular duct shown on the drawings will have to be converted to equivalent round size for a pre-fabricated system. Contractor shall confirm that there is sufficient clearance should a factory pre-fabricated system be chosen.

2. DUCT CONSTRUCTION AND INSTALLATION

- A. Duct installation methods, supports and other pertinent installation criteria shall be as indicated in the SMACNA Duct Construction Standards and SMACNA Duct Installation manuals.
- B. Seal Class: All ductwork shall be sealed to Seal Class A.

- C. Wet Air Exhaust Ducts and Accessories: Ducts for dishwashers and wet hoods shall be 18 gage stainless steel made liquid tight with continuous external weld for all seams and joints. Provide neoprene gaskets at flanged connections. Where ducts are not self draining back to the equipment, provide low point drain pocket with copper drain pipe to sanitary sewer. Provide access door in side of duct at drain pockets.
- D. Ducts for shower spaces or saunas shall be continuously welded 16 gage aluminum sloped to drain.
- E. Kitchen and Grill Hood (Ventilator) Exhaust Ducts: Comply with NFPA 96.
 - 1. Material: 18 gage stainless steel. Provide Fire-Wrap or a factory pre-insulated system to allow for zero clearance.
 - 2. Construction: Liquid tight with continuous external weld for all seams and joints. Where ducts are not self draining back to the equipment, provide low point drain pocket with copper drain pipe to sanitary sewer. Provide access doors or panels for duct cleaning inside of horizontal duct at drain pockets, at 20 feet intervals, and at each change of direction or as required by NFPA 96 or the mechanical code. The more stringent requirement shall apply.
 - 3. Access Doors or panels shall be of the same material and thickness of the duct with gaskets and sealants that are rated 1500 degrees F and shall be grease-tight.
- F. Round and Flat Oval Ducts: Furnish duct and fittings made by the same manufacturer to insure good fit of slip joints. When submitted and approved in advance, round and flat oval duct, with size converted on the basis of equal pressure drop, may be furnished in lieu of rectangular duct design shown on the drawings.
 - 1. Elbows: Diameters 3 through 8 inches shall be two sections die stamped, all others shall be gored construction, maximum 18 degree angle, with all seams continuously welded or standing seam. Coat galvanized areas of fittings damaged by welding with corrosion resistant aluminum paint or galvanized repair compound.
 - 2. Provide bell mouth, conical tees or taps, laterals, reducers, and other low loss fittings as shown in SMACNA HVAC Duct Construction Standards.
 - 3. Casings and Plenums: Construct in accordance with SMACNA HVAC Duct Construction Standards Access doors shall be hollow metal, insulated, with latches and door pulls. Provide drain for outside air louver plenum. Outside air plenum shall have exterior insulation. Drain piping shall be routed to the nearest floor drain or to exterior of building.
- G. Rigid Fiberglass Duct Board (only used as approved by Project Engineer): ANSI/ASTM C612; commercial grade; 6.0 installed 'R' value (minimum) at 75 degrees F, foil scrim kraft facing for air conditioning ducts (nominally 1.5" thick). Not to be used in exposed locations. All seams shall be sealed air and vapor tight with pressure sensitive tape and mastic. Duct board shall be equal to Certainteed, Certapro Commercial Board with FSK facing, type CB 300 (3.0 lb/cu.ft.) minimum density. Vapor barrier shall be integral and continuous across seams. All fiberglass duct board shall be installed in accordance with NAIMA Standards.
- H. Volume Dampers: Single blade or opposed blade, multi-louver type as detailed in SMACNA Standards. Any dampers required to have a motorized damper shall be provided by the mechanical contractor as a complete system including the damper, actuator and linkage attachments. Actuators shall be as provided by Belimo. It shall be the responsibility of this contractor to provide all dampers and actuators as required and these systems shall be

coordinated with the controls contractor and electrical contractor accordingly for power or control requirements.

- I. Exposed Interior Ducting: Exposed Round Supply Trunks, Branch Ducts, and Fittings:
 - 1. Round, Double Wall Ducts (Supply): Galvanized steel meeting ASTM A653 standards with paint-grip finish, one inch (1") thick fiberglass insulation, spiral outer shell and perforated inner liner. A UL approved mylar film and taped joints shall separate the internal fiberglass lining and airstream. Duct systems shall be factory pre-fabricated. Ducts shall have spiral lockseam construction. Fittings shall be constructed of a perforated sheet metal internal liner, 1 inch layer of fiberglass insulation, mylar film and an outer galvanized pressure shell with paint-grip finish. Standing seam joints shall be used wherever possible on fittings. All standing seam joints shall be sealed with a UL Classified zero flame spread and zero smoke developed cement specially formulated for bonding metal-to-metal joints. All welded joints shall be coated with a protective paint, inside and out, to prevent damage to the galvanized surface. All double wall duct and fittings shall be provided with both an inner liner coupling and an outer pressure shell coupling. Outer shell connections can be by slip joint (up to 24" diameter) or bolted flanged joint with air seal gasket.
- J. Exterior Ducts or Ducts Exposed to Weather: Duct systems exposed to weather shall be a G-120 galvanized system with 2" rigid duct board insulation and an aluminum jacket. All insulation seams shall be taped with a fiberglass mesh material and shall receive two coats of mastic. Fiberglass mesh tape shall be applied into the first coat of mastic while mastic is still wet. Second coat shall be applied once first coat is completely cured. Aluminum jacketing shall be continuous with seams only occurring on the bottom portion of the duct system. The top of the aluminum jacket shall be tented to ensure the ponding of water is not possible on the top of the duct system. Aluminum jacket shall be sealed on the bottom of the duct system with duct mastic and shall be secured through the use of sheet metal screws or rivets of similar material.
- K. FLEXIBLE DUCTS:
 - 1. VAV Box Inlet Connection Ductwork:
 - a. The duct shall be made from dead soft aluminum sheet, spiral wound into a tube and spiral corrugated. The duct shall be fabricated with a triple mechanical lock to form a continuous secure air tight joint. No adhesives may be used in the manufacture. Insulation system shall match primary supply duct insulation system. The duct shall conform to NFPA and shall be UL Listed as Class I Air Duct.
 - b. Maximum length of duct shall be 4'-0" on VAV box inlet connections.
 - c. Install with maximum bend radius of 1-1/2 diameters.
 - d. Comply with manufacturer's requirements for minimum straight inlet duct length during installation.
 - 2. Air Device Connection Ducts:
 - a. Flexible fiberglass duct with a maximum thermal conductivity of 0.24 BTU/HR - degrees F - Sq.Ft. at 75 degrees F mean temperature with a maximum flame spread rating of 25 and smoke developed rating of 50. Thickness shall be as required to meet the same insulation level as the main duct system or as required by the prevailing energy code. The duct shall conform to NFPA Standards and be listed by Underwriters Laboratories as 181 Class I Air Duct.
 - b. On all branch duct connections to air devices, flexible fiberglass duct shall be provided with bellmouth fitting with integral volume damper and stainless steel hose clamp.

Insulation shall be continuous and shall be securely connected to main duct insulation through the use of pressure sensitive tape and mastic.

- c. Flexible fiberglass duct size shall be same as air device neck size unless otherwise noted.
- d. Flexible fiberglass duct length shall be a maximum of 10 feet and a minimum of 6 feet.

L. FABRIC AIR DISPERSION SYSTEM

1. Fabric duct system shall be constructed of fabric specifically design and manufactured for air distribution systems. The fabric is a woven fire retardant and permeable fabric complying with the following characteristics:
 - a. Fabric: 100% Flame Retardant Polyester treated with an antimicrobial agent from manufacturer.
 - b. Weight: 8.5 oz./yd² per ASTM D3776
 - c. Shrinkage: Max. 0,5% per DIN EN 26 630
 - d. Color: As specified by the architect.
 - e. Temperature Range: -40°F to +284°F
 - f. Permeability: 2 (+/- 5%) per ASTM D737, Frazier – calendering of fabric NOT accepted
 - g. Fire Retardancy: Must meet the requirements in NFPA 90-A, ICC AC-167 and UL2518
 - h. Duct shall be designed from 0.25" to 3" as the maximum with a design temperature between -40°F and 284°F
2. Systems fabrication requirements:
 - a. The system is made with sewn in, but still removable, aluminum hoops. The rods support the shape of the fabric system by 180°. Hoops must be pre-installed from factory, no installation at site. Diameter of hoops and distance between as specified by manufacturer.
 - b. Elbows of 70° or more to have 2 hoops sewn in order to maintain shape.
 - c. Air dispersion accomplished by using conical aerodynamic nozzles. Diameter of nozzles to be ¾" – height to be minimum ½". Nozzles are to be used unless otherwise noted.
 - d. Color of nozzles must match color of fabric. Unless otherwise specifically mentioned on drawings or otherwise in this specification suppliers standard table is used for selection of color.
 - e. Location and number of nozzles to be specified and approved by manufacturer
 - f. The system is made of permeable fabric. Permeability of fabric must be reached based on weave construction only and weave must have gone through thermo fixation in order to secure same permeability after wash. Fabric with permeability obtained based on calendering is not accepted.
 - g. Provide system in sections optimized for maintenance, connected by zippers. Zippers must provide closure completely around the circumference to prevent leakage. Required number of zippers as specified by manufacturer.
 - h. Each section to have a unique tag including information about: manufacturers order number, position, diameter of section, length of section, maintenance instruction, code compliance and contact details for spare parts.
 - i. Fabric system shall include connectors to attach to suspension system listed below.
3. HANGERS AND SUPPORT
 - a. One row cable system located 2.0" above 12 o'clock of duct, attached to hardware using one single row of plastic hooks located 12 o'clock spaced 20 inches. Hardware to include cable, cable clamps, turnbuckles, and tie down straps as required. Use Stainless Steel Cable – all other components shall be Stainless Steel.

M. DUCT ACCESS DOORS, PANELS AND SECTIONS

1. Provide access doors (as well as associated ceiling access panels – refer to Architectural specifications), sized and located for maintenance work, upstream, in the following locations:
 - a. Each duct mounted coil and humidifier.
 - b. Each fire damper (for link service), smoke damper and automatic control damper.
 - c. Each duct mounted smoke detector.
 - d. As otherwise required by prevailing codes or applicable standards (ASHRAE, NFPA, etc.).
2. Openings shall be as large as feasible in small ducts, 12 inch by 12 inch minimum where possible. Access sections in insulated ducts shall be double-wall, insulated.
3. For all duct types, refer to SMACNA HVAC Duct Construction Standards for additional requirements.

N. FIRE DAMPERS

1. Galvanized steel, interlocking blade type, UL listing and label, 1-1/2 hour rating, 160 degrees F fusible link, 100 percent free opening with no part of the blade stack or damper frame in the air stream. All fire dampers shall be dynamically rated.
2. Fire dampers in wet air exhaust shall be of stainless steel construction, all others may be galvanized steel.
3. The damper frame may be of design and length as to function as the mounting sleeve, thus eliminating the need for a separate sleeve, as allowed by UL 555. Otherwise provide sleeves and mounting angles, minimum 14 gage, required to provide installation equivalent to the damper manufacturer's UL test installation. Submit manufacturer's installation instructions conforming to UL rating test. Damper size to match duct size.

O. SMOKE DAMPERS

1. Maximum air velocity, through free area of open damper, and pressure loss: Low pressure and medium pressure duct (supply, return, exhaust, outside air): 1500 fpm. Maximum static pressure loss: 0.13 inch W.G.
2. Maximum air leakage, closed damper: Leakage Class I
3. Shall comply with requirements of UL 555S.
4. Frame: Galvanized steel channel with side, top and bottom stops or seals.
5. Blades: Galvanized steel, parallel type preferably, 12 inch maximum width, edges sealed with neoprene, rubber or felt, if required to meet minimum leakage. Airfoil (streamlined) type for minimum noise generation and pressure drop are preferred for duct mounted dampers.
6. Shafts: Galvanized steel.
7. Bearings: Nylon, bronze sleeve or ball type.
8. Hardware: Zinc plated.
9. Operation: Automatic open/close. No smoke damper that requires manual reset or link replacement after actuation is acceptable. Coordinate operation of dampers with controls and fire alarm contractor.
10. Motor operator (actuator): Provide electric as required by the automatic control system, externally mounted on stand-offs to allow complete insulation coverage. Actuators shall be provided with dampers. This contractor shall be responsible for coordination of all power requirements with the project electrical contractor and for coordination of control requirements with both the controls and fire alarm contractors.
11. Dampers shall be dynamically rated. Damper size to match duct size.

12. Detector: Provide damper manufacturer's duct-mounted smoke detector unless an area smoke detection system is provided. Coordinate with electrical contractor.

P. COMBINATION FIRE AND SMOKE DAMPERS

1. Combination fire and smoke dampers: Multi-blade type units meeting all requirements of both fire dampers and smoke dampers shall be used where shown and may be used at the Contractor's option where applicable.
2. Dampers shall be dynamically rated. Damper size to match duct size.

Q. SOUND ATTENUATING UNITS (PROVIDE AS INDICATED ON DRAWINGS)

1. Casing, not less than 20 gage galvanized sheet steel, or 18 gage aluminum fitted with suitable flanges to make clean airtight connections to ductwork. Sound-absorbent material faced with glass fiber cloth and covered with not less than 24 gage or heavier galvanized perforated sheet steel, or 22 gage or heavier perforated aluminum. Perforations shall not exceed 5/32-inch diameter, approximately 25 percent free area. Sound absorbent material shall be long glass fiber acoustic blanket meeting requirements of NFPA 90A.
2. Entire unit shall be completely air tight and free of vibration and buckling at internal static pressures up to 8 inches W.G. at operating velocities.
3. Submit complete independent laboratory test data showing pressure drop and acoustical performance.
4. Cap open ends of attenuators at factory with plastic, heavy duty paper, cardboard, or other appropriate material to prevent entrance of dirt, water, or any other foreign matter to inside of attenuator. Caps shall not be removed until attenuator is installed in duct system.

R. PREFABRICATED ROOF CURBS (IF NOT PROVIDED BY EQUIPMENT MANUFACTURER)

1. Galvanized steel or extruded aluminum 14 inches above finish roof service, continuous welded corner seams, treated wood nailer (1-1/2 inch thick), 3 pound/cubic feet density rigid mineral fiberboard insulation with metal liner, built-in cant strip (except for gypsum or tectum decks). For surface insulated roof deck, provide raised cant strip (recessed mounting flange) to start at the upper surface of the insulation. Curbs shall be constructed for pitched roof or ridge mounting as required to keep top of curb level.

S. TURNING VANES

1. Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
2. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.
3. Manufactured Turning Vanes for Nonmetal Ducts: Fabricate curved blades of resin-bonded fiberglass with acrylic polymer coating; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting
4. Vanes shall be single wall for ducts up to 48 inches wide. Ducts shall be double wall for larger dimensions. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 4-3, "Vanes and Vane Runners," and 4-4, "Vane Support in Elbows".

T. FLEXIBLE CONNECTORS

1. Indoor System, Flexible Connector Fabric: Provide glass fabric double coated with neoprene. Fabric shall be 26 oz/square yard minimum weight, 480 lbf/inch in the warp tensile strength, 360 lbf/inch in filling tensile strength and shall have a service temperature of minus 40 to plus 200 degrees F.

2. Outdoor system, Flexible Connector Fabric: Provide glass fabric double coated with weatherproof, synthetic rubber resistant to UV Rays and ozone. Fabric shall be 24 oz/square yard minimum weight, 530 lbf/inch in the warp tensile strength, 440 lbf/inch in filling tensile strength and shall have a service temperature of minus 50 to plus 220 degrees F.
3. Materials to be flame-retardant and noncombustible fabrics.
4. Coatings to comply with UL 181, Class 1.
5. Metal Edge connectors to be factory fabricated with 3-1/2-inch-wide fabric strip attached to 2 strips of 2-3/4-inch wide, 0.028 inch thick, galvanized sheet steel or 0.032-inch thick aluminum sheets. Provide metal compatible with connected ducts.
6. Thrust limits: Provide combination coil spring and elastomeric insert with spring and insert in compression, and with a load stop. Include rod and angle-iron brackets for attaching to fan discharge and duct.
 - a. Frame: Steel, fabricated for connection to threaded rods and to allow for a maximum of 30 degrees of angular rod misalignment without binding or reducing isolation efficiency.
 - b. Outdoor Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 - c. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 - d. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 - e. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 - f. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
 - g. Coil Spring: Factory set and field adjustable for a maximum of 1/4-inch movement at start and stop.

PART 3 – EXECUTION

A. INSTALLATION

1. Fabricate and install ductwork and accessories in accordance with referenced SMACNA Standards.
2. Drawings show the general layout of ductwork and accessories but do not show all required fittings and offsets that may be necessary to connect ducts to equipment, boxes, diffusers, grilles, etc., and to coordinate with other trades. Fabricate ductwork based on field measurements. Provide all necessary fittings and offsets at no additional cost to the project. Coordinate with other trades for space available and relative location of HVAC equipment and accessories in ceiling plenum and in ceiling grid. Duct sizes on the drawings are clear, inside dimensions which shall be altered by Contractor to other dimensions with the same air handling characteristics where necessary to avoid interferences and clearance difficulties.
3. Provide duct transitions, offsets and connections to dampers, coils, and other equipment in accordance with SMACNA Standards. Repair galvanized areas with galvanizing repair compound if duct is damaged during construction.
4. Provide bolted construction and tie-rod reinforcement in accordance with SMACNA Standards.
5. Construct casings, eliminators, and pipe penetrations in accordance with SMACNA Standards, Chapter 6. Design casing access doors to swing against air pressure so that pressure helps to maintain a tight seal.
6. Install duct hangers and supports in accordance with SMACNA Standards.

7. Install fire dampers, smoke dampers and combination fire/smoke dampers in accordance with the manufacturer's instructions to conform to the installation used for the rating test. Install fire dampers, smoke dampers and combination fire/smoke dampers at locations indicated and where ducts penetrate fire rated and/or smoke rated walls, shafts and where required by the prevailing codes or standards. Install with required perimeter mounting angles, sleeves, breakaway duct connections, corrosion resistant springs, bearings, bushings and hinges per UL and NFPA. Demonstrate re-setting of fire dampers and operation of smoke dampers as required.
8. Seal openings around duct penetrations of floors and fire rated partitions with fire stop material as required by NFPA 90A.
9. Flexible duct installation: Refer to SMACNA Standards. Ducts shall be continuous, single pieces not over 5 feet long (commercial areas) or 15 feet (residential), as straight and short as feasible, adequately supported. Centerline radius of bends shall be not less than two duct diameters. Install without kinks, sharp bends, compressions, nor excessive coiled flexible ductwork. Make connections with clamps as recommended by SMACNA. Clamp per SMACNA with one clamp on the core duct and one on the insulation jacket. Flexible ducts shall not penetrate floors, or any chase or partition designated as a fire or smoke barrier, including corridor partitions fire rated one hour or two hour. Support ducts SMACNA Standards.
10. Where diffusers, registers and grilles cannot be installed to avoid seeing inside the duct, paint the inside of the duct with flat black paint to reduce visibility.
11. Control Damper Installation: Provide necessary blank-off plates required to install dampers that are smaller than duct size. Provide necessary transitions required to install dampers larger than duct size. Assemble multiple sections dampers with required interconnecting linkage and extend required number of shafts through duct for external mounting of damper motors. Provide necessary sheet metal baffle plates to eliminate stratification and provide air volumes specified. Locate baffles by experimentation, and affix and seal permanently in place, only after stratification problem has been eliminated. Install all damper control/adjustment devices on stand-offs to allow complete coverage of insulation.
12. Protection and Cleaning: Adequately protect equipment and materials against physical damage. Place equipment in first class operating condition, or return to source of supply for repair or replacement, as required. Protect equipment and ducts during construction against entry of foreign matter to the inside and clean both inside and outside before operation and painting. When new ducts are connected to existing ductwork, clean both new and existing ductwork by mopping and vacuum cleaning inside and outside before operation.

B. DUCT LEAKAGE TESTS AND REPAIR

1. Ductwork leakage testing shall be performed by the Testing and Balancing Contractor directly contracted by the General Contractor and independent of the Sheet Metal Contractor.
2. Ductwork leakage testing shall be performed for the entire air distribution system (including all supply, return, exhaust and relief ductwork), section by section, including fans, coils and filter sections. Based upon satisfactory initial duct leakage test results, the scope of the testing may be reduced by the Project Engineer on ductwork constructed up to the 2" WG duct pressure classification. In no case shall the leakage testing of ductwork constructed above the 2" WG duct pressure classification or ductwork located in shafts or other inaccessible areas be eliminated.
3. Test procedure, apparatus and report shall conform to SMACNA Leakage Test manual. The maximum leakage rate allowed is 4 percent of the design air flow rate.

4. All ductwork shall be leak tested first before enclosed in a shaft or covered in other inaccessible areas.
5. All tests shall be performed in the presence of the Mechanical Contractor, the Commissioning Agent and the Test and Balance agency. The Test and Balance agency shall measure and record duct leakage and report to the Project Engineer and identify leakage source with excessive leakage.
6. If any portion of the duct system tested fails to meet the permissible leakage level, the Contractor shall rectify sealing of ductwork to bring it into compliance and shall retest it until acceptable leakage is demonstrated to the Project Engineer and Commissioning Agent.
7. All tests and necessary repairs shall be completed prior to insulation or concealment of ductwork.
8. Make sure all openings used for testing flow and temperatures by TAB Contractor are sealed properly.
9. Duct leakage testing shall be performed in accordance with LEED requirements on projects seeking LEED certification.

C. DUCTWORK EXPOSED TO WIND VELOCITY

1. Provide additional support and bracing to all exposed ductwork installed on the roof or outside the building to withstand the design wind velocity in accordance with the prevailing codes in effect at the time of permitting. This requirement shall include both attachment of the ducts to the supporting structure as well as the attachment of the duct support structure to the roof structure or other supporting mechanism.

END OF SECTION 23 31 00