SECTION 23 31 13

DUCKWORK

PART 1 - DUCTWORK DESIGN DIRECTIVES

1.1 CODES AND QUALIFICATIONS

- A. Firms regularly engaged in manufacture of metal ductwork, products and accessories of types, materials, and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Comply with SMACNA "HVAC Duct Construction Standards, Metal and Flexible, Latest Edition" for fabrication and installation of metal ductwork. Comply with SMACNA "HVAC Air Duct Leakage Test Manual" for sealing requirements of metal ductwork.
- C. Comply with NFPA 90A "Standard for the Installation of Air Conditioning and Ventilating Systems", NFPA 90B "Standard for the Installation of Warm Air Heating and Air Conditioning Systems", NFPA 96 "Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations", and NFPA 80 "Installation of Fire Smoke Dampers".
- D. Construct, test, and label fire dampers in accordance with UL Standard 555 and 555S, "Fire Dampers and Ceiling Dampers", latest edition.
- E. Comply with the State of New Hampshire currently enforced edition of the International Mechanical Code for fabrication of metal ductwork.
- F. Work shall meet following standards, as applicable, unless otherwise specified:
 - 1. SMACNA HVAC Duct Construction Standards, Metal and Flexible, fourth edition (2020), hereinafter referred to as SMACNA DCS
 - 2. SMACNA Fire, Smoke, and Radiation Damper Installation Guide, except as required for UL Approval
 - 3. SMACNA Duct Liner Application Standard
 - 4. SMACNA Thermoplastic Duct Construction Manual
- G. Test and rate louvers in accordance with AMCA 500, "Test Method for Louvers, Dampers and Shutters"

1.2 SUBMITTALS

- A. Submit Duct Fabrication and Installation Standards Manual indicating gauges, reinforcing, and similar information for ductwork, fittings, accessories, etc., for the required sizes and static pressure classes to fully demonstrate compliance with SMACNA "HVAC Duct Construction Standards, Metal and Flexible, Latest Edition)". The Manual shall be shop specific and submitted for review well in advance of sheet metal installation.
- B. Submit Duct Testing Procedures including air leakage parameters, SMACNA square footage method or % of total air flow method. Include list of ducts to be tested and allowable leakage for each segment of duct to be tested detailed in a "Duct Leakage Summary Sheet" showing the

normal operating pressure of the duct system and the pressure under which the system shall be tested for leakage.

- C. Shop Drawings: CAD-generated and drawing to Scale 3/8"=1'-0" showing fabrication, assembly, and installation details for metal ducts, including but not limited to elevations, sections, attachment to other work, pressure classes, reinforcement, spacing, seam and joint construction, duct accessories, hangers and supports, duct and building attachment, vibration isolation and seismic restraints.
- D. Exhaust Stacks for Laboratories Air re-entrainment study design calculations by professional engineering, date signed and sealed where applicable.

1.3 DELIVERY, STORAGE, AND HANDLING

A. Store ductwork and accessories inside, above grade, and enclose with waterproof wrapping.

1.4 DESIGN CRITERIA

- A. Low static pressure classifications shall be constructed to minimum 2" water gauge.
- B. Medium static pressure classifications shall be constructed to minimum 4" water gauge.
- C. Seal all sheet metal ducts, regardless of pressure class, to SMACNA Seal Class 'A'.
- D. Ceiling registers shall be designed for one-, two-, three-, or four-way blow to suit room conditions. The design documents shall indicate the flow directions.
- E. The design documents shall indicate the clear inside dimensions of lined or double wall ducts.
- F. The designer shall determine the type of sealant required for the project and include it in the specifications.
- G. For 'KITCHEN EXHAUST SYSTEMS', refer to DC Standard 23 0500 Basic Mechanical Requirements for the requirements to determine the appropriate system for the project.
- H. With respect to rectangular ductwork, the ratio of duct height to duct width shall not exceed 2:1. In extraordinary conditions, this ratio may be extended to 2.5:1.
- I. Dartmouth College requires duct leakage testing to be performed. All concealed ductwork is to be tested. All ductwork up to terminal boxes is to be tested.
- J. The designer shall determine if the ductwork is to be painted and if so, amend the specifications to include a finish on the sheet metal that will accept field painting.
- K. This standard assumes standard galvanized duct for air distribution systems. The designer is required to ascertain the suitability of this product for extraordinary applications, such as fume hoods, swimming pool ventilation, etc
- L. Two types of control dampers are specified. For applications where dampers are exposed to outside air, and are normally closed 75% of the time or have a life safety requirement of not freezing in a position, use the insulated damper. For all other dampers use the non-insulated damper.
- M. All main electric rooms that are ventilated shall have filtered (30% efficiency) air.

N. All return air shall be ducted, plenum return is not acceptable.

PART 2 - PRODUCTS

2.1 DUCTWORK MATERIALS

A. Galvanized sheet metal shall comply with ASTM A 924, lock forming quality, with G60 zinc coating for interior, dry duct and G90 zinc coating for exterior ducts and any ductwork susceptible to moisture, in accordance with ASTM A 653.

2.2 RECTANGULAR DUCT FABRICATION

- A. Except as otherwise indicated, fabricate rectangular ducts with galvanized sheet steel, in accordance with SMACNA "HVAC Duct Construction Standards, Fourth Edition (2020)", including associated details. Conform to the requirements in the referenced standard for metal thickness, reinforcing types and intervals, tie rod applications, and joint types and intervals. Minimum duct gauge is 26.
- B. Cross break or bead duct sides that are 11" and larger and are 20 gauge or less, with more than 4 sq. ft. of unbraced panel area, as indicated in SMACNA "HVAC Duct Construction Standard, Fourth Edition (2020)" Figure 2-10, regardless if insulated.
- C. Fabricate elbows, transitions, offsets, branch connections, and other duct construction in accordance with SMACNA "HVAC Metal Duct Construction Standard, Fourth Edition (2020)", Figures 4-1 through 4-9, with the following modifications:
 - 1. Figure 4-2 Rectangular Elbows
 - a. Type RE1 Square throat is not permitted.
 - b. Types RE4, 6, 7, 8, 9, & 10 are not permitted.
 - 2. Figure 4-3 Vanes and Vane Runners
 - a. Use single thickness vanes with 4-1/2'' minimum trailing ends, SP=1-1/2''.
 - 3. Figure 4-7 Offsets and Transitions
 - a. Offset types 1& 2 are not allowed.
 - b. Minimum bell mouth radius shall be 1-1/2".
 - 4. Figure 4-8 Obstructions
 - a. Figures A & C are not allowed.
- D. Fabricate duct fittings to match adjoining ducts, and to comply with duct requirements as applicable to fittings. Limit angular tapers to 30° for contracting tapers and 20° for expanding tapers.
- E. Button punch snap lock (figure 2-2 Rectangular Duct / Longitudinal Seams, type L-2) and internal standing seam joints (figure 2-8) are not allowed.

2.3 ROUND AND FLAT OVAL DUCT AND FITTINGS FABRICATION

- A. General Fabrication Requirements: Fabricate round ducts with galvanized sheet steel, in accordance with SMACNA "HVAC Duct Construction Standards, Latest Edition ()" Chapter 3, "Round, Oval and Flexible Duct" based on indicated static-pressure class unless otherwise indicated. Tables 3-1 through 3-3 and figures 3-1 through 3-5. Conform to the requirements in the referenced standard for metal thickness and joint types. Modify the above tables and figures as follows:
 - 1. Table 3-1 Mitered Elbows
 - a. All elbows, regardless of duct velocity, shall be 1.5" radius to duct diameter.
 - 2. Figure 3-2 Round Duct Longitudinal Seams
 - a. Seam types RL-3, 6A, 6B, 7, and 8 are not allowed.
 - 3. Figure 3-4 Round Duct Elbows
 - a. Adjustable elbows are not allowed.
 - 4. Figure $3-5 90^{\circ}$ Tees and Laterals
 - a. Non-lateral taps may be used only where spatial conditions do not allow lateral taps.
 - b. Straight tap is not allowed.
 - 5. Figure 3-6 Conical Tees
 - a. Replace the transition length formula listed (L2=A-B) with the following: Limit angular tapers to 30° for contracting tapers and 20° for expanding tapers.
- B. Fittings shall be one gauge heavier than the duct size requirement, 22 gauge minimum.

2.4 SEALANT MATERIALS

- A. LEED Requirements:
 - 1. For field applications that are inside the weatherproofing system, use adhesives and sealants with VOC content limits lower than referenced in Division 1, Sustainable Design Requirements LEED latest version.
 - 2. Methylene chloride and perchloroethylene may not be intentionally added to adhesives.
 - 3. Do not use adhesives that contain urea formaldehyde.
- B. Seal all sheet metal duct regardless of pressure class to SMACNA Seal Class "A".
- C. Joint and Seam Sealants, General: The term "sealant" is not limited to materials of adhesive or mastic nature but includes tapes and combinations of open-weave fabric strips and mastics.
- D. Water-Based Joint and Seam Sealant: Flexible, adhesive sealant, resistant to UV light when cured, UL 723 listed and complying with NFPA requirements for Class 1 ducts. United McGill United Duct Sealer; Hardcast Flex Grip; or equal
- E. Flanged Joint Mastic: One-part, acid-curing, silicone, elastomeric joint sealant complying with ASTM 920, Type S, Grade NS, Class 25, Use O.

F. Flanged Gaskets: Butyl rubber or EPDM polymer with polyisobutylene plasticizer.

2.5 HANGERS AND SUPPORTS

- A. Except as otherwise indicated, fabricate hangers and supports in accordance with SMACNA "HVAC Duct Construction Standards, Fourth Edition (2020)"Chapter Five. Modify the above chapter as follows:
 - 1. Powder actuated fasteners are not allowed.
 - 2. Wire is not allowed to be used as a hanger support.

2.6 DOUBLE WALL DUCTWORK

- A. Construct double wall ductwork with a solid outer skin, gauge and reinforcement shall be as previously specified for single wall ductwork. Insulation shall be 1" thick duct liner. Inner skin shall be 26 gauge perforated galvanized steel.
- B. All Outside Air intakes shall be provided with inside double wall solid liner in ductwork to avoid moisture into the insulation.
- C. All other double wall ductwork shall be wall perforated insulated liner.

2.7 DUCT AND PLENUM ACCESS DOORS

- A. Doors shall be hinged, gasketed and installed so that doors and frames are airtight. Removable panels are NOT acceptable.
- B. Doors in insulated ducts shall be insulated and shall have extended frames to serve as insulation stops.
- C. Doors shall have rotary cam locks in sufficient number to ensure tight closure without distorting door or duct.
- D. Door may be either field fabricated or factory fabricated product of Ruskin, Buckley, Buensod-Stacey, Dowco Louvers & Dampers, Koppers, United Sheet Metal, Industrial Acoustics or Ventlok.
- E. Doors in prefabricated round or flat oval ducts shall be duct manufacturer's standard that complies to this section.
- F. In ductwork, door height shall be approximately equal to duct height but no higher than 24". Construct duct access doors per the requirements of SMACNA HVAC Duct Construction Standards, Provide insulated doors for insulated ductwork. Provide one side hinged, other side with locking devices per the SMACNA Schedule.

Access Door Schedule					
duct size (exposed width)	door size				
<20"	2" less than duct size x 16"				
>20"	18" x 18"				

G. In Plenums, casings and large ducts that can be entered by personnel: Doors shall open against pressure wherever possible and shall be operable from both sides. Door size shall be between 18"x20" and 24"x48".

- H. Access doors to equipment plenums shall have observation ports of safety glass or plexiglass, 10"x10"size, located near eye level.
- I. Access door hardware shall be piano hinge and double cam lock.

2.8 DAMPERS

- A. Provide Low-Leakage, Steel, Manual Volume Dampers of single blade type or multi blade type, constructed in accordance with SMACNA "HVAC Duct Construction Standards", Figures 7-4 Volume Dampers Single Blade Type, and 7-5 Multiblade Volume Dampers, amended as follows:
 - 1. Figures 7-4 Volume Dampers Single Blade Type, Figure A is not allowed, use only figure B regardless of duct size.
 - 2. Provide end bearings for all systems requiring Seal Class A regardless of pressure class.
- B. Provide galvanized steel control dampers with parallel blades for two position control, opposed blades for modulating control. Provide counterbalanced relief dampers with parallel blades, counterbalanced and factory set to relieve at indicated static pressure.
- C. Comply with AMCA 500-D testing for damper rating.
- D. Low-leakage rating, with linkage outside airstream, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.
- E. Suitable for horizontal and vertical applications.
- F. Provide for each manually controlled damper, quadrant lock device on one end of shaft, and end bearing plate on other end. Provide extended quadrant locks and extended end bearing plates for externally insulated ductwork.
- G. Subject to compliance with requirements, provide dampers of one of the following:
 - 1. Air Balance, Inc.
 - 2. Greenheck Fan Corporation
 - 3. American Warming & Ventilating, Inc.
 - 4. Arrow Louver and Damper; Div. of Arrow United Industries, Inc.
 - 5. Louvers & Dampers, Inc.
 - 6. Ruskin Mfg. Co.
 - 7. Vent Products Co., Inc
 - 8. Tamco
- H. Insulated dampers shall be constructed of aluminum with expanded polyurethane blades (R=2.2 min.) and a thermally broken, polystyrene filled frame. Blade & frame seals shall be extruded silicone. AMCA certified air leakage rate shall not exceed 4.1 cfm @ 4" wg (standard air). Dampers shall be manufactured to the actual opening, do not safe off the opening to use stock sizes.
- I. Subject to compliance with requirements, provide dampers of one of the following:
 - 1. Tamco series 9000 BF

2.9 FIRE DAMPERS

- A. Curtain type fire dampers constructed with casings of 20-22 galvanized steel with fusible link rated at ±212°F. Test all dampers in accordance with UL555. Curtain must be completely out of the air stream when damper is open. All dampers must be dynamic rated for design class of the duct system and the air velocity. Rating of fire damper shall be compatible with the rating of the building structure (wall or ceiling) in which it is installed.
- B. Subject to compliance with requirements, provide dampers of one of the following:
 - 1. Air Balance, Inc.
 - 2. American Warming & Ventilating, Inc.
 - 3. Greenheck
 - 4. Prefco Products
 - 5. Ruskin Mfg. Co.

2.10 FLEXIBLE DUCTWORK

- A. Inner liner shall be a laminate of aluminum foil, fiberglass, and aluminized polyester reinforced with a mechanically attached galvanized steel helix; the outer facing shall be a polyethylene material; a 1" thick fiberglass insulation shall be factory installed between the liner and the outer facing. Operating pressure shall be 12" w.g positive, 10" w.g. negative on sizes ≤12"Ø, 12" w.g positive, 4" w.g. negative on sizes 14" & 16".
- B. Subject to compliance with requirements, provide dampers of one of the following:
 - 1. Buckley Associates Flexmaster type 4
 - 2. ACCO

2.11 SHEET METAL ACCESSORIES

A. Provide flexible duct connections resistant to mildew and ultraviolet rays wherever ductwork connects to vibration isolated equipment. Construct flexible connections, serviceable from - 40°F to 250°F, of Durolon base, Hypalon coated flameproof fabric (24 ounces per square yard) crimped into duct flanges for attachment to duct and equipment. Make joint airtight.

2.12 DUCT LINER INSULATION

A. Duct liner shall be ASTM C 1071, Type I, with coated surface exposed to air stream to prevent erosion of glass fibers. Surface shall be treated with an EPA registered anti-bacterial agent to prohibit the growth of fungus and bacteria. Duct facing shall be designed to resist damage from common dry duct cleaning processes as recommended by the North American Insulation Manufacturers Association (NAIMA) Duct Cleaning Guide. Provide sheet metal nosings for all duct velocities securely installed over traversely oriented liner edges facing the air stream. Thermal performance (1" thickness): "C-Factor" equal to 0.25 or better, "R-Factor" equal to 4.0 or better, at a mean temperature of 75° F. Minimum sound absorption ratings per the following schedule as tested using the ASTM C423 method:

Sound Absorption Coefficient @ Frequency (Cycles Per Second)								
Thickness	125	250	500	1000	2000	4000	NRC	
1"	.09	.29	.67	.89	1.03	.99	.7	
2	.16	.51	.9	1.05	1.06	1.01	.9	

- B. Products: Provide products of the following manufacturers:
 - 1. CertainTeed Corporation; Insulation Group.
 - 2. Johns Manville
 - 3. Owens Corning
 - 4. Knauf
- C. Liner Adhesive: Comply with ASTM C 916.
 - 1. Hardcast: Glass Grip #GG-901
 - 2. United McGill: Uni-Grab Duct Liner Adhesive
 - 3. Duro Dyne: WIT
- D. Mechanical Fasteners: Galvanized steel welded to duct.
 - 1. DuroDyne: Spotter pins with PC metal washers

2.13 REGISTERS, GRILLES, AND DIFFUSERS

- A. All R, G, & D's shall be factory finished white. Provide diffusers, registers and grilles with border styles that are compatible with adjacent wall and ceiling systems.
- B. Directional face ceiling supply diffuser shall have square face and neck, aluminum or steel with extension panel for installation in ceiling system. Diffusers in acoustical grid ceilings shall be mounted in lay-in panels. All diffusers shall have induction vanes.
 - 1. Krueger
 - 2. Metalaire
 - 3. Tuttle & Bailey
 - 4. Price
- C. Return and exhaust grilles shall be rectangular/square face, all aluminum construction with fixed angle (40°-45°) deflecting vanes.
 - 1. Krueger
 - 2. Metalaire
 - 3. Tuttle & Bailey
 - 4. Price
- D. Double deflection sidewall return/exhaust grilles shall be extruded aluminum with front blades vertical. Provide with opposed blade damper with operator accessible through face.
 - 1. Krueger
 - 2. Metalaire
 - 3. Tuttle & Bailey
 - 4. Price

2.14 LOUVERS

A. Construct of aluminum extrusions, ASTM B 221, Alloy 6063-T52. Weld units or use stainless steel fasteners. Provide 1/2" square mesh anodized aluminum wire bird screens on inside face of exterior louvers.

- 1. Air Balance
- 2. Buckley Associates
- 3. Construction Specialties, Inc.
- 4. Louvers & Dampers, Inc.
- 5. Ruskin Mfg. Co.

2.15 AIR TERMINALS (VAV BOXES)

- A. Casing shall be constructed of not less than 22-gauge galvanized steel with round collars and rectangular slip and drive discharge openings.
 - 1. Interior of unit casing shall be lined with the following:
 - a. Not less than 1/2", 1-1/2 pcf fiberglass insulation.
 - b. Closed cell foam insulation.
 - c. Mylar faced fiberglass insulation.
 - 2. All exposed insulation edges shall be coated with an NFPA 90A approved sealant to prevent the entrainment of fibers into the airstream. Minimum box size is 6".
- B. Construct casings such that when subjected to 3" w.g. pressure, total leakage does not exceed four percent of specified air flow capacity or 10 cfm maximum with outlets sealed and inlets wide open. Construct air dampers such that when subjected to 4" w.g. inlet pressure with damper closed, total leakage does not exceed 2% of specified air flow capacity.
- C. Access doors shall be installed on all VAV boxes. Access doors shall be equipped with latches and hinges that are designed to be easily & repeatably opened. Access doors that are screwed to the box are not acceptable.
- D. Construct air dampers of materials that cannot corrode, do not require lubrication, nor periodic servicing. Linkage must be external to the box; internal linkage is not acceptable.
- E. Provide with multi-point, center-averaging flow sensor in inlet. Provide label on each unit indicating Plan Number, cfm range, cfm factory setting, and calibration curve. Provide hot water heating coils constructed of copper tubes and aluminum fins with galvanized steel casing.
 - 1. Anemostat
 - 2. Environmental Technologies
 - 3. Krueger
 - 4. Price
 - 5. Tuttle & Bailey

2.16 KITCHEN EXHAUST SYSTEMS

A. See DC Guideline HVAC Basic Mechanical materials And Methods, Section 23 05 10, for requirements of kitchen exhaust systems.

PART 3 - EXECUTION

3.1 GENERAL

- A. It is the responsibility of the sheet metal contractor to coordinate the work of his trade with all other trades prior to the commencement of construction. Any conflicts must be brought to the attention of the consultants or the owner.
- B. Open ends of ducts that are not actively being worked shall have a temporary closure of polyethylene film or other covering that will prevent entrance of dust and debris until connections are to be completed.
- C. Where duct testing is required, testing shall be performed per the SMACNA, "HVAC Air Duct Leakage Test Manual". All ducts, regardless of pressure class, shall conform to Seal Class 'A'.

3.2 DUCT APPLICATIONS

- A. Static-Pressure Classes: Unless otherwise indicated, construct ducts according to the following:
 - 1. Supply Ducts (before Air Terminal Units): 4-inch w.g.
 - 2. Supply Ducts (after Air Terminal Units): 2-inch w.g.
 - 3. Return Ducts (Negative Pressure): 2-inch w.g
 - 4. Exhaust Ducts (Negative Pressure): 4-inch w.g.
- B. Duct applications shall be as follows:
 - 1. Non-lab supply and return air ductwork galvanized steel.
 - 2. Non-lab general exhaust and toilet exhaust galvanized steel.
 - 3. Exposed ductwork round or flat oval, spiral seam, material as indicated above.
 - 4. Lab, Pools, Kitchen and other special applications ductwork material shall be determined by the designer.
 - 5. Ductwork in spaces with exposed ceilings:
 - a. All spaces with exposed ceilings (no architectural ceilings) shall have Flat Oval or Round ductwork. These spaces include, but are not limited to:
 - 1) Open Lab Spaces
 - 2) Atrium and Corridor Spaces
 - b. Refer to Architectural Ceiling plans for specific locations. Exceptions to this include supply duct runs which are required to be insulated (such as above corridors), or duct runs which are located high within the ceiling cavity and are fully obscured from view by other utilities, such as piping racks, cable trays, etc. Based on these guidelines, the Contractor shall provide coordination drawings clearly delineating areas which have Rectangular vs Flat Oval/Round ductwork.

3.3 METAL DUCTWORK

A. Assemble and install ductwork in accordance with the applicable sections of SMACNA. Support vertical ducts at every floor. Where required, provide seismic hanger assemblies. Locate ductwork runs, except as otherwise indicated, vertically and horizontally avoiding diagonal runs wherever possible.

- B. Do not route ductwork through transformer vaults and electrical equipment spaces and enclosures.
- C. Where ducts pass through interior partitions and exterior walls, and are exposed to view, conceal space between construction opening and duct or duct insulation with sheet metal flanges of same gauge as duct. Overlap opening on all four sides by at least 1 1/2". Fasten flange to duct or substrate, not both.
- D. Prior to the installation of the sheet metal ducts, the sheet metal/mechanical contractor shall coordinate with the balancing contractor to insure volume dampers are located in locations where the balancing contractor can effectively perform his trade.
- E. Where applicable, do not adhere fabrication sheets to the interior of ductwork.

3.4 DUCT LINER

- A. Fabricate lined ductwork in accordance with the SMACNA 'Duct Construction Standards" and the NAIMA "Fibrous Glass Duct Liner Standard". Duct liner is allowed in return & exhaust (except kitchen, moisture laden, and rest room) systems only. Supply systems with duct liner shall be double walled or single wall with filters downstream of the liner. Secure the liner to the duct with minimum 95% coverage of adhesive and weld type pins. Provide metal nosings for transversely oriented liner edges facing the air stream.
- B. Refer to HVAC Insulation Section 23 0700 for externally insulated ductwork.
- C. Duct Lining:
 - 1. Specific by the application.
 - 2. Transfer air ducts, 1"thick.

3.5 INSTALLATION OF FLEXIBLE DUCTS

- A. Install in accordance with Section III of SMACNA's, "HVAC Duct Construction Standards, Metal and Flexible, Second Edition (1995)", maximum 6'-0" extended length. Install insulated type flexible ducts in all supply air ductwork with temperature differences to the surrounding areas >10°F, non-insulated or insulated type flexible ducts with temperature differences <10°F and in return air systems. Attach flexible duct to metal duct and end terminals with drawbands on both the inner sleeve and the outer jacket.
- B. Flexible ductwork shall be used to make corrections for minor misalignments of metal duct connections to diffusers. The angle of adjustment shall not exceed 30°. Flexible duct shall not be used to make sharp turns or any other configuration that compromises the net free area of the duct. Where flexible duct runs are perpendicular to the outlet of the diffuser, use either a full radius elbow or a diffuser box at the diffuser connection.

3.6 INSTALLATION OF DUCTWORK ACCESSORIES

- A. Install access doors to open against system air pressure. Install access doors at all fire dampers, smoke dampers, motor operated dampers, humidifiers, both sides of coils, and similar devices requiring access.
- B. Install manual balancing dampers in all locations required to balance the system.

- C. Provide flexible connection for each ductwork connection to equipment mounted on vibration isolators and/or equipment containing rotating machinery.
- D. Fire dampers shall be installed in strict accordance with the manufacturer's written and tested installation instructions that are shipped with each fire damper. Dampers shall be installed square and shall not be malformed due to stretching or compressing to fit in misfabricated sleeves.
- E. The 2000 International Mechanical Code requires smokes detectors be located in the air handler, NFPA 72 (2002) requires the smoke detector be located in the supply duct downstream of the air handler. As a point of clarification, the Town of Hanover wishes to comply with NFPA requirement rather than the IMC requirement.

3.7 REGISTERS, GRILLES, AND DIFFUSERS

A. Provide sheet metal ceiling boxes when connecting ceiling diffusers with flexible ducts.

3.8 INSTALLATION OF AIR TERMINALS (VAV BOXES)

A. Install air terminals level and with the manufacturer's recommended straight run of metal ductwork at inlet and outlet, flexible connectors may be installed on the outlet side of the box. Install so that damper operator, damper actuator, and hot water control valve actuator (where provided) can be readily serviced.

3.9 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Duct leakage testing shall be done by a contractor regularly engage in ductwork pressure testing per direction from Dartmouth College. Contractor shall submit a report detailing the leakage rate of each air system which meets leakage requirements of this Section.
- C. Testing contractor shall identify air systems which do not meet specified leakage rates and shall report this to mechanical trade who is responsible for duct system installation and Dartmouth College. Mechanical trade shall provide modifications required so that air system meets leakage requirements, at no additional cost to the Owner. Mechanical trade shall be responsible for additional testing costs for repeat leakage testing until leakage test shows air system has met leakage requirements.
- D. Duct testing shall be observed by Dartmouth College or its designated agent.
- E. Testing shall be in accordance with SMACNA Duct Leakage Test Manual. Provide written notice to Engineer, Owner, designated agent and Commissioning Agent minimum 2 weeks before scheduled testing.
- F. Air leakage at test pressure shall be measured by calibrated orifice-type flow meter. Flow meter shall have been individually calibrated against a primary standard; calibrated curve shall be permanently attached to orifice tube assembly.
- G. Total allowable leakage of the system shall satisfy the requirements of SMACNA leakage Class A for rectangular and round ductwork. If system is tested in sections, leakage rate for each section shall be added to measure leakage rate for entire system.

- H. Leakage concentrated at one point may result in objectionable noise, even if system passes leakage rate criteria. Correct leakage noise problems to satisfaction of the Engineer and Dartmouth College.
- I. Test the following systems:
 - 1. Perform pressure testing on all ductwork in chases and spaces that will become inaccessible after construction.
 - 2. Supply Ducts with a Pressure Class of 3-Inch WG or Higher: Test 100% of total installed duct area for each designated pressure class.
 - 3. Exhaust Ducts with a Pressure Class of 3-Inch WG or Higher: Test 100% of total installed duct area for each designated pressure class.
 - 4. Outdoor Air Ducts with a Pressure Class of 3-Inch WG or Higher: Test 100% of total installed duct area for each designated pressure class.
- J. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
- K. Test for leaks before applying external insulation.
- L. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system, design pressure. Do not pressurize systems above maximum design operating pressure.
- M. Give seven days advance notice for testing and coordinate with Commissioning Agent and Dartmouth College.
- N. Duct System Cleanliness Tests:
 - 1. Visually inspect duct system to ensure that no visible contaminants are present.
- O. Duct system shall be considered defective if it does not pass tests and inspections.
- P. Prepare test and inspection reports.

END OF SECTION 23 31 13