MODEL CODE FOR THE PREVENTION OF RESIDENTIAL HAC DISTRIBUTION SYSTEM LEAKAGE AND HAC-INDUCED BUILDING LEAKAGE, 1994 EDITION

Philip Wemhoff
President
Philip Wemhoff and Associates
Jacksonville, Florida

Abstract and Introduction

This model code is the 1994 revision of an earlier code published in the **Proceedings Of The Seventh Annual Symposium On Improving Building Systems In Hot And Humid Climates**, Texas A&M University, Department of Mechanical Engineering in 1990. It contains additional closure systems, application practices, and definitions, and it addresses systems unique to mobile homes.

Modifications to local and state codes are considered an effective strategy for the prevention of residential air distribution system leakage and its impacts. A model code element has been developed to assist this strategy.

Recent field studies of Florida residences by Cummings, Tooley and Moyer[1] have revealed a mean leakage of 11 percent for the air distribution systems of central, fan-forced heating and air conditioning systems. Such leakage may cause an estimated 20 percent increase in energy consumption for air conditioning, as well as a 50 percent increase in peak cooling load and an 80 percent increase in peak heating load. In addition, building air leakage may be expected to be several times greater when duct leakage

The model duct construction code presented here contains all of the standards, definitions and code language needed to replace the current duct construction element of the local or state code. The contents of this paper were used as a principal source for language adopted by the 1991 and 1993 revisions of the Florida Energy Efficiency Code For Building Construction.

Addressed are the most appropriate standards required for the closure of metal duct, rigid fibrous glass duct, and nonmetallic flexible duct. Where conflicts among standards exist, governing standards are identified. Also addressed are (1) detailed requirements for the sealing of mechanical closets when they function as plenum chambers, (2) detailed requirements for the sealing of enclosed support platforms for air handlers and furnaces when they function as return duct, and (3) detailed requirements for the egress of air from closable rooms which receive supply air. Where necessary, commentary is provided to explain the options available for implementing the model code provision as well as its ramifications.

All provisions of this model code are cognizant of the requirements, standards and guidelines contained in related documents published by the following organizations: the Southern Building Code Congress International, Inc., the Sheet Metal and Air Conditioning Contractors National Association, the American Society of Heating, Refrigerating and Air Conditioning Engineers, Underwriters Laboratories, Inc., the Air Conditioning Contractors Of America, the North American Insulation Manufacturers Association, and the National Fire Protection Association.

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1 Cummings, J.B., Tooley, J.J., Jr., and Moyer, N., "Duct Leakage Impacts on Airtightness, Infiltration, and Peak Electrical Demand in Florida Homes," Florida Solar Energy Center and Natural Florida Retrofit, Inc., 1990. Cummings, J.B., Tooley, J.J., Jr., and Moyer, N., "Duct Doctoring: Diagnosis and Repair of Duct System Leaks," Florida Solar Energy Center, 1992.

100.0 HVAC Air Distribution Systems

In the matter of duct SEALING and insulation, the provisions of this code shall supersede all other codes, standards and manufacturer instructions where conflicts exist. The purposes of the provisions of this section are to preclude the unintentional leakage of air into or out of the air distribution system and to control thermal gains and losses resulting from conduction. **[For those key words formed entirely of UPPER CASE letters there are definitions presented in the Appendix.]**

(a) Closure, Approved Systems And Methods

When the components of the air distribution system, as defined by this Code, are constructed and SEALED according to its requirements, including the standards as referenced by and as limited by this and subsequent sections[2], they shall be deemed to be substantially airtight and shall be deemed as meeting the intent of this code.

1. **CLOSURE SYSTEMS.**
   a. **Approved CLOSURE SYSTEMS.** The following CLOSURE SYSTEMS are approved for SEALING the components of the air distribution system, when applied in the manners described in the subsequent sub sections. No other CLOSURE SYSTEMS may be used.
      1) Welds applied continuously along the seam or joint through which air leakage would otherwise occur.
      2) Longitudinal grooved seams operating at all pressures, and longitudinal snaplock seams when operating at pressures of less than 1 inch water gauge; such seams shall be those defined by SMAC-1.
      3) GASKETING material, meeting standard MODL-1, placed continuously between mated surfaces which are MECHANICALLY FASTENED with sufficient force to compress the gasket and fill all voids and cracks through which air leakage would otherwise occur.
      4) MASTIC and MASTIC-plus-embedded-fabric systems, used without dilution, provided that such systems either (a) shall have satisfied standard UL-3 [UL181A-M], when such standard shall become effective, or (b) shall have satisfied that section of standard MODL-2 related to the type of duct material being installed.
      5) DENSE MASTICS, meeting standard MODL-1 and placed within lap-joints and flange-joints, or within recesses, including inside right-angle corners, formed by the components of metal-to-metal joints.
      6) Pressure-sensitive tapes, which meet standard UL-2 [UL181A-P]. In no instance shall tapes utilizing rubber-based adhesives be used.
      7) Heat-activated tapes, which meet standard UL-2 [UL181A-H], when applied to fibrous glass duct board.
   b. **Closure location.** All CLOSURE SYSTEMS shall be applied to the AIR BARRIER component of the mated duct materials to form a continuous barrier to conditioned air leakage.
   c. **Access to SEAL site.** In all cases, where SEAL must be established in and between air distribution components, including AIR HANDLERS, while they are in-place, there shall be provided sufficient access to the SEAL site to assure the thorough application of an allowable CLOSURE SYSTEM and the necessary preparation of the receiving surfaces.
   d. **Surface preparation.** The surfaces upon which CLOSURE SYSTEMS are to be applied shall be clean and dry. Dust, dirt, oil, grease, moisture, and any other extraneous substance which may diminish the bond of the CLOSURE SYSTEM shall be removed entirely, by solvents if necessary, from the receiving surfaces. Cleaning substances and solvents shall be of a non-residue type.
   e. **MECHANICAL FASTENING.** When CLOSURE SYSTEMS are applied to joints or seams between sections of AIR DUCT, intermediate and terminal fittings, mechanical equipment, or to other components of the air distribution system, as well as to joints and seams between subsections of these components, such joints and seams shall be MECHANICALLY FASTENED to such an extent that the components of the joints and seams are secured and supported independently of the CLOSURE SYSTEMS. Excluded from this requirement are joints and seams between and within sections of fibrous glass duct board; such joints and seams shall be constructed in accord with standard NAIM-1.

2. **Installation and application procedures for pressure-sensitive, aluminum foil-backed tapes and mastic-plus-embedded fabric systems**
   a. **Pressure-sensitive tapes.** All pressure-sensitive tapes shall be applied and installed according to the requirements of

2 This paragraph is stating that certain external standards are adopted as part of this code, but that in some cases they may be "limited" by the code, meaning that, where there is a conflict, the code is preeminent.

NAIM-1, including, but not limited to, the following requirements:

1) Cold weather conditions. At temperature below 50 °F, pressure-sensitive tapes shall not be used, unless the following conditions have been achieved: (a) that the tape will have been maintained at a temperature of 70 °F during use and for 12 hours prior to use, (b) that, immediately prior to applying the tape to fibrous glass duct board, the receiving surface has been pre-heated by the application of a 400 ± 25 °F iron, and (c) that, immediately following its application, the tape has been heated in place by the application of a 400 ± 25 °F iron.
2) Tape application. The tape shall be centered over the joint or seam, and it shall be burnished to the extent that the underlying patterns of the joint components (and for fibrous glass duct board the patterns of the scrim reinforcement and staples) produce impressions within the tape. After its application, it shall be free of wrinkles; it shall be uniformly adhered, and it shall be free of punctures.

b. MASTIC and MASTIC-plus-embedded fabric systems. All MASTIC and MASTIC-plus-embedded fabric systems shall be applied and installed according to the requirements of NAIM-1, including, but not limited to, the following requirements:

1) MASTIC shall be applied to the joint or seam in a minimum 2½-inch wide course; it shall straddling the joint or seam and, in the case of sheet metal duct and fibrous glass duct board, it shall cover the MECHANICAL FASTENING. Without delay, fiberglass reinforcing fabric shall be embed within the MASTIC, and a second coat of MASTIC shall be applied over the fabric, to the extent that the fabric is entirely covered and that all of its cells are filled.
2) Until the MASTIC system has cured, no force shall be applied to the closed joint or seam which could cause movement in the CLOSURE SYSTEM or relative movement between the components of the joint or seam, and no material object, including insulation wraps, shall be permitted to contact the CLOSURE SYSTEM.

(b) Air Distribution System Component Construction

All BREACHES, in and between the AIR BARRIERS of air distribution system components, including AIR HANDLERS not contained within PLENUM CHAMBERS, shall be SEALED to 100 percent closure, meaning that approved CLOSURE SYSTEMS shall be applied to these BREACHES to the extent necessary to assure that no air leakage can occur during system operation.

1. Metal duct systems, rigid and flexible. All metal AIR DUCTS and metal DUCT FITTINGS, whether located inside or outside the conditioned boundary of the building, shall be SEALED according to the following requirements.

a. Operating pressures of one (1) inch water gauge and less. The following CLOSURE SYSTEMS and application standards are approved for rigid metal duct designed to be operated at pressures of one (1) inch water gauge and less.

1) Continuous welds;
2) Longitudinal grooved seams and snaplock seams[3], which are formed by the manufacturer;
3) MASTIC and MASTIC-plus-embedded-fabric systems, applied according to standard NAIM-1;
4) DENSE MASTICS, without reinforcing fabrics, when they are located continuously within lap-joints or flange-joints whose mutual contact areas are one-half inch wide or more and which are MECHANICALLY FASTENED, and DENSE MASTICS applied continuously within recesses, including inside right-angle corners, formed by the components of metal-to-metal joints;
5) GASKETING materials, when they are located continuously within lap-joints or flange-joints and are compressed by MECHANICAL FASTENING, and
6) Pressure-sensitive tapes, meeting standard UL-2 [UL181A-P] and applied according to the requirements of Section 100.0(a)2.

b. Operating pressures greater than one (1) inch water gauge. The following CLOSURE SYSTEMS and application standards are approved for rigid metal duct designed to be operated at pressures greater than one (1) inch water gauge.

1) Continuous welds;
2) Longitudinal grooved seams which are formed and closed by the manufacturer and which are certified by the manufacturer to be without leakage at the application pressure;

3 A joint study group of ASHRAE, SMACNA and NAIMA (formerly named TIMA), reported by ASHRAE 1989 Fundamentals Handbook, Chapter 32, found very low leakage for the unsealed longitudinal snap-lock seams of round metal duct, when such duct was operated at pressures of one (1) inch water gauge and below.

3) MASTIC and MASTIC-plus-embedded-fabric systems, applied according to standard NAIM-1;
4) DENSE MASTICS, when they are located continuously within lap-joints or flange-joints whose mutual contact areas are one-half inch wide or more and which are MECHANICALLY FASTENED, and DENSE MASTICS applied continuously within recesses, including inside right-angle corners, formed by the components of metal-to-metal joints, and
5) GASKETING materials, when they are located continuously within lap-joints or flange-joints and are compressed by MECHANICAL FASTENING.

c. **Operating pressures greater than three (3) inches water gauge.** Duct systems designed to operate at pressures greater than three (3) inches water gauge (4 inches water gauge pressure class) shall be SEALED to the requirements of 100.0(b)1.b., and shall be tested in accordance with standard SMAC-3. Leakage testing may be limited to representative sections of the duct system, but in no case shall such tested sections include less than 25 percent of the total installed duct area and 25 percent of the transverse joints.

d. **MECHANICAL FASTENING to mechanical equipment.** When a section of metal duct is joined to mechanical equipment, there shall be established sufficient MECHANICAL FASTENING between the duct and mechanical equipment to support the duct independently of the CLOSURE SYSTEM.

2. **Fibrous glass duct board systems.** All rigid fibrous glass AIR DUCTS, whether located inside or outside the conditioned boundary of the building, shall constructed, SEALED and erected according to the provisions of standard NAIM-1, as modified by the requirements below.

a. **Operating pressures less than two (2) inches water gauge, approved CLOSURE SYSTEMS.** The following CLOSURE SYSTEMS and application standards are approved for rigid fibrous glass duct designed to be operated at pressures less than two (2) inches water gauge:
1) Heat-activated tapes meeting standard UL-2 [UL181A-H] and applied in accordance with standard NAIM-1;
2) MASTIC and MASTIC-plus-embedded-fabric systems, applied according to the requirements of Section 100.0(a)2., and
3) Pressure-sensitive tapes meeting standard UL-2 [UL181A-P] and applied according to the requirements of Section 100.0(a)2.

b. **Operating pressures of two (2) inches water gauge and greater, approved CLOSURE SYSTEMS.** The following CLOSURE SYSTEMS and application standards are approved for rigid fibrous glass duct designed to be operated at pressures two (2) inches water gauge and greater:
1) Heat-activated tapes meeting standard UL-2 [UL181A-H] and applied in accordance with standard NAIM-1, and
2) MASTIC and MASTIC-plus-embedded-fabric systems, applied according to the requirements of Section 100.0(a)2.

3. **NONMETALLIC FLEXIBLE DUCT systems.** All NONMETALLIC FLEXIBLE DUCTS shall be equipped with non-porous inner cores, and, whether located inside or outside the conditioned boundary of the building, they shall be MECHANICALLY FASTENED and SEALED according to the following requirements.

a. **Required use of DUCT FITTINGS.** NONMETALLIC FLEXIBLE DUCT sections shall be joined to all other air distribution systems components using a DUCT FITTING. Fittings, without flanges, shall be used to join one flexible duct section to another, and INTEGRAL-FLANGE DUCT FITTINGS shall be use to join flexible duct sections to rigid duct, including fibrous glass duct board and sheet metal duct. The flanges of INTEGRAL-FLANGE DUCT FITTINGS shall be utilized in the closure and shall be of 5/8 inch minimum width. The DUCT FITTING shall be designed so that it extends a minimum of three (3) inches into the duct inner core.

b. **Duct inner core to DUCT FITTING, MECHANICAL FASTENING.** The inner core of the duct section shall be MECHANICALLY FASTENED to the DUCT FITTING by a DRAWBAND. When the duct section exceeds 12 inches in diameter or if the operating pressure will exceed one (1) inch water gauge, the DRAWBAND shall be secured by a raised bead or indented groove within the fitting.

c. **Duct inner core to DUCT FITTING, approved closure.** The inner core of the flexible duct section shall be SEALED to the DUCT FITTING using one of the following CLOSURE SYSTEMS.
1) GASKETING, which is located continuously between the duct inner core and DUCT FITTING and

beneath the DRAWBAND and which is compressed against the inner core, to the extent that all leak pathways are eliminated, by the securing of the DRAWBAND;

2) MASTIC and MASTIC-plus-embedded-fabric systems, applied both (a) between the fitting and inner core and (b) over the joint according to the requirements of Section 100.0(a)2.;
3) Pressure-sensitive tapes meeting standard UL-2 [UL181A-P] or UL-4 [UL181B], when such standard shall become effective, and applied according to the requirements of Section 100.0(a)2., provided, however, that tapes shall be applied so that they extend a minimum of two (2) inches onto the duct inner core and a minimum of one (1) inch onto the DUCT FITTING, with all tape overlaps exceeding one (1) inch, or
4) DENSE MASTICS, when they are located continuously between the duct inner core and the DUCT FITTING and beneath the DRAWBAND and which are compressed, to the extent that all leak pathways are eliminated, by the securing of the DRAWBAND.

d. DUCT FITTING to rigid duct, MECHANICAL FASTENING. When NONMETALLIC FLEXIBLE DUCT is joined to fibrous glass duct board or to sheet metal ducts, an INTEGRAL-FLANGE DUCT FITTING shall be used, and this fitting shall be MECHANICALLY FASTENED to the rigid duct board or sheet metal by appropriate fasteners, either screws, spin-in flanges, or dovetail flanges. When the fitting employs a dovetail flange, in order to fasten it to fibrous glass duct board, all functional tabs of the dovetail shall be engaged in securing the fitting **{Optional:**, and the fitting shall incorporate a ring of one (1) inch minimum width between the tabs of the fitting and the duct board[4]. The ring shall be sufficiently rigid to distribute uniformly the forces applied by the tabs**}**.

e. DUCT FITTING to rigid duct, approved closure. The integral-flange of the DUCT FITTING shall be SEALED to the rigid fibrous glass duct board or sheet metal duct using one of the following CLOSURE SYSTEMS:

1) GASKETING, which is located continuously between the rigid duct and the flange of the fitting and which is compressed, to the extent that all leak pathways are eliminated, by the MECHANICAL FASTENING of the fitting;
2) Pressure-sensitive tapes meeting standard UL-2 [UL181A-P] and applied according to the requirements of Section 100.0(a)2.;
3) MASTIC and MASTIC-plus-embedded-fabric systems, applied both (a) between the fitting and the AIR BARRIER of the rigid duct and (b) over the joint according to the requirements of Section 100.0(a)2., or
4) DENSE MASTICS, without reinforcing fabrics, which are located continuously between the rigid duct and the flange of the DUCT FITTING and which are compressed, to the extent that all leak pathways are eliminated, and secured by the MECHANICAL FASTENING of the DUCT FITTING.

f. Duct outer jacket to DUCT FITTING. Once the Building Official has inspected the inner core to fitting joint, the outer jacket may be fastened.

1) Inspection. The attachment of the outer jacket to the fitting shall be delayed until after a duct inspection, so that the SEALS and attachments between the inner core and DUCT FITTING and between the DUCT FITTING and the rigid duct board or sheet metal may be examined.
2) Attachment. The outer jacket of a flexible duct section shall be MECHANICALLY FASTENED either to the fitting or to the adjoining duct; however, in no case shall it be interposed between the flange of the DUCT FITTING and the rigid fibrous glass duct board, sheet metal or flexible duct to which it is joined[5].

4 The use of a tab-ring is a current requirement in many local jurisdictions. The ring strengthens the attachment against torque and prolongs the SEAL by minimizing the crushing of the duct board and the potential loosening of the fitting; erosion is also reduced.

5 This statement prohibits the use of "diapered" joints, a joint prone to faulty assembly and leakage. Such joints (and all other compression joints) are not now, nor have they ever been, recognized as acceptable closure methods by industry consensus fabrication standards as expressed in SMAC-2, SMACNA HVAC Duct Systems Inspection Guide (1989), and in SMAC-1, SMACNA HVAC Duct Construction Standards: Metal and Flexible (1985), and in their predecessors: SMACNA Flexible Duct Performance Standards and Flexible Duct Installation Standards (1980) and SMACNA Flexible Duct Installation Standards (1979). In addition, no duct manufacturer is prohibited from using his product by the barring of these joints. According to Jack Bono, then-President of Underwriters Laboratories, Inc. in a written communication to the Jacksonville Electric Authority, dated February 8, 1990, "It is my understanding that all UL-Listed ducts which have provisions for use of the DIAPERED JOINTS, are also Listed with provisions for other joint connection methods. Therefore, the use of DIAPERED JOINTS does not appear mandatory for any of the currently-Listed products."

g. **NONMETALLIC FLEXIBLE DUCT, installation and support.** NONMETALLIC FLEXIBLE DUCTS shall be configured and supported so as to prevent the use of excessive duct lengths, to prevent duct and joint dislocation or damage, and to prevent constriction of the duct below the rated duct diameter. The following requirements shall apply to all NONMETALLIC FLEXIBLE DUCTS and air connectors.

1) Such duct shall be supported at the manufacturer's recommended intervals, but in no case shall the distance between supports exceed five (5) feet. Duct sag between supports shall not exceed 1/2 inch per foot of spacing between supports.
2) The length of duct material used for a given run, if extended, shall not exceed by more than five (5) percent the minimum extended length needed for that run. Ducts shall be installed fully extended.
3) Ducts shall be supported within 1½ feet of an intermediate fitting when the intermediate fitting is attached at its flange-end to fibrous glass duct board. All supports shall be distinct from the duct system and shall maintain contact with the lower one-half of the circumference of the outer jacket. When a bend is to occur near an intermediate fitting, the duct shall be extended straight outward from the fitting for several inches before beginning the bend, and the duct shall be supported between the fitting and the bend. Terminal fittings shall be supported independently of the flexible duct.
4) The inside diameter of a bend shall exceed the outside diameter of the specific duct product undergoing the bend. Long horizontal duct runs with sharp bends shall have supports before and after the bend, located within one (1) duct diameter distance from the beginning and end of the bend.
5) Where used, supports 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 support. In no case shall the material contacting the flexible duct be less than one (1) inch wide.
6) Vertically-installed duct shall be stabilized by support straps at a maximum of six (6) feet on center.

4. **Combination duct systems.** When air distribution systems contain multiple AIR DUCT types, each type shall be SEALED in accord with related requirements of this Code, provided, however, that when the components of a joint are fibrous glass duct board and metal duct, including metal equipment housings, the CLOSURE SYSTEMS and closure methods approved for fibrous glass duct board, Section 100.0(b)2., shall be used.

5. **Terminal and intermediate fittings.** All seams and joints between fitting subsections and between fittings and other air distribution system components shall be MECHANICALLY FASTENED and SEALED using CLOSURE SYSTEMS approved for the fabrication material used.

a. **Fitting subsections.** Joints between the subsections of metal fittings, shall be SEALED according to the provisions of Section 100.0(b)1., and joints between fitting subsections, whose components are fibrous glass duct and sheet metal, shall be SEALED according to the provisions of Section 100.0(b)2.

b. **Fitting to rigid duct joints.**
   1) Joints between metal DUCT FITTINGS and fibrous glass duct shall be SEALED according to the provisions of Section 100.0(b)3.e.
   2) When a fitting employs a dovetail flange, in order to fasten it to fibrous glass duct board, all functional tabs of the dovetail shall be engaged in securing the fitting {**Optional:**, and the fitting shall incorporate a ring of one (1) inch minimum width between the tabs of the fitting and the duct board[6]. The ring shall be sufficiently rigid to distribute uniformly the forces applied by the tabs}.

b. **Terminal fittings to building envelope components.**
   1) Envelope penetrations. All terminal fittings and AIR DUCTS, which penetrate the building envelope, shall be SEALED to that component of the envelope which is penetrated. Such terminal fittings shall be SEALED to the panelized material, such as gypsum wallboard, which sheathes the ceiling, wall or floor and shall be MECHANICALLY FASTENED to the structure to prevent dislodgement and damage to the CLOSURE SYSTEM.

6 The use of a tab-ring is a current requirement in many local jurisdictions. The ring strengthens the attachment against torque and prolongs the SEAL by minimizing the crushing of the duct board and the potential loosening of the fitting; erosion is also reduced.

2) Approved CLOSURE SYSTEMS. Long-lived caulks or MASTICS shall be used to SEAL the AIR BARRIER of the terminal fitting to the ceiling, wall or floor sheathing, provided, however, that gaskets may be substituted for caulks and MASTICS, if the CLOSURE SYSTEM is designed in such a manner that the fastening of the grille or register to the fitting will compress the gasket between the fitting and the sheathing. Caulks and MASTICS used in this application need not conform to the approved CLOSURE SYSTEMS of Section 100.0(a)1.

6. **Air handling units.** All AIR HANDLERS located outside of PLENUM CHAMBERS, including AIR HANDLERS within conditioned space shall be SEALED[7]. Potential leak sites covered by this requirement include, but are not limited to, all joints, seams, and wall penetrations in and between components of the AIR HANDLER casing, the refrigerant lines and drain line, the principal access panel, the filter access door, and external filter housings. The approved CLOSURE SYSTEMS are those permissible for closing rigid metal duct, Section 100.0(b)1.

7. **Cavities of the building structure.** When uninhabitable cavities of the building, including, but not limited to, dropped soffits and ceiling, wall and floor cavities, will contain a supply or return air stream, the air stream shall be confined throughout its course within the cavity by AIR DUCT which is insulated in accordance with Section 100.0(f) and constructed and SEALED in accordance with the requirements of Section 100.0(b), appropriate for the duct type or combination of duct types used.

Excluded from this requirement are suspended ceiling cavities used to gather air from multiple, diffuse returns. Such cavities shall be SEALED according to the specific requirements of a PLENUM CHAMBER, Section 100.0(c)1. The result of this closure effort shall be to isolate the suspended ceiling cavity effectively from the building structure and to preclude the possibility of air leakage into the return air stream from the cavities of adjoining walls, floors or ceilings. Further, if the walls or ceilings of this cavity adjoin unconditioned space, such walls and ceilings shall be insulated according to the requirements of Section 100.0(f), for air distribution system components located on the exterior of the building.

No storage cabinet, vanity or other fixture of the building may be utilized as an air containment vessel of the air distribution system.

(c) MECHANICAL CLOSETS And ENCLOSED SUPPORT PLATFORMS For Central Air Conditioning And Heating Systems

PLENUM CHAMBERS. A PLENUM CHAMBER is a room or closet within a conditioned space (1) which contains either a return air inlet or an inlet of an AIR HANDLER, but which contains no supply air outlet, and (2) which confines, by means of its walls, ceiling and floor, a return air stream during all of or a portion of its journey to the inlet of an AIR HANDLER. A MECHANICAL CLOSET is considered a PLENUM CHAMBER when its interior surfaces confine return air in this manner. Such PLENUM CHAMBERS shall meet the requirements of Section 100.0(c)1., below. No atmospheric combustion appliance, including combustion furnaces and combustion water heaters, shall be located within a PLENUM CHAMBER.

ENCLOSED SUPPORT PLATFORMS. When an enclosed platform supports a central heating unit or the AIR HANDLER of a central air conditioner or HEAT PUMP and provides a housing for the transport of return air from the return air inlet(s) to the inlet of the heating or air conditioning unit, the platform shall contain a duct section fabricated to contain without leakage the return air stream. Such support platforms and return duct sections, whether they are located inside or outside the conditioned space, shall meet the requirements of Section 100.0(c)2., below.

1. **MECHANICAL CLOSETS meeting the definition of PLENUM CHAMBER.** When a MECHANICAL CLOSET meets the definition in 100.0(c) of a PLENUM CHAMBER, regardless of its location, it shall be SEALED in such a way as to preclude the possibility of air leakage into the return air stream from the cavities of adjoining ceilings, walls or floors[8] or from outside the conditioned space.

7 Typical AIR HANDLER leakage is 3 to 5 percent. Even when AIR HANDLERS are located within the conditioned space, such leakage can diminish planned air distribution, can increase coil and filter by-pass, and can produce health hazards through localized depressurization. If the AIR HANDLER is a combustion appliance, or if combustion appliances are nearby, flue gases may be drawn into the indoor environment, or flame roll-out may occur. Within furnaces there are often BREACHES in the AIR BARRIER between the combustion chamber and the incoming air stream. These BREACHES provide pathways for toxic fumes to enter the air stream.

8 This code language eliminates the need to establish the origin of leakage air as air from outside the conditioned space. It is often perceived, incorrectly, that ATTIC air cannot be drawn through partition walls into the MECHANICAL CLOSET from an ATTIC immediately above the MECHANICAL CLOSET. In addition, it is often argued, in error, that air leakage from wall cavities into a

a. **Approved AIR BARRIERS.** All interior surfaces of the PLENUM CHAMBER shall be sheathed with a continuous AIR BARRIER. The floor of the PLENUM CHAMBER may be excluded from this requirement if its construction within the SEALED portion of the PLENUM CHAMBER is continuous, fissure-less concrete[9]. The following AIR BARRIERS are approved for use in PLENUM CHAMBERS:
   1) One-half inch thick or greater gypsum wallboard, as defined by ASTM C 36[10], and
   2) Other panelized materials whose AIR POROSITY is no greater than that of a duct product meeting section 22 of UL-1 [UL181], provided that, if its AIR BARRIER is a membrane, that membrane shall face the interior of the PLENUM CHAMBER.

b. **Approved CLOSURE SYSTEMS.** Using an approved CLOSURE SYSTEM, all joints shall be SEALED between AIR BARRIER segments, between the AIR BARRIERS of the walls and those of the ceiling and floor, and between the AIR BARRIERS of the walls and the door framing and the AIR HANDLER support platform[11], if one is present. All penetrations of the AIR BARRIER, including but not limited to those by AIR DUCTS, service lines, electrical wiring, refrigerant lines, and condensate drain lines shall be SEALED to the AIR BARRIER. The refrigerant line chase, if it emerges within the PLENUM CHAMBER, shall be SEALED to close both its inside and outside openings. The following CLOSURE SYSTEMS are approved for closing PLENUM CHAMBERS:
   1) For fibrous glass duct board, CLOSURE SYSTEMS complying with the product and application standards of Section 100.0(a)2.;
   2) For all other applications, including joints between gypsum wallboard panels, a suitable long-life caulk or MASTIC[12], provided, however, that acceptable materials shall be used in combination with MASTICS to bridge all gaps between the wall sheathing and the floor. Caulks and MASTICS used in this application need not conform to the approved CLOSURE SYSTEMS of Section 100.0(a)1.; however, their characteristics should be guided by applicable provisions of the locally-adopted mechanical code;[13]
   3) If the sheathing material is gypsum wallboard, sealants may be omitted at flat, vertical butt joints, only, provided that the gypsum wallboard panels are attached using adhesives meeting standard ASTM C 557, and are installed in accordance with Section 6 of standard GYPS-1, which recommends that a separate bead of adhesive be located between each panel and the common vertical framing member. Gypsum wallboard joint compound shall not be an acceptable sealant[14].

MECHANICAL CLOSET located on the first floor of a two-story building could not have its origin outside the conditioned space. In fact this could well be the case, with air entering second-floor partition walls from the ATTIC, passing through the between-floor space and into first-floor partition walls.

9 A wood panel floor would not meet the Class 1 Surface Burning Standards [MODL-1] required by the Standard Mechanical Code (Section 509) of all exposed surfaces within a PLENUM CHAMBER.

10 The definition of non-combustible in the Standard Building and Standard Mechanical Codes is intended to apply to gypsum wallboard. This code accepts as non-combustible "Materials having a structural base (meaning the gypsum) of noncombustible materials as defined in 1 (by ASTM E 136), with a surfacing (meaning the paper facing) not more than 1/8 inch thick which has a flame spread rating not greater than 50 (no requirement related to smoke developed rating) when tested in accordance with ASTM E 84." For example, the Standard Mechanical Code, Section 509, provides that this sheathing material and the floor covering must be either non-combustible materials or must meet Class 1 Surface Burning Standards [MODL-1]. Most gypsum wallboards and all UL181-rated fibrous glass duct boards meet this standard, but most foam board insulations and wood panels do not.

11 If there is a support platform which is attached by ledgers to the wall framing (which is frequently the case), the top of the support platform (as well as the ledgers) will penetrate the wall sheathing. A new development has been the direct attachment of AIR HANDLERS to a wall using a bracket made of sheet metal. This bracket does not usually penetrate the sheathing.

12 Sealants to meet standard MODL-1 are not difficult to acquire and are not expensive. Most acoustical sealants, formulated to adhere well to gypsum wallboard, are available at gypsum product suppliers and cost approximately $2.80 per one-quart tube. Some brands which meet MODL-1 are Ohio Sealant Rubber Base Sound Sealant and Ohio Sealant Water Base Sound Sealant (800 321-3578), Tremco Acoustical (Rubber Base) Sealant (800 321-7906), and US Gypsum Acoustical (Water Base) Sealant (800 342-0585).

13 When combustible materials are used within PLENUM CHAMBERS they must meet Class 1 Surface Burning Standards [MODL-1], according to the Standard Mechanical Code, Section 509. Sealants to meet this Class 1 Surface Burning requirement are not difficult to acquire and are not expensive. Most acoustical sealants, formulated to adhere well to gypsum wallboard, are available at gypsum product suppliers and cost approximately $2.80 per one-quart tube. Some brands which meet MODL-1 are Ohio Sealant Rubber Base Sound Sealant (SC170) and Ohio Sealant Water Base Sound Sealant (SC175) (800 321-3578), Tremco Acoustical (Rubber Base) Sealant (800 321-7906), and US Gypsum Acoustical (Water Base) Sealant (800 342-0585).

14 Joint compound should not be used at any location in the PLENUM CHAMBER to achieve a seal, for the following reasons: (a) it does not adhere to wood; so, it would not form a SEAL between the gypsum wallboard and the door jamb and between the wallboard and bottom plate or floor; (b) it should not be used on horizontal joints (between wall and ceiling), since truss uplift over time may break the joint compound which is thin and brittle; (c) it should not be used in corners because the panels on adjoining walls are attached to different framing members; if the walls are vibrated (which can happen, because AIR HANDLERS are often hung from the walls), the joint compound may crack;

2. **Enclosed support platforms containing return air stream.**
   a. **Mandatory duct section.** Whether located inside or outside the conditioned space, all ENCLOSED SUPPORT PLATFORMS, positioned between the return air inlet(s) from conditioned space and the inlet of the air handling unit or furnace, shall contain a continuous duct section constructed entirely of rigid fibrous glass duct board, rigid sheet metal, or NONMETALLIC FLEXIBLE DUCT and shall be insulated according to the requirements of Section 100.0(f).

      This duct section shall be so designed and so constructed that (1) no portion of the support platform or of the building structure, including adjoining walls, floors and ceilings, shall be in contact with the return air stream or function as a component of this duct section and (2) the duct section shall be effectively isolated from the building structure, so that air cannot be transferred to the return air stream from the cavities of adjoining walls, floors or ceilings.

      In no instance shall this duct section be penetrated by a refrigerant line chase, refrigerant line, wiring, pipe or any object other than a component of the air distribution system.[15]
   b. **Closure requirements.** The subsections of this duct section and its jointing to the mechanical equipment and to all other connecting duct sections shall be MECHANICALLY FASTENED and SEALED according to the respective requirements of Section 100.0(b). The result of this closure effort shall be to preclude over the entire surface area of the duct section, including those areas not exposed to view, any present or future possibility of air leakage into the return air stream.
   c. **Non-supporting enclosures.** Enclosures, which are located directly below MECHANICAL CLOSETS and which house passageways for return air, but which may not physically support mechanical equipment, are also covered by the requirements of this subsection.

3. **Through-wall, through-floor, and through-ceiling returns.** Such returns shall be constructed so as to preclude the possibility of air leakage into the return air stream from adjoining wall, ceiling or floor cavities.
   a. **Leading to PLENUM CHAMBERS and used for air-egress.** When a through-wall, through-floor and through-ceiling return air passageway leads to a PLENUM CHAMBER or is used for air-egress, it shall be isolated from the remainder of the building cavity it traverses by surrounding the passageway continuously using framing or another rigid AIR BARRIER. The segments of this AIR BARRIER shall be SEALED, using caulks or MASTICS, to one another and to the AIR BARRIERS sheathing the walls, ceilings or floors on both ends of the passageway. Caulks and MASTICS used in this application need not conform to the approved CLOSURE SYSTEMS of Section 100.0(a)1. However, in the case of PLENUM CHAMBERS, their characteristics should be guided by applicable provisions of the locally-adopted mechanical code.
   b. **Leading to ENCLOSED SUPPORT PLATFORMS.** When a through-wall, through-floor or through-ceiling air passageway leads to the duct section within an ENCLOSED SUPPORT PLATFORM, the wall, ceiling, or floor penetration shall contain a branch duct which is fabricated entirely of rigid fibrous glass duct board, rigid metal duct, or NONMETALLIC FLEXIBLE DUCT and which extends to and is SEALED to both the duct section and the grille side wall surface. This branch duct shall be fabricated and shall be joined to the duct section in accordance with Section 100.0(b), respective of the types of duct used.

(d) Return Air Requirements

All bedrooms, and such other rooms as the Building Official shall designate, which are enclosed by a door and to which conditioned air is supplied, shall be equipped with a permanent, non-closable means for air-egress, so that conditioned air will be able to return to the AIR HANDLER or furnace. The required cross-sectional area of the air-egress, whether return duct, through-wall transfer grille, or other air passageway, shall be determined according to the following standards[16]:

however, (d) MASTIC can be omitted at vertical, butt joints, if adhesive is used to fasten the wallboard (see GYPS-1), because adjoining panels in these locations are MECHANICALLY FASTENED and glued to the same framing member; the adhesive (which by code should be applied in two separate vertical beads at butt joints) will assure air-tightness, and the joint compound, located between the air stream and the adhesive, will assure that the adhesive does not have to meet MODL-1.

15 In no other residential application is supply or return duct allowed to be penetrated by wires, pipes, and chases in communication with the soil. This prohibition could cause a departure from the current practice of placing the refrigerant chase within the support platform. However, if the support platform is designed correctly, the chase can still emerge within the platform, but avoid contact with the duct section. Otherwise, additional space would be consumed in the garage to allow the chase to emerge outside the support platform.

16 The Net Free Grille Areas are derived from ACCA Manual D (1984) p. 25, which recommends a 400 FPM face velocity at return grilles and from SMACNA SMAC-4, p. 8.2, which

1. **Ducted returns.**
If conditioned air is to be removed from an enclosed room by means of a ducted return, the designs and sizes of the return duct and return grilles should be determined using the methods of ASHR-1 or ACCA-1, or another approved method, and, for each room[17], the return duct(s) shall carry the same cumulative air flow as the supply duct(s). However, in the absence of such sizing being performed, the required areas of the return grille and return duct shall be determined by either method a. or b., below, as designated by the Building Official. A ducted-return is one in which return air is confined solely by AIR DUCT throughout its passage from the enclosed room to the inlet of the AIR HANDLER or furnace.
   a. **Method a.** For a given room the diameter of the return duct shall exceed the diameter of the supply duct by two (2) inches. For return grilles see **Method b.**
   b. **Method b.** For a given room the cross-sectional area of the return duct and the Net Free Grille Area shall exceed the cumulative cross sectional area(s) of the supply duct(s) by 16 percent plus 20 square inches ($A_{Return} = 1.16A_{Supply} + 20$); however, when the return grille is designed to contain a filter element, its Net Free Grille Area shall exceed the cumulative supply duct area by a minimum of 30 percent.

Note that these air not sizing calculations for return duct.

2. **Other, non-ducted methods of air egress.**
If conditioned air is to exit an enclosed room by means of a through-wall grille, a transfer duct, a door under-cut, or by another non-ducted-return, both the cross-sectional area of the air-egress passageway and the Net Free Grille Area shall equal or exceed twice[18] the cumulative cross sectional area(s) of the supply duct(s) terminating in that enclosed room. Throughout the air-egress passageway, its cross-sectional area, determined at right angles to the direction of air flow, shall equal or exceed this minimum requirement.

If a door under-cut is to be used for air-egress, the arithmetic product of the door width times the distance between the door and the floor covering at its most restrictive location shall equal or exceed the required area; in addition, the height of the undercut above the uncompressed carpet or other floor covering shall be a minimum of two (2) inches but no more than 2¼ inches[19]. If the door under-cut does not achieve the required area, it shall be achieved by another method, either alone or in combination with the under-cut.

The passageways of through-wall transfer grilles shall be isolated from the remainder of the wall cavity according to the requirements of sections 100.0(b)7. and 100.0(c)3. Transfer ducts, which originate within the closable room and terminate in an adjacent hallway, shall be constructed of terminal fittings and AIR DUCT which are constructed, SEALED, insulated, and supported according the requirements of this Code.

(e) HUD-Regulated Manufactured Homes And Buildings[20]

All equipment, materials, measures, practices, and features related to the air distribution system, which are to be affixed to a new manufactured home at its first set-up shall be subject to this Code, when identical equipment, materials, measures, practices, and features, if affixed to a new site-built home, would be subject to the requirements of this Code.

1. **System design.** When both factory-installed and site-installed space conditioning systems serve a manufactured home or manufactured building and share the same supply registers, there shall be installed in the air distribution system automatic dampers, or such other automatic flow-control devices as necessary, to prevent the functioning of return grilles as supply registers and to prevent the forced passage of conditioned air through inactive AIR HANDLERS when another system is in operation. **{Option which excludes the factory-installed system:** When both factory-

states "Return air grilles shall be sized to return 100 percent of the air being supplied to the conditioned space with air velocities not to exceed 450 FPM face velocity."

17 Note also that in order to comply with standard SMAC-4, ducted returns shall not be used for air egress from bathrooms, kitchens, utility spaces, spaces used for storage of fuel or flammable materials, or from a confined space in which a draft diverter or draft regulator is located or to which combustion air is supplied. In these cases, non-ducted means of air egress should be used.

18 Based on a maximum of 2.0 pascals (0.008 inch WG) pressure difference across the room partition. If a transfer duct is used for air-egress, its diameter relative to the supply duct is $D_{egress} = D_{supply} \times (2)^{1/2} = D_{supply} \times 1.414$.

19 For many hollow-core doors, the structural rails within the door, at the top and bottom, can be trimmed only one (1) inch each, for a total of two (2) inches of height removed. Of course, solid doors provide opportunities for a larger undercut.

20 Concerning site-installed air conditioning equipment, the mobile home buyer receives no benefit from the HUD Standards, only injury. The HUD inspection program never monitors the at-site installation of air conditioning equipment and ductwork, and the perceived jurisdiction of HUD over this equipment, by many local code officials, prevents all other possible inspections by local or state agencies. The anomaly of the HUD Standards is that, compared to other site-installed equipment, the site-installed air conditioning equipment is uniquely and selectively regulated by HUD. No other site-installed equipment is within the jurisdiction of the HUD program. Even the septic tank, which is far more vital to the inhabitability of the mobile home, is not regulated by the HUD program, though its attachment by piping is analogous to that of an externally-mounted air conditioner. The HUD standards are contained in Part 3280, and the HUD regulations in Part 3282, of 24 CFR Ch. XX.

installed and site-installed space conditioning systems serve a manufactured home or manufactured building and share the same supply registers, there shall be installed within the site-installed air distribution system automatic dampers, or such other automatic flow-control devices as necessary, to prevent the forced passage of conditioned air through the site-installed air distribution system when the factory-installed system is in operation.}

2. **Closure requirements.**
   a. **Site-installed components.** All site-installed flow-control devices, AIR DUCT and related fittings, shall be constructed, SEALED, insulated and supported in accordance with the requirements of this Code.
   b. **Jointing of factory-installed and site-installed components.** When factory-installed air distribution system components are joined at the site or when factory-installed components are joined to site-installed components, all portions of those components which are directly related to the jointing shall be constructed, SEALED, insulated and supported in accordance with the requirements of this Code.
   c. **Access to SEAL site.** There shall be provided sufficient access to the SEAL site to assure the thorough application of an allowable CLOSURE SYSTEM. {**Optional:** In all cases, including ATTIC locations, when such joints will be inaccessible as a result of building assembly, either the Building Official shall be present and perform related inspections during building assembly, or access to the SEAL site shall be provided to allow related inspections after the building assembly has been completed.}

(f) Air Distribution System Insulation

All duct insulation values shall be determined by using flat specimens to determine thermal resistance (R) using the relationship R = t/k, where t is the installed thickness in inches and k (Btu-in/hr sq. ft. °F) is determined for the insulation using ASTM C 518 or ASTM C 177 and conducting the test at 75°F mean temperature.

Duct wrap for metal duct. Such wrap shall be tested at 75 percent of its nominal thickness and the installed thickness value shall also be assumed to be 75 percent of the nominal thickness.

Rigid fibrous glass duct board and duct liner. For such products the nominal value shall be used for thickness.

Insulation for NONMETALLIC FLEXIBLE DUCTS. Such insulation shall be tested at a thickness equal to the installed duct wall thickness. The installed duct wall thickness shall be determined by circumferentially cutting the outer jacket and insulation from a sample, removing it from the inner lining, laying it onto a flat surface and measuring its width with a rule, to the nearest 1/16 inch. The installed R-Value of the AIR DUCT or air connector, calculated in accordance with this standard, shall be printed or labelled on the product at maximum intervals of 10 feet.[21]

1. **Insulation requirements.**
   All air distribution system components, including, but not limited to, AIR DUCTS, DUCT FITTINGS, and AIR HANDLERS, in or on buildings, or portions thereof, shall be insulated to provide a minimum installed thermal resistance, excluding air film resistances, as indicated in the following table.

Insulation Requirements

In ATTIC	R-6
Exterior of building	R-6
Enclosed attached garage	R-4.2
Enclosed unconditioned basement	R-4.2
Enclosed vented crawlspace	R-4.2
AIR HANDLERS in unconditioned space	R-4.2

The duct sections within ENCLOSED SUPPORT PLATFORMS shall be insulated to meet these requirements.

When the floor of a PLENUM CHAMBER is raised-wood over unconditioned space, the wood floor shall be insulated to meet these requirements.[22]

2. **Additional insulation requirements.**
   Additional insulation with vapor barrier shall be provided where the minimum duct insulation requirements of subsection 1., above, are determined to be insufficient to prevent condensation. However, insulation may be omitted when it can be shown that the criteria in subsection 1, above, have been met and that condensation resulting from its absence will not be detrimental to the distribution system, mechanical system or

21 This insulation-measuring standard and the labelling recommendation were adopted by the Air Diffusion Council, the association of NONMETALLIC FLEXIBLE DUCT manufacturers, at its December, 1989 meeting.

22 Since the wood floor would be exposed in a PLENUM CHAMBER, to the return air stream, it would not fulfill the Standard Mechanical Code requirement that all exposed surfaces meet Class 1 Surface Burning Standards [MODL-1], at minimum. If the wood floor were to be covered with fibrous glass duct board, it would then meet both the insulation requirement and the MODL-1.

building structure, and that the health and safety of the building occupants will not be adversely affected.

3. **Omission of duct insulation.**
   Duct insulation (except where required to prevent condensation) is not required in any of the following cases:
   a. When the heat gain or loss of the ducts, without insulation, will not increase the energy requirements of the building.
   b. Exhaust AIR DUCTS.

4. **Crawlspace PLENUM.**
   Crawlspaces, whether SEALED or unsealed, shall not be used as supply or return PLENUMS.

Appendix: Definitions

Air Barrier. Related to the air distribution system, a material object in direct contact with supply or return air which impedes or restricts the free movement of air. For fibrous glass duct, the air barrier is its foil cladding; for flexible non-metal duct, the air barrier is its nonporous inner core in contact with the air stream, and for sheet metal duct, DUCT FITTINGS, and air handling units, the air barrier is the metal in contact with or nearest the air stream. For PLENUM CHAMBERS, the air barrier may be a uniform panelized material, such as gypsum wallboard which meets ASTM C 36, or it may be a membrane which alone acts as an air barrier but which is attached to a panel, such as the foil cladding of fibrous glass duct board.

Air Duct. A conduit used to transport air to or from heating, cooling, air conditioning, or ventilating equipment, including DUCT FITTINGS, PLENUM CHAMBERS, and PLENUMS attached directly to the HAC equipment; but excluding those portions of the building which are typically inhabitable, as well as cavities of the building, storage cabinets and vanities, and other fixtures of the building.

Air Handler. The fan unit of a furnace and the fan-coil unit of a split-system or packaged air conditioner or HEAT PUMP.

Air Porosity. A measure of the ability of a material to transmit air through the plane of the material.

Attic. An enclosed unconditioned space, located immediately below an uninsulated roof and immediately above a ceiling of a building.

Breach. In an AIR BARRIER, a joint, seam, crack, rupture, tear, rift, fissure or other discontinuity or interruption.

Closure Systems. The materials, processes and related standards, as identified in Section 100.0(a)1. when installed in accord with the provisions of Section 100.0(a)2.

Dense Mastics. Frequently supplied by manufacturers as semifluid, putty-like ribbons, DENSE MASTICS contain nearly 100 percent solids; others are supplied as solids, which are applied using heat to render them temporarily fluid. They require no curing in air and may be used without reinforcing fabric, but may be used only in *lap-joints* or *flange-joints*, wherein the mastic resides between two parallel surfaces of the AIR BARRIER, or in *fillet-joints*, wherein the mastic resides within a recess or an inside right-angle formed by the AIR BARRIER. All mastics must meet standard MODL-1 at minimum. See also MASTICS.

Diapered Joint. A diapered joint is a joint formed between a DUCT FITTING and fibrous glass duct board in which the outer jacket of a NONMETALLIC FLEXIBLE DUCT section passes over the flange of and intervening DUCT FITTING, between the flange and the rigid duct board, through a hole cut into the rigid duct board and into the duct board cavity where it is attached to the fitting.

Drawband. A clamp which surrounds the mated union of a DUCT FITTING and either the inner core or the outer jacket of a section of NONMETALLIC FLEXIBLE DUCT. The clamp, when tightened, shall fastening either the inner core or the outer jacket to the DUCT FITTING. A raised bead should be present on the DUCT FITTING to prevent movement of the drawband and to prevent separation of the union. Tension ties, clinch bands, draw ties, and straps are considered drawbands.

Duct Fitting. A general expression for all couplings used to join sections of AIR DUCT to other distribution system components. Duct fittings are used to join separate sections of NONMETALLIC FLEXIBLE DUCT or to join a section of NONMETALLIC FLEXIBLE DUCT to another distribution system component. Duct fittings may be classified as either *terminal* fittings or *intermediate* fittings. *Terminal* fittings join NONMETALLIC FLEXIBLE DUCT and other AIR DUCT to supply outlets and return inlets at the ends of the distribution system; this class of fittings includes register and return boots and register and return boxes. *Intermediate* fittings join NONMETALLIC FLEXIBLE DUCT to other sections of NONMETALLIC FLEXIBLE DUCT, to sections of other types of duct such as rigid fibrous glass duct board, and to mechanical equipment components such as AIR HANDLERS and furnaces; this class of fittings includes collars, take-offs, tap-ins, sleeves, and the inlets and outlets of AIR HANDLER cabinets and furnaces. A raised bead or an indented groove should be present on the duct fitting to prevent movement of the DRAWBAND and thus detachment of the NONMETALLIC FLEXIBLE DUCT from the duct fitting.

Enclosed Support Platform. A framed enclosure which supports the AIR HANDLER of a central heating or air conditioning unit. When such an enclosed platform provides a housing for the transport of return air from the return air inlet(s) to the inlet of the heating or air conditioning unit, the platform must contain a duct section fabricated to contain without leakage the return air stream. In jurisdictions which have adopted the Standard

Mechanical Code, materials used in constructing return duct, if located within two feet of the heating unit casing, must meet either Class 0 or Class 1 Surface Burning Standards [MODL-1]. At distances of two feet and greater, return duct materials may be less fire resistant, with Flame Spread Ratings $\leq$ 200. Refer to Section 503, Standard Mechanical Code, for additional information on allowable materials. To meet the requirements of the National Fire Protection Association standard 90B, which is incorporated by reference into the Standard Mechanical Code, that portion of return ducts directly beneath heating units with bottom-return shall be fabricated of non-combustible material(s), as tested under ASTM E 136, if incandescent particles could fall from the heating unit.

Gasketing. When used in relation to air distribution systems, a compressible, resilient packing capable of filling all gaps and creating an air-tight SEAL between the duct components being joined. It is a material which is distinct from the components being joined. Gasketing should meet standard MODL-1.

Heat Pump. A mechanical refrigeration-cycle system which has been designed to accomplish space heating or water heating or both and which, when the evaporator and condenser effects are reversed, may be used for space air conditioning or water chilling.

Infiltration. The uncontrolled air leakage through cracks and openings in any building element and around windows and doors of a building, caused by the pressure effects of wind, HVAC distribution system leaks or the effect of differences between the indoor and outdoor air densities, called stack effect.

Integral-Flange Duct Fitting. A type of intermediate DUCT FITTING. To be an integral-flange duct fitting, the fitting must have a flange of 5/8 inch minimum width which is MECHANICALLY FASTENED to and SEALED to the cylinder or sleeve of the fitting. A function of this flange is to provide a surface which can be SEALED to rigid duct board.

Mastic. When used in relation to air distribution systems, a thick, pliable paste capable of filling gaps between the mated parts of distribution system components and of adhering well to them. Mastics are frequently used in combination with reinforcing fabric. All mastics must meet standard MODL-1 at minimum. See also DENSE MASTICS.

Mechanical Closet. A room which contains the AIR HANDLER of a central heating or air conditioning unit and which is less than 60 square feet in floor area. A mechanical closet may or may not be a PLENUM CHAMBER.

Mechanically Fastened or Mechanical Fastening. The attachment of one object or sub-part of an object to another in which the principal device binding the objects is a fastener or fasteners. Fasteners include DRAWBANDS, clinching staples, metal wire, welds, screws, bolts, nuts, nails, rivets, and sheet metal crimps, spin-in flanges, dovetail flanges, drive-slips, standing seams, pocket locks, Pittsburgh locks, snap locks, grooved seams, double corner seams, and cleats, but do not include adhesives, pressure-sensitive tapes or MASTICS.

Nonmetallic Flexible Duct. A type of round flexible AIR DUCT comprised of a three-layer composite. The innermost layer, which contacts the air stream, is a wire-reinforced inner core, most often made of plastic and reinforced by a helical wire. The middle layer is an insulation blanket. And, the outermost layer is a scrim-reinforced jacket usually made of plastic.

Plenum. Part of the distribution system, the plenum is a dispensing or gathering manifold to which two or more AIR DUCTS are connected. It is considered AIR DUCT; and all closure, insulation and other requirements of AIR DUCT shall apply to a plenum.

Plenum Chamber. A plenum chamber is a room or closet within a conditioned space (1) which contains either a return air inlet or an inlet of an AIR HANDLER, but which contains no supply air outlet, and (2) which confines, by means of its walls, ceiling and floor, a return air stream during all of or a portion of its journey to the inlet of an AIR HANDLER. A MECHANICAL CLOSET is considered a PLENUM CHAMBER, when its interior surfaces confine return air in this manner. The walls, ceilings, floors and other contents of plenum chambers are restricted by the Standard Mechanical Code either (a) to materials which are non-combustible tested under standard ASTM E 136 or (b) to combustible materials which meet Class 1 Surface Burning Standards [MODL-1]: Flame Spread $\leq$ 25, Smoke Developed $\leq$ 50. For residential buildings, wood louvered doors, wood frame mechanical equipment supports and approved plumbing and electrical wiring are exempted by this mechanical code from these non-combustible and Class 1 Surface Burning requirements. The Standard Mechanical and Building Codes in their Definitions chapters, apparently include gypsum wallboard in its definition of non-combustible materials.

Seal, Sealing or Sealed. When used in relation to air distribution systems and mechanical equipment, seal, sealing or sealed shall mean the use of an approved CLOSURE SYSTEM, either continuous welds, adhesives, gaskets, tape systems or combinations thereof, to close joints, seams, and other openings in the AIR BARRIERS of AIR DUCT, AIR HANDLERS, and PLENUM CHAMBERS, through which air leakage would otherwise occur. No joint or opening from which a CLOSURE SYSTEM is absent shall be considered SEALED unless considered otherwise in specific cases identified by this Code. Closeness of fit between mated parts, alone, shall not be considered a SEAL.

Appendix: Standards

ACCA-1 **Manual D: Duct Design For Residential Winter And Summer Air Conditioning And Equipment Selection (Second Edition)**, Air Conditioning Contractors Of America.

ASHR-1 **ASHRAE Handbook, Fundamentals Volume, 1993 Edition**, American Society of Heating, Refrigerating and Air Conditioning Engineers.

GYPS-1 **Recommended Specifications for the Application and Finishing of Gypsum Board, 1989**, Gypsum Association. (This standard, as GA-216, is a part of the Standard Building Code by reference.)

MODL-1 Class 1 Surface Burning Standards. A product meets Class 1 Surface Burning standards if it exhibits the following surface burning characteristics when tested under either UL 723 or ASTM E 84 test procedures: a Flame Spread Rating of not over 25 without evidence of continued progressive combustion and a Smoke Developed Rating of not over 50. Compliance by a product with this definition is not equivalent to compliance with UL standard 181. However, since the UL 723 test procedure is one part of the UL 181 standard, all products meeting the UL 181 standard also satisfy this definition. It is not mandatory that a product be tested solely by UL but only that it be tested under either UL 723 or ASTM E 84 test procedures.

MODL-2 Model Code standard for mastic systems. Applied Research Laboratories (ARL) is in the process of developing a listing for mastics based on this standard. Contact ARL at 305 624-4800 for more information. Mastics must have undergone successfully the following component tests of UL181 which are relevant to the type of duct material being closed.

a. **Galvanized Metal Duct:** Surface Burning Characteristics Class 1 (waived in some cases), Burning, Mold Growth and Humidity, Temperature, Static Load, Impact, Pressure, Collapse, Tension, Torsion, and Leakage;

b. **Fibrous Glass Duct Board**: Surface Burning Characteristics Class 1, Burning, Mold Growth and Humidity, Temperature, Puncture, Impact, Pressure, Tension, and Leakage; and

c. **Nonmetallic Flexible Duct:** Surface Burning Characteristics Class 1, Bending, Burning, Mold Growth and Humidity, Temperature, Static Load, Impact, Pressure, Collapse, Tension, Torsion, and Leakage.

Underwriters Laboratories, Inc. identified these component tests by duct type in letters to the Jacksonville Electric Authority dated January 23, 1992 and August 23, 1993.

NAIM-1 Three NAIMA texts comprise this standard: **Fibrous Glass Duct Construction Standards** (AH-116), **Residential Fibrous Glass Duct Construction Standards** (AH-119), and **Fibrous Glass Duct Construction With 1½" Duct Board** (AH-120), North American Insulation Manufacturers Association (NAIMA, formerly called TIMA, the Thermal Insulation Manufacturers Association), 1993.

SMAC-1 **HVAC Duct Construction Standards, Metal and Flexible, First Edition 1985**, Sheet Metal and Air Conditioning Contractors National Association, Inc.

SMAC-2 **HVAC Duct Systems Inspection Guide**, Sheet Metal and Air Conditioning Contractors National Association, Inc., 1989.

SMAC-3 **HVAC Air Duct Leakage Manual, First Edition**, Sheet Metal and Air Conditioning Contractors National Association, Inc., 1985.

SMAC-4 **Installation Standards for Residential Heating and Air Conditioning Systems**, Sheet Metal and Air Conditioning Contractors National Association, Inc., 1985.

UL-1 **UL181, Standard for Factory-Made Air Ducts and Connectors, 1990**, Underwriters Laboratories, Inc.

UL-2 **UL181A, Closure Systems For Use With Air Ducts And Connectors**, UL181A-P for pressure-sensitive tapes and UL181A-H for heat-activated tapes, 1991, Appendix A of Standard UL181, Underwriters Laboratories, Inc.

UL-3 Under development. UL181A-M, Mastic Closure Systems For Use With Air Ducts And Connectors, Appendix A of Standard UL181, Underwriters Laboratories, Inc.

UL-4 Under development. UL181B, Closure Systems For Use With Flexible Nonmetallic Air Ducts And Connectors, Appendix B of Standard UL181, Underwriters Laboratories, Inc.