mance based on normal temperature and, where applicable, elevated temperature. Calculations and manufacturer's fan curves shall be part of the documentation procedures. Fans shall be supported and restrained by noncombustible devices in accordance with the structural design requirements of the *International Building Code*. Motors driving fans shall not be operating beyond their nameplate horsepower (kilowatts) as determined from measurement of actual current draw. Motors driving fans shall have a minimum service factor of 1.15.

[F] 513.11 Power systems. The smoke control system shall be supplied with two sources of power. Primary power shall be the normal building power systems. Secondary power shall be from an *approved* standby source complying with Chapter 27 of the *International Building Code*. The standby power source and its transfer switches shall be in a room separate from the normal power transformers and switch gear and ventilated directly to and from the exterior. The room shall be enclosed with not less than 1-hour fire-resistance-rated fire barriers constructed in accordance with Section 707 of the *International Building Code* or horizontal assemblies constructed in accordance with Section 711 of the *International Building Code*, or both. Power distribution from the two sources shall be by independent routes. Transfer to full standby power shall be automatic and within 60 seconds of failure of the primary power. The systems shall comply with NFPA 70.

[F] 513.11.1 Power sources and power surges. Elements of the smoke management system relying on volatile memories or the like shall be supplied with uninterruptible power sources of sufficient duration to span 15-minute primary power interruption. Elements of the smoke management system susceptible to power surges shall be suitably protected by conditioners, suppressors or other *approved* means.

[F] 513.12 Detection and control systems. Fire detection systems providing control input or output signals to mechanical smoke control systems or elements thereof shall comply with NFPA 72 and the requirements of Chapter 9 of the *International Building Code* or the *International Fire Code*. Such systems shall be equipped with a control unit complying with UL 864 and listed as smoke control *equipment*.

Control systems for mechanical smoke control systems shall include provisions for verification. Verification shall include positive confirmation of actuation, testing, manual override, the presence of power downstream of all disconnects and, through a preprogrammed weekly test sequence report, abnormal conditions audibly, visually and by printed report.

[F] 513.12.1 Wiring. In addition to meeting the requirements of NFPA 70, all wiring, regardless of voltage, shall be fully enclosed within continuous raceways.

[F] 513.12.2 Activation. Smoke control systems shall be activated in accordance with the *International Building Code* or the *International Fire Code*.

[F] 513.12.3 Automatic control. Where completely automatic control is required or used, the automatic control sequences shall be initiated from an appropriately zoned automatic sprinkler system complying with Section 903.3.1.1 of the *International Fire Code*, from manual controls that are readily accessible to the fire department, and any smoke detectors required by engineering analysis.

[F] 513.13 Control-air tubing. Control-air tubing shall be of sufficient size to meet the required response times. Tubing shall be flushed clean and dry prior to final connections. Tubing shall be adequately supported and protected from damage. Tubing passing through concrete or masonry shall be sleeved and protected from abrasion and electrolytic action.

[F] 513.13.1 Materials. Control-air tubing shall be hard-drawn copper, Type L, ACR in accordance with ASTM B 42, ASTM B 43, ASTM B 68, ASTM B 88, ASTM B 251 and ASTM B 280. Fittings shall be wrought copper or brass, solder type in accordance with ASME B 16.18 or ASME B 16.22. Changes in direction shall be made with appropriate tool bends. Brass compression-type fittings shall be used at final connection to devices; other joints shall be brazed using a BCuP5 brazing alloy with solidus above 1,100°F (593°C) and liquids below 1,500°F (816°C). Brazing flux shall be used on copper-to-brass joints only.

Exception: Nonmetallic tubing used within control panels and at the final connection to devices provided all of the following conditions are met:

1. Tubing shall comply with the requirements of Section 602.2.1.3.
2. Tubing and connected device shall be completely enclosed within a galvanized or paint-grade steel enclosure having a minimum thickness of 0.0296 inch (0.7534 mm) (No. 22 gage). Entry to the enclosure shall be by copper tubing with a protective grommet of Neoprene or Teflon or by suitable brass compression to male barbed adapter.
3. Tubing shall be identified by appropriately documented coding.
4. Tubing shall be neatly tied and supported within the enclosure. Tubing bridging cabinets and doors or moveable devices shall be of sufficient length to avoid tension and excessive stress. Tubing shall be protected against abrasion. Tubing serving devices on doors shall be fastened along hinges.

[F] 513.13.2 Isolation from other functions. Control tubing serving other than smoke control functions shall be isolated by automatic isolation valves or shall be an independent system.

[F] 513.13.3 Testing. Test control-air tubing at three times the operating pressure for not less than 30 minutes without any noticeable loss in gauge pressure prior to final connection to devices.

[F] 513.14 Marking and identification. The detection and control systems shall be clearly marked at all junctions, accesses and terminations.

[F] 513.15 Control diagrams. Identical control diagrams shall be provided and maintained as required by the *International Fire Code*.

[F] 513.16 Fire fighter's smoke control panel. A fire fighter's smoke control panel for fire department emergency response purposes only shall be provided in accordance with the *International Fire Code*.

[F] 513.17 System response time. Smoke control system activation shall comply with the *International Fire Code*.

[F] 513.18 Acceptance testing. Devices, *equipment*, components and sequences shall be tested in accordance with the *International Fire Code*.

[F] 513.19 System acceptance. Acceptance of the smoke control system shall be in accordance with the *International Fire Code*.

SECTION 514
ENERGY RECOVERY VENTILATION SYSTEMS

514.1 General. Energy recovery ventilation systems shall be installed in accordance with this section. Where required for purposes of energy conservation, energy recovery ventilation systems shall also comply with the *International Energy Conservation Code*. Ducted heat recovery ventilators shall be listed and labeled in accordance with UL 1812. Nonducted heat recovery ventilators shall be listed and labeled in accordance with UL 1815.

514.2 Prohibited applications. Energy recovery ventilation systems shall not be used in the following systems:

1. Hazardous exhaust systems covered in Section 510.
2. Dust, stock and refuse systems that convey explosive or flammable vapors, fumes or dust.
3. Smoke control systems covered in Section 513.
4. Commercial kitchen exhaust systems serving Type I and Type II hoods.
5. Clothes dryer exhaust systems covered in Section 504.

514.3 Access. A means of access shall be provided to the heat exchanger and other components of the system as required for service, maintenance, repair or replacement.

514.4 Recirculated air. Air conveyed within energy recovery systems shall not be considered as recirculated air where the energy recovery ventilation system is constructed to limit cross-leakage between air streams to less than 10 percent of the total airflow design capacity.

CHAPTER 6
DUCT SYSTEMS

SECTION 601
GENERAL

601.1 Scope. Duct systems used for the movement of air in air-conditioning, heating, ventilating and exhaust systems shall conform to the provisions of this chapter except as otherwise specified in Chapters 5 and 7.

Exception: Ducts discharging combustible material directly into any *combustion* chamber shall conform to the requirements of NFPA 82.

[B] 601.2 Air movement in egress elements. Corridors shall not serve as supply, return, exhaust, relief or *ventilation air* ducts.

Exceptions:

1. Use of a corridor as a source of *makeup air* for exhaust systems in rooms that open directly onto such corridors, including toilet rooms, bathrooms, dressing rooms, smoking lounges and janitor closets, shall be permitted, provided that each such corridor is directly supplied with outdoor air at a rate greater than the rate of *makeup air* taken from the corridor.
2. Where located within a *dwelling unit*, the use of corridors for conveying return air shall not be prohibited.
3. Where located within tenant spaces of 1,000 square feet (93 m^2) or less in area, use of corridors for conveying return air is permitted.
4. Incidental air movement from pressurized rooms within health care facilities, provided that the corridor is not the primary source of supply or return to the room.

[B] 601.2.1 Corridor ceiling. Use of the space between the corridor ceiling and the floor or roof structure above as a return air *plenum* is permitted for one or more of the following conditions:

1. The corridor is not required to be of fire-resistance-rated construction;
2. The corridor is separated from the *plenum* by fire-resistance-rated construction;
3. The air-handling system serving the corridor is shut down upon activation of the air-handling unit smoke detectors required by this code;
4. The air-handling system serving the corridor is shut down upon detection of sprinkler waterflow where the building is equipped throughout with an automatic sprinkler system; or
5. The space between the corridor ceiling and the floor or roof structure above the corridor is used as a component of an *approved* engineered smoke control system.

[B] 601.3 Exits. *Equipment* and ductwork for exit enclosure ventilation shall comply with one of the following items:

1. Such *equipment* and ductwork shall be located exterior to the building and shall be directly connected to the exit enclosure by ductwork enclosed in construction as required by the *International Building Code* for shafts.
2. Where such *equipment* and ductwork is located within the exit enclosure, the intake air shall be taken directly from the outdoors and the *exhaust air* shall be discharged directly to the outdoors, or such air shall be conveyed through ducts enclosed in construction as required by the *International Building Code* for shafts.
3. Where located within the building, such *equipment* and ductwork shall be separated from the remainder of the building, including other mechanical *equipment*, with construction as required by the *International Building Code* for shafts.

In each case, openings into fire-resistance-rated construction shall be limited to those needed for maintenance and operation and shall be protected by self-closing fire-resistance-rated devices in accordance with the *International Building Code* for enclosure wall opening protectives. Exit enclosure ventilation systems shall be independent of other building ventilation systems.

601.4 Contamination prevention. Exhaust ducts under positive pressure, chimneys and vents shall not extend into or pass through ducts or plenums.

Exceptions:

1. Exhaust systems located in ceiling return air plenums over spaces that are permitted to have 10 percent recirculation in accordance with Section 403.2.1, Item 4. The exhaust duct joints, seams and connections shall comply with Section 603.9.
2. This section shall not apply to chimneys and vents that pass through plenums where such venting systems comply with one of the following requirements:
   2.1. The venting system shall be listed for positive pressure applications and shall be sealed in accordance with the vent manufacturer's instructions.
   2.2. The venting system shall be installed such that fittings and joints between sections are not installed in the above ceiling space.
   2.3. The venting system shall be installed in a conduit or enclosure with sealed joints separating the interior of the conduit or enclosure from the ceiling space.

SECTION 602
PLENUMS

602.1 General. Supply, return, exhaust, relief and *ventilation air* plenums shall be limited to uninhabited crawl spaces, areas above a ceiling or below the floor, attic spaces and mechanical *equipment* rooms. Plenums shall be limited to one fire area. Fuel-fired appliances shall not be installed within a *plenum*.

602.2 Construction. *Plenum* enclosures shall be constructed of materials permitted for the type of construction classification of the building.

The use of gypsum boards to form plenums shall be limited to systems where the air temperatures do not exceed 125ºF (52ºC) and the building and mechanical system design conditions are such that the gypsum board surface temperature will be maintained above the airstream dew-point temperature. Air plenums formed by gypsum boards shall not be incorporated in air-handling systems utilizing evaporative coolers.

602.2.1 Materials within plenums. Except as required by Sections 602.2.1.1 through 602.2.1.5, materials within plenums shall be noncombustible or shall be listed and labeled as having a flame spread index of not more than 25 and a smoke-developed index of not more than 50 when tested in accordance with ASTM E 84 or UL 723.

Exceptions:

1. Rigid and flexible ducts and connectors shall conform to Section 603.
2. Duct coverings, linings, tape and connectors shall conform to Sections 603 and 604.
3. This section shall not apply to materials exposed within plenums in one- and two-family dwellings.
4. This section shall not apply to smoke detectors.
5. Combustible materials fully enclosed within one of the following:
   - 5.1. Continuous noncombustible raceways or enclosures.
   - 5.2. Approved gypsum board assemblies.
   - 5.3. Materials listed and labeled for installation within a plenum.
6. Materials in Group H, Division 5 fabrication areas and the areas above and below the fabrication area that share a common air recirculation path with the fabrication area.

602.2.1.1 Wiring. Combustible electrical wires and cables and optical fiber cables exposed within a plenum shall be listed as having a maximum peak optical density of 0.50 or less, an average optical density of 0.15 or less, and a maximum flame spread distance of 5 feet (1524 mm) or less when tested in accordance with NFPA 262 or shall be installed in metal raceways or metal sheathed cable. Combustible optical fiber and communication raceways exposed within a plenum shall be listed as having a maximum peak optical density of 0.5 or less, an average optical density of 0.15 or less, and a maximum flame spread distance of 5 feet (1524 mm) or less when tested in accordance with ANSI/UL 2024. Only plenum-rated wires and cables shall be installed in plenum-rated raceways. Electrical wires and cables, optical fiber cables and raceways addressed in this section shall be listed and labeled and shall be installed in accordance with NFPA 70.

602.2.1.2 Fire sprinkler piping. Plastic fire sprinkler piping exposed within a *plenum* shall be used only in wet pipe systems and shall have a peak optical density not greater than 0.50, an average optical density not greater than 0.15, and a flame spread of not greater than 5 feet (1524 mm) when tested in accordance with UL 1887. Piping shall be *listed* and *labeled*.

602.2.1.3 Pneumatic tubing. Combustible pneumatic tubing exposed within a *plenum* shall have a peak optical density not greater than 0.50, an average optical density not greater than 0.15, and a flame spread of not greater than 5 feet (1524 mm) when tested in accordance with UL 1820. Combustible pneumatic tubing shall be *listed* and *labeled*.

602.2.1.4 Electrical equipment in plenums. Electrical *equipment* exposed within a *plenum* shall comply with Sections 602.2.1.4.1 and 602.2.1.4.2.

602.2.1.4.1 Equipment in metallic enclosures. Electrical *equipment* with metallic enclosures exposed within a *plenum* shall be permitted.

602.2.1.4.2 Equipment in combustible enclosures. Electrical *equipment* with combustible enclosures exposed within a *plenum* shall be *listed* and *labeled* for such use in accordance with UL 2043.

602.2.1.5 Foam plastic insulation. Foam plastic insulation used as interior wall or ceiling finish, or as interior trim, in plenums shall exhibit a flame spread index of 75 or less and a smoke-developed index of 450 or less when tested in accordance with ASTM E 84 or UL 723 and shall also comply with one or more of Sections 602.2.1.5.1, 602.2.1.5.2 and 602.2.1.5.3.

602.2.1.5.1 Separation required. The foam plastic insulation shall be separated from the plenum by a thermal barrier complying with Section 2603.4 of the *International Building Code* and shall exhibit a flame spread index of 75 or less and a smoke-developed index of 450 or less when tested in accordance with ASTM E 84 or UL 723 at the thickness and density intended for use.

602.2.1.5.2 Approval. The foam plastic insulation shall exhibit a flame spread index of 25 or less and a smoke-developed index of 50 or less when tested in accordance with ASTM E 84 or UL 723 at the thickness and density intended for use and shall meet the acceptance criteria of Section 803.1.2 of the *International Building Code* when tested in accordance with NFPA 286.

The foam plastic insulation shall be approved based on tests conducted in accordance with Section 2603.10 of the *International Building Code*.

602.2.1.5.3 Covering. The foam plastic insulation shall be covered by corrosion-resistant steel having a base metal thickness of not less than 0.0160 inch (0.4 mm) and shall exhibit a flame spread index of 75 or less and a smoke-developed index of 450 or less when tested in accordance with ASTM E 84 or UL 723 at the thickness and density intended for use.

602.3 Stud cavity and joist space plenums. Stud wall cavities and the spaces between solid floor joists to be utilized as air plenums shall comply with the following conditions:

1. Such cavities or spaces shall not be utilized as a *plenum* for supply air.
2. Such cavities or spaces shall not be part of a required fire-resistance-rated assembly.
3. Stud wall cavities shall not convey air from more than one floor level.
4. Stud wall cavities and joist space plenums shall comply with the floor penetration protection requirements of the *International Building Code*.
5. Stud wall cavities and joist space plenums shall be isolated from adjacent concealed spaces by *approved* fireblocking as required in the *International Building Code*.
6. Studwall cavities in the outside walls of building envelope assemblies shall not be utilized as air plenums.

[B] 602.4 Flood hazard. For structures located in flood hazard areas, plenum spaces shall be located above the elevation required by Section 1612 of the *International Building Code* for utilities and attendant equipment or shall be designed and constructed to prevent water from entering or accumulating within the plenum spaces during floods up to such elevation. If the plenum spaces are located below the elevation required by Section 1612 of the *International Building Code* for utilities and attendant equipment, they shall be capable of resisting hydrostatic and hydrodynamic loads and stresses, including the effects of buoyancy, during the occurrence of flooding up to such elevation.

SECTION 603
DUCT CONSTRUCTION AND INSTALLATION

603.1 General. An air distribution system shall be designed and installed to supply the required distribution of air. The installation of an air distribution system shall not affect the fire protection requirements specified in the *International Building Code*. Ducts shall be constructed, braced, reinforced and installed to provide structural strength and durability.

603.2 Duct sizing. Ducts installed within a single *dwelling unit* shall be sized in accordance with ACCA Manual D or other *approved* methods. Ducts installed within all other buildings shall be sized in accordance with the ASHRAE *Handbook of Fundamentals* or other equivalent computation procedure.

603.3 Duct classification. Ducts shall be classified based on the maximum operating pressure of the duct at pressures of positive or negative 0.5, 1.0, 2.0, 3.0, 4.0, 6.0 or 10.0 inches (1 inch w.c. = 248.7 Pa) of water column. The pressure classification of ducts shall equal or exceed the design pressure of the air distribution in which the ducts are utilized.

603.4 Metallic ducts. All metallic ducts shall be constructed as specified in the SMACNA *HVAC Duct Construction Standards-Metal and Flexible*.

Exception: Ducts installed within single *dwelling units* shall have a minimum thickness as specified in Table 603.4.

603.4.1 Minimum fasteners. Round metallic ducts shall be mechanically fastened by means of at least three sheet metal screws or rivets spaced equally around the joint.

Exception: Where a duct connection is made that is partially inaccessible, three screws or rivets shall be equally spaced on the exposed portion so as to prevent a hinge effect.

603.5 Nonmetallic ducts. Nonmetallic ducts shall be constructed with Class 0 or Class 1 duct material and shall comply with UL 181. Fibrous duct construction shall conform to the SMACNA *Fibrous Glass Duct Construction Standards* or NAIMA *Fibrous Glass Duct Construction Standards*. The air temperature within nonmetallic ducts shall not exceed 250ºF (121ºC).

603.5.1 Gypsum ducts. The use of gypsum boards to form air shafts (ducts) shall be limited to return air systems where the air temperatures do not exceed 125ºF

TABLE 603.4
DUCT CONSTRUCTION MINIMUM SHEET METAL THICKNESSES FOR SINGLE DWELLING UNITS

DUCT SIZE	GALVANIZED		ALUMINUM
	Minimum thickness (in.)	Equivalent galvanized gage no.	MINIMUM THICKNESS (in.)
Round ducts and enclosed rectangular ducts			
14 inches or less	0.0157	28	0.0175
16 and 18 inches	0.0187	26	0.018
20 inches and over	0.0236	24	0.023
Exposed rectangular ducts			
14 inches or less	0.0157	28	0.0175
Over 14 inches[a]	0.0187	26	0.018

For SI: 1 inch = 25.4 mm, 1 inch water gage = 249 Pa.

a. For duct gages and reinforcement requirements at static pressures of $^1/_2$-inch, 1-inch and 2-inch w.g., SMACNA *HVAC Duct Construction Standards*, Tables 2-1, 2-2 and 2-3, shall apply.

(52ºC) and the gypsum board surface temperature is maintained above the airstream dew-point temperature. Air ducts formed by gypsum boards shall not be incorporated in air-handling systems utilizing evaporative coolers.

603.6 Flexible air ducts and flexible air connectors. Flexible air ducts, both metallic and nonmetallic, shall comply with Sections 603.6.1, 603.6.1.1, 603.6.3 and 603.6.4. Flexible air connectors, both metallic and nonmetallic, shall comply with Sections 603.6.2 through 603.6.4.

603.6.1 Flexible air ducts. Flexible air ducts, both metallic and nonmetallic, shall be tested in accordance with UL 181. Such ducts shall be *listed* and *labeled* as Class 0 or Class 1 flexible air ducts and shall be installed in accordance with Section 304.1.

603.6.1.1 Duct length. Flexible air ducts shall not be limited in length.

603.6.2 Flexible air connectors. Flexible air connectors, both metallic and nonmetallic, shall be tested in accordance with UL 181. Such connectors shall be *listed* and *labeled* as Class 0 or Class 1 flexible air connectors and shall be installed in accordance with Section 304.1.

603.6.2.1 Connector length. Flexible air connectors shall be limited in length to 14 feet (4267 mm).

603.6.2.2 Connector penetration limitations. Flexible air connectors shall not pass through any wall, floor or ceiling.

603.6.3 Air temperature. The design temperature of air to be conveyed in flexible air ducts and flexible air connectors shall be less than 250ºF (121ºC).

603.6.4 Flexible air duct and air connector clearance. Flexible air ducts and air connectors shall be installed with a minimum *clearance* to an *appliance* as specified in the *appliance* manufacturer's installation instructions.

603.7 Rigid duct penetrations. Duct system penetrations of walls, floors, ceilings and roofs and air transfer openings in such building components shall be protected as required by Section 607. Ducts in a private garage that penetrate a wall or ceiling that separates a dwelling from a private garage shall be continuous, shall be constructed of sheet steel having a thickness of not less than 0.0187 inch (0.4712 mm) (No.26 gage) and shall not have openings into the garage. Fire and smoke dampers are not required in such ducts passing through the wall or ceiling separating a dwelling from a private garage except where required by Chapter 7 of the *International Building Code*.

603.8 Underground ducts. Ducts shall be *approved* for underground installation. Metallic ducts not having an *approved* protective coating shall be completely encased in a minimum of 2 inches (51 mm) of concrete.

603.8.1 Slope. Ducts shall have a minimum slope of $^1/_8$ inch per foot (10.4 mm/m) to allow drainage to a point provided with access.

603.8.2 Sealing. Ducts shall be sealed and secured prior to pouring the concrete encasement.

603.8.3 Plastic ducts and fittings. Plastic ducts shall be constructed of PVC having a minimum pipe stiffness of 8 psi (55 kPa) at 5-percent deflection when tested in accordance with ASTM D 2412. Plastic duct fittings shall be constructed of either PVC or high-density polyethylene. Plastic duct and fittings shall be utilized in underground installations only. The maximum design temperature for systems utilizing plastic duct and fittings shall be 150°F (66°C).

603.9 Joints, seams and connections. All longitudinal and transverse joints, seams and connections in metallic and nonmetallic ducts shall be constructed as specified in SMACNA *HVAC Duct Construction Standards—Metal and Flexible* and NAIMA *Fibrous Glass Duct Construction Standards*. All joints, longitudinal and transverse seams and connections in ductwork shall be securely fastened and sealed with welds, gaskets, mastics (adhesives), mastic-plus-embedded-fabric systems, liquid sealants or tapes. Closure systems used to seal ductwork *listed* and *labeled* in accordance with UL 181A shall be marked "181A-P" for pressure-sensitive tape, "181 A-M" for mastic or "181 A-H" for heat-sensitive tape. Closure systems used to seal flexible air ducts and flexible air connectors shall comply with UL 181B and shall be marked "181B-FX" for pressure-sensitive tape or "181B-M" for mastic. Duct connections to flanges of air distribution system *equipment* shall be sealed and mechanically fastened. Mechanical fasteners for use with flexible nonmetallic air ducts shall comply with UL 181B and shall be marked "181B-C." Closure systems used to seal metal ductwork shall be installed in accordance with the manufacturer's installation instructions. Unlisted duct tape is not permitted as a sealant on any duct.

Exception: Continuously welded and locking-type longitudinal joints and seams in ducts operating at static pressures less than 2 inches of water column (500 Pa) pressure classification shall not require additional closure systems.

603.10 Supports. Ducts shall be supported at intervals not to exceed 12 feet (3658 mm) and shall be in accordance with SMACNA *HVAC Duct Construction Standards—Metal and Flexible*. Flexible and other factory-made ducts shall be supported in accordance with the manufacturer's instructions.

603.11 Furnace connections. Ducts connecting to a furnace shall have a *clearance* to combustibles in accordance with the furnace manufacturer's installation instructions.

603.12 Condensation. Provisions shall be made to prevent the formation of condensation on the exterior of any duct.

[B] 603.13 Flood hazard areas. For structures in flood hazard areas, ducts shall be located above the elevation required by Section 1612 of the *International Building Code* for utilities and attendant equipment or shall be designed and constructed to prevent water from entering or accumulating within the ducts during floods up to such elevation. If the ducts are located below the elevation required by Section 1612 of the *International Building Code* for utilities and attendant equipment, the ducts shall be capable of resisting hydrostatic and hydrodynamic loads and stresses, including the effects of buoyancy, during the occurrence of flooding up to such elevation.

603.14 Location. Ducts shall not be installed in or within 4 inches (102 mm) of the earth, except where such ducts comply with Section 603.8.

603.15 Mechanical protection. Ducts installed in locations where they are exposed to mechanical damage by vehicles or from other causes shall be protected by *approved* barriers.

603.16 Weather protection. All ducts including linings, coverings and vibration isolation connectors installed on the exterior of the building shall be protected against the elements.

603.17 Air dispersion systems. Air dispersion systems shall:

1. Be installed entirely in exposed locations.
2. Be utilized in systems under positive pressure.
3. Not pass through or penetrate fire-resistant-rated construction.
4. Be listed and labeled in compliance with UL 2518.

603.18 Registers, grilles and diffusers. Duct registers, grilles and diffusers shall be installed in accordance with the manufacturer's installation instructions. Volume dampers or other means of supply air adjustment shall be provided in the branch ducts or at each individual duct register, grille or diffuser. Each volume damper or other means of supply air adjustment used in balancing shall be provided with access.

603.18.1 Floor registers. Floor registers shall resist, without structural failure, a 200-pound (90.8 kg) concentrated load on a 2-inch-diameter (51 mm) disc applied to the most critical area of the exposed face.

603.18.2 Prohibited locations. Diffusers, registers and grilles shall be prohibited in the floor or its upward extension within toilet and bathing rooms required by the *International Building Code* to have smooth, hard, nonabsorbent surfaces.

Exception: *Dwelling units*.

SECTION 604
INSULATION

604.1 General. Duct insulation shall conform to the requirements of Sections 604.2 through 604.13 and the *International Energy Conservation Code*.

604.2 Surface temperature. Ducts that operate at temperatures exceeding 120°F (49°C) shall have sufficient thermal insulation to limit the exposed surface temperature to 120°F (49°C).

604.3 Coverings and linings. Coverings and linings, including adhesives when used, shall have a flame spread index not more than 25 and a smoke-developed index not more than 50, when tested in accordance with ASTM E 84 or UL 723, using the specimen preparation and mounting procedures of ASTM E 2231. Duct coverings and linings shall not flame, glow, smolder or smoke when tested in accordance with ASTM C 411 at the temperature to which they are exposed in service. The test temperature shall not fall below 250°F (121°C). Coverings and linings shall be listed and labeled.

604.4 Foam plastic insulation. Foam plastic used as duct coverings and linings shall conform to the requirements of Section 604.

604.5 Appliance insulation. *Listed* and *labeled* appliances that are internally insulated shall be considered as conforming to the requirements of Section 604.

604.6 Penetration of assemblies. Duct coverings shall not penetrate a wall or floor required to have a fire-resistance rating or required to be fireblocked.

604.7 Identification. External duct insulation, except spray polyurethane foam, and factory-insulated flexible duct shall be legibly printed or identified at intervals not greater than 36 inches (914 mm) with the name of the manufacturer, the thermal resistance *R*-value at the specified installed thickness and the flame spread and smoke-developed indexes of the composite materials. All duct insulation product *R*-values shall be based on insulation only, excluding air films, vapor retarders or other duct components, and shall be based on tested *C*-values at 75ºF (24ºC) mean temperature at the installed thickness, in accordance with recognized industry procedures. The installed thickness of duct insulation used to determine its *R*-value shall be determined as follows:

1. For duct board, duct liner and factory-made rigid ducts not normally subjected to compression, the nominal insulation thickness shall be used.
2. For duct wrap, the installed thickness shall be assumed to be 75 percent (25 percent compression) of nominal thickness.
3. For factory-made flexible air ducts, the installed thickness shall be determined by dividing the difference between the actual outside diameter and nominal inside diameter by two.
4. For spray polyurethane foam, the aged *R*-value per inch, measured in accordance with recognized industry standards, shall be provided to the customer in writing at the time of foam application.

604.8 Lining installation. Linings shall be interrupted at the area of operation of a fire damper and at a minimum of 6 inches (152 mm) upstream of and 6 inches (152 mm) downstream of electric-resistance and fuel-burning heaters in a duct system. Metal nosings or sleeves shall be installed over exposed duct liner edges that face opposite the direction of airflow.

604.9 Thermal continuity. Where a duct liner has been interrupted, a duct covering of equal thermal performance shall be installed.

604.10 Service openings. Service openings shall not be concealed by duct coverings unless the exact location of the opening is properly identified.

604.11 Vapor retarders. Where ducts used for cooling are externally insulated, the insulation shall be covered with a vapor retarder having a maximum permeance of 0.05 perm [2.87 ng/(Pa • s • m^2)] or aluminum foil having a minimum thickness of 2 mils (0.051 mm). Insulations having a permeance of 0.05 perm [2.87 ng/(Pa • s • m^2)] or less shall not be

required to be covered. All joints and seams shall be sealed to maintain the continuity of the vapor retarder.

604.12 Weatherproof barriers. Insulated exterior ducts shall be protected with an *approved* weatherproof barrier.

604.13 Internal insulation. Materials used as internal insulation and exposed to the airstream in ducts shall be shown to be durable when tested in accordance with UL 181. Exposed internal insulation that is not impermeable to water shall not be used to line ducts or plenums from the exit of a cooling coil to the downstream end of the drain pan.

SECTION 605
AIR FILTERS

605.1 General. Heating and air-conditioning systems of the central type shall be provided with *approved* air filters. Filters shall be installed in the return air system, upstream from any heat exchanger or coil, in an *approved* convenient location. Liquid adhesive coatings used on filters shall have a flash point not lower than 325ºF (163ºC).

605.2 Approval. Media-type and electrostatic-type air filters shall be *listed* and *labeled*. Media-type air filters shall comply with UL 900. High efficiency particulate air filters shall comply with UL 586. Electrostatic-type air filters shall comply with UL 867. Air filters utilized within *dwelling units* shall be designed for the intended application and shall not be required to be *listed* and *labeled*.

605.3 Airflow over the filter. Ducts shall be constructed to allow an even distribution of air over the entire filter.

SECTION 606
SMOKE DETECTION SYSTEMS CONTROL

606.1 Controls required. Air distribution systems shall be equipped with smoke detectors *listed* and *labeled* for installation in air distribution systems, as required by this section. Duct smoke detectors shall comply with UL 268A. Other smoke detectors shall comply with UL 268.

606.2 Where required. Smoke detectors shall be installed where indicated in Sections 606.2.1 through 606.2.3.

Exception: Smoke detectors shall not be required where air distribution systems are incapable of spreading smoke beyond the enclosing walls, floors and ceilings of the room or space in which the smoke is generated.

606.2.1 Return air systems. Smoke detectors shall be installed in return air systems with a design capacity greater than 2,000 cfm (0.9 m^3/s), in the return air duct or *plenum* upstream of any filters, *exhaust air* connections, outdoor air connections, or decontamination *equipment* and appliances.

Exception: Smoke detectors are not required in the return air system where all portions of the building served by the air distribution system are protected by area smoke detectors connected to a fire alarm system in accordance with the *International Fire Code*. The area smoke detection system shall comply with Section 606.4.

606.2.2 Common supply and return air systems. Where multiple air-handling systems share common supply or return air ducts or plenums with a combined design capacity greater than 2,000 cfm (0.9 m^3/s), the return air system shall be provided with smoke detectors in accordance with Section 606.2.1.

Exception: Individual smoke detectors shall not be required for each fan-powered terminal unit, provided that such units do not have an individual design capacity greater than 2,000 cfm (0.9 m^3/s) and will be shut down by activation of one of the following:

1. Smoke detectors required by Sections 606.2.1 and 606.2.3.
2. An *approved* area smoke detector system located in the return air *plenum* serving such units.
3. An area smoke detector system as prescribed in the exception to Section 606.2.1.

In all cases, the smoke detectors shall comply with Sections 606.4 and 606.4.1.

606.2.3 Return air risers. Where return air risers serve two or more stories and serve any portion of a return air system having a design capacity greater than 15,000 cfm (7.1 m^3/s), smoke detectors shall be installed at each story. Such smoke detectors shall be located upstream of the connection between the return air riser and any air ducts or plenums.

[F] 606.3 Installation. Smoke detectors required by this section shall be installed in accordance with NFPA 72. The required smoke detectors shall be installed to monitor the entire airflow conveyed by the system including return air and exhaust or relief air. Access shall be provided to smoke detectors for inspection and maintenance.

[F] 606.4 Controls operation. Upon activation, the smoke detectors shall shut down all operational capabilities of the air distribution system in accordance with the listing and labeling of appliances used in the system. Air distribution systems that are part of a smoke control system shall switch to the smoke control mode upon activation of a detector.

[F] 606.4.1 Supervision. The duct smoke detectors shall be connected to a fire alarm system where a fire alarm system is required by Section 907.2 of the *International Fire Code*. The actuation of a duct smoke detector shall activate a visible and audible supervisory signal at a constantly attended location.

Exceptions:

1. The supervisory signal at a constantly attended location is not required where the duct smoke detector activates the building's alarm-indicating appliances.
2. In occupancies not required to be equipped with a fire alarm system, actuation of a smoke detector shall activate a visible and audible signal in an *approved* location. Duct smoke detector trouble conditions shall activate a visible or audible signal in an *approved* location and shall be identified as air duct detector trouble.

[B] SECTION 607
DUCT AND TRANSFER OPENINGS

607.1 General. The provisions of this section shall govern the protection of duct penetrations and air transfer openings in assemblies required to be protected.

607.1.1 Ducts that penetrate fire-resistance-rated assemblies without dampers. Ducts that penetrate fire-resistance-rated assemblies and are not required by this section to have dampers shall comply with the requirements of Sections 714.2 through 714.3.3 of the *International Building Code*. Ducts that penetrate horizontal assemblies not required to be contained within a shaft and not required by this section to have dampers shall comply with the requirements of Sections 714.4 through 714.4.2.2 of the *International Building Code*.

607.1.1.1 Ducts that penetrate nonfire-resistance-rated assemblies. The space around a duct penetrating a nonfire-resistance-rated floor assembly shall comply with Section 717.6.3 of the *International Building Code*.

607.2 Installation. Fire dampers, smoke dampers, combination fire/smoke dampers and ceiling radiation dampers located within air distribution and smoke control systems shall be installed in accordance with the requirements of this section, and the manufacturer's installation instructions and listing.

607.2.1 Smoke control system. Where the installation of a fire damper will interfere with the operation of a required smoke control system in accordance with Section 909 of the *International Building Code*, *approved* alternative protection shall be used. Where mechanical systems including ducts and dampers used for normal building ventilation serve as part of the smoke control system, the expected performance of these systems in smoke control mode shall be addressed in the rational analysis required by Section 909.4 of the *International Building Code*.

607.2.2 Hazardous exhaust ducts. Fire dampers for hazardous exhaust duct systems shall comply with Section 510.

607.3 Damper testing, ratings and actuation. Damper testing, ratings and actuation shall be in accordance with Sections 607.3.1 through 607.3.3.

607.3.1 Damper testing. Dampers shall be listed and labeled in accordance with the standards in this section. Fire dampers shall comply with the requirements of UL 555. Only fire dampers *labeled* for use in dynamic systems shall be installed in heating, ventilation and *air-conditioning* systems designed to operate with fans on during a fire. Smoke dampers shall comply with the requirements of UL 555S. Combination fire/smoke dampers shall comply with the requirements of both UL 555 and UL 555S. Ceiling radiation dampers shall comply with the requirements of UL 555C or shall be tested as part of a fire-resistance-rated floor/ceiling or roof/ceiling assembly in accordance with ASTM E119 or UL 263.

607.3.2 Damper rating. Damper ratings shall be in accordance with Sections 607.3.2.1 through 607.3.2.3.

607.3.2.1 Fire damper ratings. Fire dampers shall have the minimum fire protection rating specified in Table 607.3.2.1 for the type of penetration.

TABLE 607.3.2.1
FIRE DAMPER RATING

TYPE OF PENETRATION	MINIMUM DAMPER RATING (hour)
Less than 3-hour fire-resistance-rated assemblies	$1^1/_2$
3-hour or greater fire-resistance-rated assemblies	3

607.3.2.2 Smoke damper ratings. Smoke damper leakage ratings shall be Class I or II. Elevated temperature ratings shall not be less than 250°F (121°C).

607.3.2.3 Combination fire/smoke damper ratings. Combination fire/smoke dampers shall have the minimum fire protection rating specified for fire dampers in Table 717.3.2.1 of the *International Building Code* for the type of penetration and shall also have a minimum smoke damper rating as specified in Section 717.3.2.2 of the *International Building Code*.

607.3.3 Damper actuation. Damper actuation shall be in accordance with Sections 607.3.3.1 through 607.3.3.4 as applicable.

607.3.3.1 Fire damper actuation device. The fire damper actuation device shall meet one of the following requirements:

1. The operating temperature shall be approximately 50°F (28°C) above the normal temperature within the duct system, but not less than 160°F (71°C).
2. The operating temperature shall be not more than 350°F (177°C) where located in a smoke control system complying with Section 909 of the *International Building Code.*

607.3.3.2 Smoke damper actuation. The smoke damper shall close upon actuation of a *listed* smoke detector or detectors installed in accordance with Section 907.3 of the *International Building Code* and one of the following methods, as applicable:

1. Where a smoke damper is installed within a duct, a smoke detector shall be installed in the duct within 5 feet (1524 mm) of the damper with no air outlets or inlets between the detector and the damper. The detector shall be *listed* for the air velocity, temperature and humidity anticipated at the point where it is installed. Other than in mechanical smoke control systems, dampers shall be closed upon fan shutdown where local smoke detectors require a minimum velocity to operate.
2. Where a smoke damper is installed above smoke barrier doors in a smoke barrier, a spot-type detector *listed* for releasing service shall be installed on either side of the smoke barrier door opening.

3. Where a smoke damper is installed within an unducted opening in a wall, a spot-type detector *listed* for releasing service shall be installed within 5 feet (1524 mm) horizontally of the damper.
4. Where a smoke damper is installed in a corridor wall or ceiling, the damper shall be permitted to be controlled by a smoke detection system installed in the corridor.
5. Where a total-coverage smoke detector system is provided within areas served by a heating, ventilation and air-conditioning (HVAC) system, smoke dampers shall be permitted to be controlled by the smoke detection system.

607.3.3.3 Combination fire/smoke damper actuation. Combination fire/smoke damper actuation shall be in accordance with Sections 607.3.3.1 and 607.3.3.2. Combination fire/smoke dampers installed in smoke control system shaft penetrations shall not be activated by local area smoke detection unless it is secondary to the smoke management system controls.

607.3.3.4 Ceiling radiation damper actuation. The operating temperature of a ceiling radiation damper actuation device shall be 50°F (28°C) above the normal temperature within the duct system, but not less than 160°F (71°C).

607.4 Access and identification. Fire and smoke dampers shall be provided with an *approved* means of access, large enough to permit inspection and maintenance of the damper and its operating parts. The access shall not affect the integrity of fire-resistance-rated assemblies. The access openings shall not reduce the fire-resistance rating of the assembly. Access points shall be permanently identified on the exterior by a label having letters not less than 0.5 inch (12.7 mm) in height reading: FIRE/SMOKE DAMPER, SMOKE DAMPER or FIRE DAMPER. Access doors in ducts shall be tight fitting and suitable for the required duct construction.

607.5 Where required. Fire dampers, smoke dampers and combination fire/smoke dampers shall be provided at the locations prescribed in Sections 607.5.1 through 607.5.7. Where an assembly is required to have both fire dampers and smoke dampers, combination fire/smoke dampers or a fire damper and smoke damper shall be required.

607.5.1 Fire walls. Ducts and air transfer openings permitted in fire walls in accordance with Section 706.11 of the *International Building Code* shall be protected with *listed* fire dampers installed in accordance with their listing.

607.5.1.1 Horizontal exits. A *listed smoke damper* designed to resist the passage of smoke shall be provided at each point that a duct or air transfer opening penetrates a *fire wall* that serves as a horizontal *exit.*

607.5.2 Fire barriers. Ducts and air transfer openings that penetrate fire barriers shall be protected with *listed* fire dampers installed in accordance with their listing. Ducts and air transfer openings shall not penetrate exit enclosures and exit passageways except as permitted by Sections 1022.5 and 1023.6, respectively, of the *International Building Code*.

Exception: Fire dampers are not required at penetrations of fire barriers where any of the following apply:

1. Penetrations are tested in accordance with ASTM E 119 or UL 263 as part of the fire-resistance-rated assembly.
2. Ducts are used as part of an *approved* smoke control system in accordance with Section 513 and where the fire damper would interfere with the operation of the smoke control system.
3. Such walls are penetrated by ducted HVAC systems, have a required fire-resistance rating of 1 hour or less, are in areas of other than Group H and are in buildings equipped throughout with an automatic sprinkler system in accordance with Section 903.3.1.1 or 903.3.1.2 of the *International Building Code*. For the purposes of this exception, a ducted HVAC system shall be a duct system for the structure's HVAC system. Such a duct system shall be constructed of sheet steel not less than 26 gage [0.0217 inch (0.55 mm)] thickness and shall be continuous from the air-handling *appliance* or *equipment* to the air outlet and inlet terminals.

607.5.2.1 Horizontal exits. A *listed smoke damper* designed to resist the passage of smoke shall be provided at each point that a duct or air transfer opening penetrates a *fire barrier* that serves as a horizontal *exit*.

607.5.3 Fire partitions. Ducts and air transfer openings that penetrate fire partitions shall be protected with *listed* fire dampers installed in accordance with their listing.

Exception: In occupancies other than Group H, fire dampers are not required where any of the following apply:

1. Corridor walls in buildings equipped throughout with an automatic sprinkler system in accordance with Section 903.3.1.1 or 903.3.1.2 of the *International Building Code* and the duct is protected as a through penetration in accordance with Section 714 of the *International Building Code*.
2. The partitions are tenant partitions in covered and open mall buildings where the walls are not required by provisions elsewhere in the *International Building Code* to extend to the underside of the floor or roof sheathing, slab or deck above.
3. The duct system is constructed of *approved* materials in accordance with Section 603 and the duct penetrating the wall complies with all of the following requirements:
   3.1. The duct shall not exceed 100 square inches (0.06 m^2).
   3.2. The duct shall be constructed of steel a minimum of 0.0217 inch (0.55 mm) in thickness.