Source: https://codes.iccsafe.org/content/IRC2021P3/chapter-1-scope-and-administration

Chapter 3 General Regulations

User note:

About this chapter: *Chapter 3 contains broadly applicable requirements that are necessarily placed in an overarching "general" chapter. These general requirements would not be suitably located in any other chapter that is specific to unique subject matter. General requirements include those related to installation, access, location, testing, structural and clearances.*

Section 301 General

301.1 Scope.

This chapter shall govern the approval and installation of all *equipment* and *appliances* that comprise parts of the *building* mechanical systems regulated by this code in accordance with Section 101.2.

301.2 Energy utilization.

Heating, ventilating and air-conditioning systems of all structures shall be designed and installed for efficient utilization of energy in accordance with the *International Energy Conservation Code*.

301.3 Identification.

Each length of pipe and tubing and each pipe fitting utilized in a mechanical system shall bear the identification of the manufacturer.

301.4 Plastic pipe, fittings and components.

Plastic pipe, fittings and components shall be *third-party certified* as conforming to NSF 14.

301.5 Third-party testing and certification.

Piping, tubing and fittings shall comply with the applicable referenced standards, specifications and performance criteria of this code and shall be identified in accordance with Section 301.3. Piping, tubing and fittings shall either be tested by an approved third-party testing agency or certified by an approved *third-party certification agency*.

301.6 Fuel gas appliances and equipment.

The approval and installation of fuel gas distribution piping and *equipment*, fuel gas-fired *appliances* and fuel gas-fired *appliance* venting systems shall be in accordance with the *International Fuel Gas Code*.

301.7 Listed and labeled.

Appliances regulated by this code shall be *listed* and *labeled* for the application in which they are installed and used, unless otherwise *approved* in accordance with Section 105.

> **Exception:** Listing and labeling of *equipment* and *appliances* used for refrigeration shall be in accordance with Section 1101.2.

301.8 Labeling.

Labeling shall be in accordance with the procedures set forth in Sections 301.8.1 through 301.8.2.3.

INSIGHTS (1)

301.8.1 Testing.

An *approved* agency shall test a representative sample of the mechanical *equipment* and *appliances* being labeled to the relevant standard or standards. The *approved* agency shall maintain a record of all of the tests performed. The record shall provide sufficient detail to verify compliance with the test standard.

301.8.2 Inspection and identification.

The *approved* agency shall periodically perform an inspection, which shall be in-plant if necessary, of the mechanical *equipment* and *appliances* to be labeled. The inspection shall verify that the labeled mechanical *equipment* and *appliances* are representative of the mechanical *equipment* and *appliances* tested.

301.8.2.1 Independent.

The agency to be *approved* shall be objective and competent. To confirm its objectivity, the agency shall disclose all possible conflicts of interest.

301.8.2.2 Equipment.

An *approved* agency shall have adequate *equipment* to perform all required tests. The *equipment* shall be periodically calibrated.

301.8.2.3 Personnel.

An *approved* agency shall employ experienced personnel educated in conducting, supervising and evaluating tests.

301.9 Label information.

A permanent factory-applied nameplate(s) shall be affixed to *appliances* on which shall appear in legible lettering, the manufacturer's name or trademark, the model number, serial number and the seal or mark of the *approved* agency. A label shall include the following:

1.

Electrical *equipment* and *appliances*: Electrical rating in volts, amperes and motor phase; identification of individual electrical components in volts, amperes or watts, motor phase; Btu/h (W) output; and required clearances.

2.

Absorption units: Hourly rating in Btu/h (W); minimum hourly rating for units having step or automatic modulating controls; type of fuel; type of refrigerant; cooling capacity in Btu/h (W); and required clearances.

3.

Fuel-burning units: Hourly rating in Btu/h (W); type of fuel *approved* for use with the *appliance*; and required clearances.

4.

Electric comfort heating *appliances*: electric rating in volts, amperes and phase; Btu/h (W) output rating; individual marking for each electrical component in amperes or watts, volts and phase; and required *clearances* from combustibles.

301.10 Electrical.

Electrical wiring, controls and connections to *equipment* and *appliances* regulated by this code shall be in accordance with NFPA 70.

301.11 Plumbing connections.

Potable water supply and *building* drainage system connections to *equipment* and *appliances* regulated by this code shall be in accordance with the *International Plumbing Code*.

301.12 Fuel types.

Fuel-fired *appliances* shall be designed for use with the type of fuel to which they will be connected and the altitude at which they are installed. *Appliances* that comprise parts of the building mechanical system shall not be converted for the usage of a different fuel, except where *approved* and converted in accordance with the manufacturer's instructions. The fuel input rate shall not be increased or decreased beyond the limit rating for the altitude at which the *appliance* is installed.

INSIGHTS (1)

301.13 Vibration isolation.

Where vibration isolation of *equipment* and *appliances* is employed, an *approved* means of supplemental restraint shall be used to accomplish the support and restraint.

301.14 Repair.

Defective material or parts shall be replaced or repaired in such a manner so as to preserve the original approval or listing.

301.15 Wind resistance.

Mechanical *equipment*, *appliances* and supports that are exposed to wind shall be designed and installed to resist the wind pressures determined in accordance with the *International Building Code*.

[BS] 301.16 Flood hazard.

For structures located in flood hazard areas, mechanical systems, *equipment* and *appliances* shall be located at or above the elevation required by Section 1612 of the *International Building Code* for utilities and attendant *equipment*.

> **Exception:** Mechanical systems, equipment and appliances are permitted to be located below the elevation required by Section 1612 of the of the *International Building Code* for utilities and attendant equipment provided that they are designed and installed to prevent water from entering or accumulating within the components and to resist hydrostatic and hydrodynamic loads and stresses, including the effects of buoyancy, during the occurrence of flooding up to such elevation.

INSIGHTS (1)

[BS] 301.16.1 Coastal high-hazard areas and coastal A zones.

In coastal high-hazard areas and coastal A zones, mechanical systems and *equipment* shall not be mounted on or penetrate walls intended to break away under flood loads.

301.17 Rodentproofing.

Buildings or structures and the walls enclosing habitable or occupiable rooms and spaces in which persons live, sleep or work, or in which feed, food or foodstuffs are stored, prepared, processed, served or sold, shall be constructed to protect against the entrance of rodents in accordance with the *International Building Code*.

301.18 Seismic resistance.

Where earthquake loads are applicable in accordance with the *International Building Code*, mechanical system supports, anchorage and bracing shall be designed and installed for seismic forces in accordance with Chapter 16 of the *International Building Code*.

INSIGHTS (2)

Section 302 Protection of Structure

302.1 Structural safety.

The *building* or structure shall not be weakened by the installation of mechanical systems. Where floors, walls, ceilings or any other portion of the *building* or structure are required to be altered or replaced in the process of installing or repairing any system, the *building* or structure shall be left in a safe structural condition in accordance with the *International Building Code*.

INSIGHTS (1)

302.2 Penetrations of floor/ceiling assemblies and fire-resistance-rated assemblies.

Penetrations of floor/ceiling assemblies and assemblies required to have a fire-resistance rating shall be protected in accordance with Chapter 7 of the *International Building Code*.

INSIGHTS (1)

[BS] 302.3 Cutting, notching and boring in wood framing.

The cutting, notching and boring of wood framing members shall comply with Sections 302.3.1 through 302.3.4.

INSIGHTS (1)

[BS] 302.3.1 Joist notching.

Notches on the ends of joists shall not exceed one-fourth the joist depth. Holes bored in joists shall not be within 2 inches (51 mm) of the top or bottom of the joist, and the diameter of any such hole shall not exceed one-third the depth of the joist. Notches in the top or bottom of joists shall not exceed one-sixth the depth and shall not be located in the middle third of the span.

INSIGHTS (1)

[BS] 302.3.2 Stud cutting and notching.

In exterior walls and bearing partitions, a wood stud shall not be cut or notched in excess of 25 percent of its depth. In nonbearing partitions that do not support loads other than the weight of the partition, a stud shall not be cut or notched in excess of 40 percent of its depth.

[BS] 302.3.3 Bored holes.

The diameter of bored holes in wood studs shall not exceed 40 percent of the stud depth. The diameter of bored holes in wood studs shall not exceed 60 percent of the stud depth in nonbearing partitions. The diameter of bored holes in wood studs shall not exceed 60 percent of the stud depth in any wall where each stud is doubled, provided that not more than two such successive doubled studs are so bored. The edge of the bored hole shall be not closer than 5/8 inch (15.9 mm) to the edge of the stud. Bored holes shall be not located at the same section of stud as a cut or notch.

[BS] 302.3.4 Engineered wood products.

Cuts, notches and holes bored in trusses, structural composite lumber, structural glue-laminated members and I-joists are prohibited except where permitted by the manufacturer's recommendations or where the effects of such alterations are specifically considered in the design of the member by a registered design professional.

[BS] 302.4 Alterations to trusses.

Truss members and components shall not be cut, drilled, notched, spliced or otherwise altered in any way without written concurrence and approval of a *registered design professional*. Alterations resulting in the addition of loads to any member, such as HVAC *equipment* and water heaters, shall not be permitted without verification that the truss is capable of supporting such additional loading.

INSIGHTS (1)

[BS] 302.5 Cutting, notching and boring in steel framing.

The cutting, notching and boring of steel framing members shall comply with Sections 302.5.1 through 302.5.3.

INSIGHTS (1)

[BS] 302.5.1 Cutting, notching and boring holes in structural steel framing.

The cutting, notching and boring of holes in structural steel framing members shall be as prescribed by the *registered design professional*.

[BS] 302.5.2 Cutting, notching and boring holes in cold-formed steel framing.

Flanges and lips of load-bearing cold-formed steel framing members shall not be cut or notched. Holes in webs of load-bearing cold-formed steel framing members shall be permitted along the centerline of the web of the framing member and shall not exceed the dimensional limitations, penetration spacing or minimum hole edge distance as prescribed by the *registered design professional*. Cutting, notching and boring holes of steel floor/roof decking shall be as prescribed by the *registered design professional*.

[BS] 302.5.3 Cutting, notching and boring holes in non-structural cold-formed steel wall framing.

Flanges and lips of nonstructural cold-formed steel wall studs shall not be cut or notched. Holes in webs of nonstructural cold-formed steel wall studs shall be permitted along the centerline of the web of the framing member, shall not exceed 1 1/2 inches (38 mm) in width or

4 inches (102 mm) in length, and shall not be spaced less than 24 inches (610 mm) center to center from another hole or less than 10 inches (254 mm) from the bearing end.

Section 303 Equipment and Appliance Location

303.1 General.

Equipment and *appliances* shall be located as required by this section, specific requirements elsewhere in this code and the conditions of the *equipment* and *appliance* listing.

303.2 Hazardous locations.

Appliances shall not be located in a *hazardous location* unless *listed* and *approved* for the specific installation.

303.3 Prohibited locations.

Fuel-fired *appliances* shall not be located in, or obtain *combustion* air from, any of the following rooms or spaces:

1.

Sleeping rooms.

2.

Bathrooms.

3.

Toilet rooms.

4.

Storage closets.

5.

Surgical rooms.

Exception: This section shall not apply to the following *appliances*:

1.

Direct-vent appliances that obtain all *combustion* air directly from the outdoors.

2.

Solid fuel-fired *appliances*, provided that combustion air is provided in accordance with the manufacturer's instructions.

3.

Appliances installed in a dedicated enclosure in which all *combustion* air is taken directly from the outdoors, in accordance with Chapter 7. *Access* to such enclosure shall be through a solid door, weather-stripped in accordance with the exterior door air leakage requirements of the *International Energy Conservation Code* and equipped with an *approved* self-closing device.

303.4 Protection from damage.

Appliances shall not be installed in a location where subject to mechanical damage unless protected by *approved* barriers.

303.5 Indoor locations.

Furnaces and boilers installed in closets and alcoves shall be *listed* for such installation.

INSIGHTS (1)

303.6 Outdoor locations.

Appliances installed in other than indoor locations shall be *listed* and *labeled* for outdoor installation.

303.7 Pit locations.

Appliances installed in pits or excavations shall not come in direct contact with the surrounding soil and shall be installed not less than 3 inches (76 mm) above the pit floor. The sides of the pit or excavation shall be held back not less than 12 inches (305 mm) from the *appliance*. Where the depth exceeds 12 inches (305 mm) below adjoining grade, the walls of the pit or excavation shall be lined with concrete or masonry. Such concrete or masonry shall extend not less than 4 inches (102 mm) above adjoining grade and shall have sufficient lateral load-bearing capacity to resist collapse. Excavation on the control side of the *appliance* shall extend not less than 30 inches (762 mm) horizontally. The *appliance* shall be protected from flooding in an *approved* manner.

INSIGHTS (1)

[BF] 303.8 Elevator shafts.

Mechanical systems shall not be located in an elevator shaft.

303.9 Fireplaces in Group I-2, Condition 2 occupancies.

Fuel-burning *appliances* and fireplaces in Group I-2, Condition 2 *occupancies* shall be in accordance with Section 901.4.

Section 304 Installation

304.1 General.

Equipment and *appliances* shall be installed as required by the terms of their approval, in accordance with the conditions of the listing, the manufacturer's installation instructions and this code. Manufacturer's installation instructions shall be available on the job site at the time of inspection.

INSIGHTS (1)

304.2 Conflicts.

Where conflicts between this code and the conditions of listing or the manufacturer's installation instructions occur, the provisions of this code shall apply.

> **Exception:** Where a code provision is less restrictive than the conditions of the listing of the *equipment* or *appliance* or the manufacturer's installation instructions, the conditions of the listing and the manufacturer's installation instructions shall apply.

304.3 Elevation of ignition source.

Equipment and *appliances* having an *ignition source* and located in *hazardous locations* and public garages, private garages, repair garages, automotive motor fuel-dispensing facilities and parking garages shall be elevated such that the source of ignition is not less than 18 inches (457 mm) above the floor surface on which the *equipment* or *appliance* rests. For the purpose of this section, rooms or spaces that are not part of the living space of a *dwelling unit* and that communicate directly with a private garage through openings shall be considered to be part of the private garage.

> **Exception:** Elevation of the *ignition source* is not required for *appliances* that are *listed* as flammable vapor ignition resistant.

INSIGHTS (2)

304.3.1 Parking garages.

Connection of a parking garage with any room in which there is a fuel-fired *appliance* shall be by means of a vestibule providing a two-doorway separation, except that a single door is permitted where the sources of ignition in the *appliance* are elevated in accordance with Section 304.3.

Exception: This section shall not apply to *appliance* installations complying with Section 304.6.

304.4 Prohibited equipment and appliance location.

Equipment and *appliances* having an *ignition source* shall not be installed in Group H *occupancies* or control areas where open use, handling or dispensing of combustible, flammable or explosive materials occurs.

[FG] 304.5 Hydrogen-generating and refueling operations.

Hydrogen-generating and refueling *appliances* shall be installed and located in accordance with their listing and the manufacturer's instructions. Ventilation shall be required in accordance with Section 304.5.1, 304.5.2 or 304.5.3 in public garages, private garages, repair garages, automotive motor fuel-dispensing facilities and parking garages that contain hydrogen-generating *appliances* or refueling systems. For the purpose of this section, rooms or spaces that are not part of the living space of a *dwelling unit* and that communicate directly with a private garage through openings shall be considered to be part of the private garage.

INSIGHTS (1)

[FG] 304.5.1 Natural ventilation.

Indoor locations intended for hydrogen-generating or refueling operations shall be limited to a maximum floor area of 850 square feet (79 m^2) and shall communicate with the outdoors in accordance with Sections 304.5.1.1 and 304.5.1.2. The maximum rated output capacity of hydrogen-generating *appliances* shall not exceed 4 standard cubic feet per minute (0.00189 m^3/s) of hydrogen for each 250 square feet (23 m^2) of floor area in such spaces. The minimum cross-sectional dimension of air openings shall be 3 inches (76 mm). Where ducts are used, they shall be of the same cross-sectional area as the free area of the openings to which they connect.

In such locations, *equipment* and *appliances* having an *ignition source* shall be located such that the source of ignition is not within 12 inches (305 mm) of the ceiling.

INSIGHTS (1)

[FG] 304.5.1.1 Two openings.

Two permanent openings shall be provided within the garage. The upper opening shall be located entirely within 12 inches (305 mm) of the ceiling of the garage. The lower opening shall be located entirely within 12 inches (305 mm) of the floor of the garage. Both openings shall be provided in the same exterior wall. The openings shall communicate directly with the outdoors and shall have a minimum free area of 1/2 square foot per 1,000 cubic feet (1 m^2/610 m^3) of garage volume.

[FG] 304.5.1.2 Louvers and grilles.

In calculating free area required by Section 304.5.1, the required size of openings shall be based on the net free area of each opening. If the free area through a design of louver or grille is known, it shall be used in calculating the size opening required to provide the free area specified. If the design and free area are not known, it shall be assumed that wood louvers will have 25-percent free area and metal louvers and grilles will have 75-percent free area. Louvers and grilles shall be fixed in the open position.

[FG] 304.5.2 Mechanical ventilation.

Indoor locations intended for hydrogen-generating or refueling operations shall be ventilated in accordance with Section 502.16. In such locations, *equipment* and *appliances* having an *ignition source* shall be located such that the source of ignition is below the mechanical ventilation outlet(s).

[FG] 304.5.3 Specially engineered installations.

As an alternative to the provisions of Sections 304.5.1 and 304.5.2, the necessary supply of air for ventilation and dilution of flammable gases shall be provided by an *approved* engineered system.

304.6 Public garages.

Appliances located in public garages, motor fuel-dispensing facilities, repair garages or other areas frequented by motor vehicles, shall be installed not less than 8 feet (2438 mm) above the floor. Where motor vehicles are capable of passing under an *appliance*, the *appliance* shall be installed at the *clearances* required by the *appliance* manufacturer and not less than 1 foot (305 mm) higher than the tallest vehicle garage door opening.

> **Exception:** The requirements of this section shall not apply where the *appliances* are protected from motor vehicle impact and installed in accordance with Section 304.3 and NFPA 30A.

INSIGHTS (1)

304.7 Private garages.

Appliances located in private garages and carports shall be installed with a minimum clearance of 6 feet (1829 mm) above the floor.

> **Exception:** The requirements of this section shall not apply where the *appliances* are protected from motor vehicle impact and installed in accordance with Section 304.3.

INSIGHTS (1)

304.8 Construction and protection.

Boiler rooms and furnace rooms shall be protected as required by the *International Building Code*.

304.9 Clearances to combustible construction.

Heat-producing *equipment* and *appliances* shall be installed to maintain the required *clearances* to combustible construction as specified in the listing and manufacturer's instructions. Such *clearances* shall be reduced only in accordance with Section 308. *Clearances* to combustibles shall include such considerations as door swing, drawer pull, overhead projections or shelving and window swing, shutters, coverings and drapes. Devices such as doorstops or limits, closers, drapery ties or guards shall not be used to provide the required *clearances*.

304.10 Clearances from grade.

Equipment and *appliances* installed at grade level shall be supported on a level concrete slab or other *approved* material extending not less than 3 inches (76 mm) above adjoining grade or shall be suspended not less than 6 inches (152 mm) above adjoining grade. Such support shall be in accordance with the manufacturer's installation instructions.

INSIGHTS (1)

[BE] 304.11 Guards.

Guards shall be provided where various components that require service and roof hatch openings are located within 10 feet (3048 mm) of a roof edge or open side of a walking surface and such edge or open side is located more than 30 inches (762 mm) above the floor, roof, or grade below. The guard shall extend not less than 30 inches (762 mm) beyond each end of components that require service and each end of the roof hatch parallel to the roof edge. The top of the guard shall be located not less than 42 inches (1067 mm) above the elevated surface adjacent to the guard. The guard shall be constructed so as to prevent the passage of a 21-inch-diameter (533 mm) sphere and shall comply with the loading requirements for guards specified in the *International Building Code*.

> **Exception:** Guards are not required where fall arrest/restraint anchorage connector devices that comply with ANSI/ASSP Z359.1 are installed.

INSIGHTS (4)

304.12 Area served.

Appliances serving different areas of a building other than where they are installed shall be permanently marked in an *approved* manner that uniquely identifies the *appliance* and the area it serves.

Section 305 Piping Support

305.1 General.

Mechanical system piping shall be supported in accordance with this section.

305.2 Materials.

Pipe hangers and supports shall have sufficient strength to withstand all anticipated static and specified dynamic loading conditions associated with the intended use. Pipe hangers and supports that are in direct contact with piping shall be of *approved* materials that are compatible with the piping and that will not promote galvanic action.

305.3 Structural attachment.

Hangers and anchors shall be attached to the *building* construction in an *approved* manner.

305.4 Interval of support.

Piping shall be supported at distances not exceeding the spacing specified in Table 305.4, or in accordance with ANSI/MSS SP-58.

INSIGHTS (1)

TABLE 305.4 PIPING SUPPORT SPACING[a]

PIPING MATERIAL	MAXIMUM HORIZONTAL SPACING (feet)	MAXIMUM VERTICAL SPACING (feet)
ABS pipe	4	10[c]
Aluminum pipe and tubing	10	15
Cast-iron pipe[b]	5	15
Copper or copper-alloy pipe	12	10
Copper or copper-alloy tubing	8	10
CPVC pipe or tubing, 1 inch and smaller	3	10[c]
CPVC pipe or tubing, 1 1/4-inches and larger	4	10[c]
Lead pipe	Continuous	4
PB pipe or tubing	2 2/3 (32 inches)	4
PE-RT 1 inch and smaller	2 2/3 (32 inches)	10[c]
PE-RT 1 1/4 inches and larger	4	10[c]
PEX tubing 1 inch and smaller	2 2/3 (32 inches)	10[c]
PEX tubing 1 1/4 inches and larger	4	10[c]
Polypropylene (PP) pipe or tubing, 1 inch and smaller	2 2/3 (32 inches)	10[c]
Polypropylene (PP) pipe or tubing, 1 1/4 inches and larger	4	10[c]
PVC pipe	4	10[c]
Steel pipe	12	15
Steel tubing	8	10

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

a.
See Section 301.18.

b.
The maximum horizontal spacing of cast-iron pipe hangers shall be increased to 10 feet where 10-foot lengths of pipe are installed.

c.
Mid-story guide.

305.5 Protection against physical damage.

In concealed locations where piping, other than cast-iron or steel, is installed through holes or notches in studs, joists, rafters or similar members less than 1 1/2 inches (38 mm) from the nearest edge of the member, the pipe shall be protected by shield plates. Protective steel shield plates having a minimum thickness of 0.0575 inch (1.463 mm) (No. 16 gage) shall cover the area of the pipe where the member is notched or bored, and shall extend not less than 2 inches (51 mm) above sole plates and below top plates.

Section 306 Access and Service Space

306.1 Access.

Appliances, controls devices, heat exchangers and HVAC system components that utilize energy shall be accessible for inspection, service, repair and replacement without disabling the function of a fire-resistance-rated assembly or removing permanent construction, other *appliances*, venting systems or any other piping or ducts not connected to the *appliance* being inspected, serviced, repaired or replaced. A level working space not less than 30 inches deep and 30 inches wide (762 mm by 762 mm) shall be provided in front of the control side to service an *appliance*.

INSIGHTS (2)

306.2 Appliances in rooms.

Rooms containing *appliances* shall be provided with a door and an unobstructed passageway measuring not less than 36 inches (914 mm) wide and 80 inches (2032 mm) high.

> **Exception:** Within a *dwelling unit*, *appliances* installed in a compartment, alcove, basement or similar space shall be accessed by an opening or door and an unobstructed passageway measuring not less than 24 inches (610 mm) wide and large enough to allow removal of the largest *appliance* in the space, provided that a level service space of not less than 30 inches (762 mm) deep and the height of the *appliance*, but not less than 30 inches (762 mm), is present at the front or service side of the *appliance* with the door open.

INSIGHTS (1)

306.3 Appliances in attics.

Attics containing *appliances* shall be provided with an opening and unobstructed passageway large enough to allow removal of the largest *appliance*. The passageway shall be not less than 30 inches (762 mm) high and 22 inches (559 mm) wide and not more than 20 feet (6096 mm) in length measured along the centerline of the passageway from the opening to the *appliance*. The passageway shall have continuous solid flooring not less than 24 inches (610 mm) wide. A level service space not less than 30 inches (762 mm) deep and 30 inches (762 mm) wide shall be present at the front or service side of the *appliance*. The clear access opening dimensions shall be not less than 20 inches by 30 inches (508 mm by 762 mm), and large enough to allow removal of the largest *appliance*.

Exceptions:

1.

The passageway and level service space are not required where the *appliance* is capable of being serviced and removed through the required opening.

2.

Where the passageway is unobstructed and not less than 6 feet (1829 mm) high and 22 inches (559 mm) wide for its entire length, the passageway shall be not greater than 50 feet (15 250 mm) in length.

INSIGHTS (2)

306.3.1 Electrical requirements.

A luminaire controlled by a switch located at the required passageway opening and a receptacle outlet shall be provided at or near the *appliance* location in accordance with NFPA 70.

306.4 Appliances under floors.

Underfloor spaces containing *appliances* shall be provided with an access opening and unobstructed passageway large enough to remove the largest *appliance*. The passageway shall be not less than 30 inches (762 mm) high and 22 inches (559 mm) wide, nor more than 20 feet (6096 mm) in length measured along the centerline of the passageway from the opening to the *appliance*. A level service space not less than 30 inches (762 mm) deep and 30 inches (762 mm) wide shall be present at the front or service side of the *appliance*. If the depth of the passageway or the service space exceeds 12 inches (305 mm) below the adjoining grade, the walls of the passageway shall be lined with concrete or masonry. Such concrete or masonry shall extend not less than 4 inches (102 mm) above the adjoining grade and shall have sufficient lateral-bearing capacity to resist collapse. The clear access opening dimensions shall be not less than 22 inches by 30 inches (559 mm by 762 mm), and large enough to allow removal of the largest *appliance*.

Exceptions:

1.

The passageway is not required where the level service space is present when the access is open and the *appliance* is capable of being serviced and removed through the required opening.

2.

Where the passageway is unobstructed and not less than 6 feet high (1929 mm) and 22 inches (559 mm) wide for its entire length, the passageway shall not be limited in length.

INSIGHTS (1)

306.4.1 Electrical requirements.

A luminaire controlled by a switch located at the required passageway opening and a receptacle outlet shall be provided at or near the *appliance* location in accordance with NFPA 70.

306.5 Equipment and appliances on roofs or elevated structures.

Where *equipment* requiring access or *appliances* are located on an elevated structure or the roof of a building such that personnel will have to climb higher than 16 feet (4877 mm) above grade to access such *equipment* or *appliances*, an interior or exterior means of access shall be provided. Such access shall not require climbing over obstructions greater than 30 inches (762 mm) in height or walking on roofs having a slope greater than 4 units vertical in 12 units horizontal (33-percent slope). Such access shall not require the use of portable ladders. Where access involves climbing over parapet walls, the height shall be measured to the top of the parapet wall.

Permanent ladders installed to provide the required access shall comply with the following minimum design criteria:

1.

The side railing shall extend above the parapet or roof edge not less than 30 inches (762 mm).

2.

Ladders shall have rung spacing not to exceed 14 inches (356 mm) on center. The uppermost rung shall be not greater than 24 inches (610 mm) below the upper edge of the roof hatch, roof or parapet, as applicable.

3.

Ladders shall have a toe spacing not less than 6 inches (152mm) deep.

4.

There shall be not less than 18 inches (457 mm) between rails.

5.

Rungs shall have a diameter not less than 0.75-inch (19.1 mm) and be capable of withstanding a 300-pound (136 kg) load.

6.

Ladders over 30 feet (9144 mm) in height shall be provided with offset sections and landings capable of withstanding 100 pounds per square foot (488 kg/m^2). Landing dimensions shall be not less than 18 inches (457 mm) and not less than the width of the ladder served. A guard rail shall be provided on all open sides of the landing.

7.

Climbing clearance. The distance from the centerline of the rungs to the nearest permanent object on the climbing side of the ladder shall be not less than 30 inches (762 mm) measured perpendicular to the rungs. This distance shall be maintained from the point of ladder access to the bottom of the roof hatch. A minimum clear width of 15 inches (381 mm) shall be provided on both sides of the ladder measured from the midpoint of and parallel with the rungs except where cages or wells are installed.

8.

Landing required. The ladder shall be provided with a clear and unobstructed bottom landing area having a minimum dimension of 30 inches (762 mm) by 30 inches (762 mm) centered in front of the ladder.

9.

Ladders shall be protected against corrosion by *approved* means.

10.

Access to ladders shall be provided at all times.

Catwalks installed to provide the required access shall be not less than 24 inches (610 mm) wide and shall have railings as required for service platforms.

Exception: This section shall not apply to Group R-3 *occupancies*.

INSIGHTS (2)

306.5.1 Sloped roofs.

Where *appliances*, *equipment*, fans or other components that require service are installed on a roof having a slope of 3 units vertical in 12 units horizontal (25-percent slope) or greater and having an edge more than 30 inches (762 mm) above grade at such edge, a level platform shall be provided on each side of the *appliance* or *equipment* to which *access* is required for service, repair or maintenance. The platform shall be not less than 30 inches (762 mm) in any dimension and shall be provided with guards. The guards shall extend not less than 42 inches (1067 mm) above the platform, shall be constructed so as to prevent the passage of a 21-inch-diameter (533 mm) sphere and shall comply with the loading requirements for guards specified in the *International Building Code*. *Access* shall not require walking on roofs having a slope greater than 4 units vertical in 12 units horizontal (33-percent slope). Where *access* involves obstructions greater than 30 inches (762 mm) in height, such obstructions shall be provided with ladders installed in accordance with Section 306.5 or stairways installed in accordance with the requirements specified in the *International Building Code* in the path of travel to and from *appliances*, fans or *equipment* requiring service.

306.5.2 Electrical requirements.

A receptacle outlet shall be provided at or near the *equipment* location in accordance with NFPA 70.

Section 307 Condensate Disposal

307.1 Fuel-burning appliances.

Liquid *combustion* by-products of condensing *appliances* shall be collected and discharged to an *approved* plumbing fixture or disposal area in accordance with the manufacturer's installation instructions. Condensate piping shall be of *approved* corrosion-resistant material and shall not be smaller than the drain connection on the *appliance*. Such piping shall maintain a minimum horizontal slope in the direction of discharge of not less than 1/8 unit vertical in 12 units horizontal(1-percent slope).

INSIGHTS (2)

307.1.1 Identification.

The termination of concealed condensate piping shall be marked to indicate whether the piping is connected to the primary or secondary drain.

INSIGHTS (2)

307.2 Evaporators and cooling coils.

Condensate drain systems shall be provided for *equipment* and *appliances* containing evaporators or cooling coils. Condensate drain systems shall be designed, constructed and installed in accordance with Sections 307.2.1 through 307.2.5.

> **Exception:** Evaporators and cooling coils that are designed to operate in sensible cooling only and not support condensation shall not be required to meet the requirements of this section.

307.2.1 Condensate disposal.

Condensate from all cooling coils and evaporators shall be conveyed from the drain pan outlet to an *approved* place of disposal. Such piping shall maintain a minimum horizontal slope in the direction of discharge of not less than 1/8 unit vertical in 12 units horizontal (1 percent slope). Condensate shall not discharge into a street, alley or other areas so as to cause a nuisance.

307.2.1.1 Condensate discharge.

Condensate drains shall not directly connect to any plumbing drain, waste or vent pipe. Condensate drains shall not discharge into a plumbing fixture other than a floor sink, floor drain, trench drain, mop sink, hub drain, standpipe, utility sink or laundry sink. Condensate drain connections to a lavatory wye branch tailpiece or to a bathtub overflow pipe shall not be considered as discharging to a plumbing fixture. Except where discharging to grade outdoors, the point of discharge of condensate drains shall be located within the same *occupancy*, tenant space or *dwelling unit* as the source of the condensate.

INSIGHTS (3)

307.2.2 Drain pipe materials and sizes.

Components of the condensate disposal system shall be ABS, cast iron, copper and copper alloy, CPVC, cross-linked polyethylene, galvanized steel, PE-RT, polyethylene, polypropylene, PVC or PVDF pipe or tubing. Components shall be selected for the pressure and temperature rating of the installation. Joints and connections shall be made in accordance with the applicable provisions of Chapter 7 of the *International Plumbing Code* relative to the material type. Condensate waste and drain line size shall be not less than 3/4-inch pipe size and shall not decrease in size from the drain pan connection to the place of condensate disposal. Where the drain pipes from more than one unit are manifolded together for condensate drainage, the pipe or tubing shall be sized in accordance with Table 307.2.2.

INSIGHTS (3)

TABLE 307.2.2 CONDENSATE DRAIN SIZING

EQUIPMENT CAPACITY	MINIMUM CONDENSATE PIPE DIAMETER
Up to 20 tons of refrigeration	3/4 inch
Over 20 tons to 40 tons of refrigeration	1 inch
Over 40 tons to 90 tons of refrigeration	1 1/4 inch
Over 90 tons to 125 tons of refrigeration	1 1/2 inch
Over 125 tons to 250 tons of refrigeration	2 inch

For SI: 1 inch = 25.4 mm, 1 ton = 3.517 kW.

307.2.3 Auxiliary and secondary drain systems.

In addition to the requirements of Section 307.2.1, where damage to any *building* components could occur as a result of overflow from the *equipment* primary condensate removal system, one of the following auxiliary protection methods shall be provided for each cooling coil or fuel-fired *appliance* that produces condensate:

1.

An auxiliary drain pan with a separate drain shall be provided under the coils on which condensation will occur. The auxiliary pan drain shall discharge to a conspicuous point of disposal to alert occupants in the event of a stoppage of the primary drain. The pan shall have a minimum depth of 1 1/2 inches (38 mm), shall be not less than 3 inches (76 mm) larger than the unit, or the coil dimensions in width and length and shall be constructed of corrosion-resistant material. Galvanized sheet steel pans shall have a minimum thickness of not less than 0.0236 inch (0.6010 mm) (No. 24 gage). Nonmetallic pans shall have a minimum thickness of not less than 0.0625 inch (1.6 mm).

2.

A separate overflow drain line shall be connected to the drain pan provided with the *equipment*. Such overflow drain shall discharge to a conspicuous point of disposal to alert occupants in the event of a stoppage of the primary drain. The overflow drain line shall connect to the drain pan at a higher level than the primary drain connection.

3.

An auxiliary drain pan without a separate drain line shall be provided under the coils on which condensate will occur. Such pan shall be equipped with a water-level detection device conforming to UL 508 that will shut off the *equipment* served prior to overflow of the pan. The auxiliary drain pan shall be constructed in accordance with Item 1 of this section.

4.

A water-level detection device conforming to UL 508 shall be provided that will shut off the *equipment* served in the event that the primary drain is blocked. The device shall be installed in the primary drain line, the overflow drain line, or in the equipment-supplied drain pan, located at a point higher than the primary drain line connection and below the overflow rim of such pan.

Exception: Fuel-fired *appliances* that automatically shut down operation in the event of a stoppage in the condensate drainage system.

INSIGHTS (1)

307.2.3.1 Water-level monitoring devices.

On down-flow units and all other coils that do not have a secondary drain or provisions to install a secondary or auxiliary drain pan, a water-level monitoring device shall be installed inside the primary drain pan. This device shall shut off the *equipment* served in the event that the primary drain becomes restricted. Devices installed in the drain line shall not be permitted.

307.2.3.2 Appliance, equipment and insulation in pans.

Where *appliances*, *equipment* or insulation are subject to water damage when auxiliary drain pans fill, that portion of the *appliance*, *equipment* and insulation shall be installed above the rim of the pan. Supports located inside of the pan to support the *appliance* or *equipment* shall be water resistant and *approved*.

307.2.3.3 Identification.

The termination of concealed condensate piping shall be marked to indicate whether the piping is connected to the primary or secondary drain.

INSIGHTS (2)

307.2.4 Traps.

Condensate drains shall be trapped as required by the *equipment* or *appliance* manufacturer.

307.2.4.1 Ductless mini-split system traps.

Ductless mini-split *equipment* that produces condensate shall be provided with an inline check valve located in the drain line, or a trap.

307.2.5 Drain line maintenance.

Condensate drain lines shall be configured to permit the clearing of blockages and performance of maintenance without requiring the drain line to be cut.

307.3 Condensate pumps.

Condensate pumps located in uninhabitable spaces, such as attics and crawl spaces, shall be connected to the *appliance* or *equipment* served such that when the pump fails, the *appliance* or *equipment* will be prevented from operating. Pumps shall be installed in accordance with the manufacturer's instructions.

INSIGHTS (1)

Section 308 Clearance Reduction

308.1 Scope.

This section shall govern the reduction in required *clearances* to combustible materials and combustible assemblies for *chimneys,* vents, kitchen exhaust *equipment*, mechanical *appliances*, and mechanical devices and *equipment*.

INSIGHTS (1)

308.2 Listed appliances and equipment.

The reduction of the required *clearances* to combustibles for *listed* and *labeled appliances* and *equipment* shall be in accordance with the requirements of this section except that such *clearances* shall not be reduced where reduction is specifically prohibited by the terms of the *appliance* or *equipment* listing.

308.3 Protective assembly construction and installation.

Reduced *clearance* protective assemblies, including structural and support elements, shall be constructed of noncombustible materials. Spacers utilized to maintain an airspace between the protective assembly and the protected material or assembly shall be noncombustible. Where a space between the protective assembly and protected combustible material or assembly is specified, the same space shall be provided around the edges of the protective assembly and the spacers shall be placed so as to allow air circulation by convection in such space. Protective assemblies shall not be placed less than 1 inch (25 mm) from the mechanical *appliances*, devices or *equipment*, regardless of the allowable reduced *clearance*.

INSIGHTS (1)

308.4 Allowable reduction.

The reduction of required *clearances* to combustible assemblies or combustible materials shall be based on the utilization of a reduced *clearance* protective assembly in accordance with Section 308.4.1 or 308.4.2.

308.4.1 Labeled assemblies.

The allowable *clearance* reduction shall be based on an *approved* reduced *clearance* protective assembly that is *listed* and *labeled* in accordance with UL 1618.

308.4.2 Reduction table.

The allowable *clearance* reduction shall be based on one of the methods specified in Table 308.4.2. Where required *clearances* are not listed in Table 308.4.2, the reduced *clearances* shall be determined by linear interpolation between the distances listed in the table. Reduced *clearances* shall not be derived by extrapolation below the range of the table.

INSIGHTS (1)

TABLE 308.4.2 CLEARANCE REDUCTION METHODS[b]

TYPE OF PROTECTIVE ASSEMBLY[a]	REDUCED CLEARANCE WITH PROTECTION (inches)[a]							
	Horizontal combustible assemblies located above the heat source				Horizontal combustible assemblies located beneath the heat source and all vertical combustible assemblies			
	Required clearance to combustibles without protection (inches)[a]				Required clearance to combustibles without protection (inches)			
	36	18	9	6	36	18	9	6
Galvanized sheet steel, having a minimum thickness of 0.0236 inch (No. 24 gage), mounted on 1-inch glass fiber or mineral wool batt reinforced with wire on the back, 1 inch off the combustible assembly	18	9	5	3	12	6	3	3
Galvanized sheet steel, having a minimum thickness of 0.0236 inch (No. 24 gage), spaced 1 inch off the combustible assembly	18	9	5	3	12	6	3	2
Two layers of galvanized sheet steel, having a minimum thickness of 0.0236 inch (No. 24 gage), having a 1-inch airspace between layers, spaced 1 inch off the combustible assembly	18	9	5	3	12	6	3	3
Two layers of galvanized sheet steel, having a minimum thickness of 0.0236 inch (No. 24 gage), having 1 inch of fiberglass insulation between layers, spaced 1 inch off the combustible assembly	18	9	5	3	12	6	3	3
0.5-inch inorganic insulating board, over 1 inch of fiberglass or mineral wool batt, against the combustible assembly	24	12	6	4	18	9	5	
3 1/2-inch brick wall, spaced 1 inch off the combustible wall	—	—	—	—	12	6	6	6
3 1/2-inch brick wall, against the combustible wall	—	—	—	—	24	12	6	5

For SI: 1 inch = 25.4 mm, °C = [(°F) – 32]/1.8, 1 pound per cubic foot = 16.02 kg/m[3], 1.0 Btu • in/(ft[2] • h • °F) = 0.144 W/m[2] • K.

a.
Mineral wool and glass fiber batts (blanket or board) shall have a minimum density of 8 pounds per cubic foot and a minimum melting point of 1,500°F. Insulation material utilized as part of a clearance reduction system shall have a thermal conductivity of 1.0 Btu • in/(ft^2• h• °F) or less. Insulation board shall be formed of noncombustible material.

b.
For limitations on clearance reduction for solid fuel-burning appliances, masonry chimneys, connector pass-throughs, masonry fireplaces and kitchen ducts, see Sections 308.4.2.1 through 308.4.2.5.

308.4.2.1 Solid fuel-burning appliances.

he clearance reduction methods specified in Table 308.4.2 shall not be utilized to reduce the clearance required for solid fuel-burning appliances that are labeled for installation with clearances of 12 inches (305 mm) or less. Where appliances are labeled for installation with clearances of greater than 12 inches (305 mm), the clearance reduction methods of Table 308.4.2 shall not reduce the clearance to less than 12 inches (305 mm).

308.4.2.2 Masonry chimneys.

The *clearance* reduction methods specified in Table 308.4.2 shall not be utilized to reduce the *clearances* required for masonry *chimneys* as specified in Chapter 8 and the *International Building Code*.

308.4.2.3 Chimney connector pass-throughs.

The *clearance* reduction methods specified in Table 308.4.2 shall not be utilized to reduce the *clearances* required for *chimney* connector pass-throughs as specified in Section 803.10.4.

308.4.2.4 Masonry fireplaces.

The *clearance* reduction methods specified in Table 308.4.2 shall not be utilized to reduce the *clearances* required for masonry fireplaces as specified in Chapter 8 and the *International Building Code*.

308.4.2.5 Kitchen exhaust ducts.

The *clearance* reduction methods specified in Table 308.4.2 shall not be utilized to reduce the minimum *clearances* required by Section 506.3.11.1 for kitchen exhaust ducts enclosed in a shaft.

Section 309 Temperature Control

[BG] 309.1 Space-heating systems.

Interior spaces intended for human occupancy shall be provided with active or passive space-heating systems capable of maintaining an indoor temperature of not less than 68°F (20°C) at a point 3 feet (914 mm) above floor on the design heating day. The installation of portable space heaters shall not be used to achieve compliance with this section.

Exceptions:

1.

Interior spaces where the primary purpose is not associated with human comfort.

2.

Group F, H, S and U *occupancies*.

Section 310 Explosion Control

[F] 310.1 Required.

Structures occupied for purposes involving explosion hazards shall be provided with explosion control where required by the *International Fire Code*. Explosion control systems shall be designed and installed in accordance with Section 911 of the *International Fire Code*.

Section 311 Smoke and Heat Vents

[F] 311.1 Required.

Approved smoke and heat vents shall be installed in the roofs of one-story buildings where required by the *International Fire Code*. Smoke and heat vents shall be designed and installed in accordance with the *International Fire Code*.

Section 312 Heating and Cooling Load Calculations

312.1 Load calculations.

Heating and cooling system design loads for the purpose of sizing systems, *appliances* and *equipment* shall be determined in accordance with the procedures described in the ASHRAE/ACCA Standard 183. Alternatively, design loads shall be determined by an *approved* equivalent computation procedure, using the design parameters specified in Chapter 3 [CE] of the *International Energy Conservation Code*.

Chapter 4 Ventilation

User note:

About this chapter: *Chapter 4 intends to provide an indoor atmosphere that protects the health and well-being of building occupants. Both mechanical and natural ventilation are addressed. Mechanical ventilation provides what is considered to be acceptable indoor air quality. Mechanical ventilation minimizes adverse health effects and provides an atmosphere that generally is not objectionable to occupants.*

Section 401 General

401.1 Scope.

This chapter shall govern the ventilation of spaces within a building intended to be occupied. Mechanical exhaust systems, including exhaust systems serving clothes dryers and cooking *appliances*; hazardous exhaust systems; dust, stock and refuse conveyor systems; subslab soil exhaust systems; smoke control systems; energy recovery ventilation systems and other systems specified in Section 502 shall comply with Chapter 5.

INSIGHTS (1)

401.2 Ventilation required.

Every occupied space shall be ventilated by natural means in accordance with Section 402 or by mechanical means in accordance with Section 403. *Dwelling units* complying with the air leakage requirements of the *International Energy Conservation Code* or ASHRAE 90.1 shall be ventilated by mechanical means in accordance with Section 403. Ambulatory care facilities and Group I-2 *occupancies* shall be ventilated by mechanical means in accordance with Section 407.

INSIGHTS (4)

401.3 When required.

Ventilation shall be provided during the periods that the room or space is occupied.

INSIGHTS (1)

401.4 Intake opening location.

Air intake openings shall comply with all of the following:

1.

Intake openings shall be located not less than 10 feet (3048 mm) from lot lines or buildings on the same lot.

2.

Mechanical and gravity outdoor air intake openings shall be located not less than 10 feet (3048 mm) horizontally from any hazardous or noxious contaminant source, such as vents, streets, alleys, parking lots and loading docks, except as specified in Item 3 or Section 501.3.1. Outdoor air intake openings shall be permitted to be located less than 10 feet (3048 mm) horizontally from streets, alleys, parking lots and loading docks provided that the openings are located not less than 25 feet (7620 mm) vertically above such locations. Where openings front on a street or public way, the distance shall be measured from the closest edge of the street or public way.

3.

Intake openings shall be located not less than 3 feet (914 mm) below contaminant sources where such sources are located within 10 feet (3048 mm) of the opening. Separation is not required between intake air openings and living space *exhaust air* openings of an individual *dwelling unit* or *sleeping unit* where an approved factory-built intake/exhaust combination termination fitting is used to separate the air streams in accordance with the manufacturer's instructions.

4.

Intake openings on structures in flood hazard areas shall be at or above the elevation required by Section 1612 of the *International Building Code* for utilities and attendant equipment.

INSIGHTS (5)

401.5 Intake opening protection.

Air intake openings that terminate outdoors shall be protected with corrosion-resistant screens, louvers or grilles. Openings in louvers, grilles and screens shall be sized in accordance with Table 401.5, and shall be protected against local weather conditions. Louvers that protect air intake openings in structures located in hurricane-prone regions, as defined in the

International Building Code, shall comply with AMCA 550. Outdoor air intake openings located in exterior walls shall meet the provisions for exterior wall opening protectives in accordance with the *International Building Code*.

INSIGHTS (1)

TABLE 401.5 OPENING SIZES IN LOUVERS, GRILLES AND SCREENS PROTECTING AIR INTAKE OPENINGS

OUTDOOR OPENING TYPE	MINIMUM AND MAXIMUM OPENING SIZES IN LOUVERS, GRILLES AND SCREENS[a]
Intake openings in residential occupancies	Not < 1/4 inch and not > 1/2 inch
Intake openings in other than residential occupancies	> 1/4 inch and not > 1 inch

For SI: 1 inch = 25.4 mm.

a.
For rectangular openings, the table requirements apply to the shortest side. For round openings, the table requirements apply to the diameter. For square openings, the table requirements apply to any side.

401.6 Contaminant sources.

Stationary local sources producing airborne particulates, heat, odors, fumes, spray, vapors, smoke or gases in such quantities as to be irritating or injurious to health shall be provided with an exhaust system in accordance with Chapter 5 or a means of collection and removal of the contaminants. Such exhaust shall discharge directly to an *approved* location at the exterior of the *building*.

INSIGHTS (1)

Section 402 Natural Ventilation

[BG] 402.1 Natural ventilation.

Natural ventilation of an occupied space shall be through windows, doors, louvers or other openings to the outdoors. The operating mechanism for such openings shall be provided with *ready access* so that the openings are readily controllable by the *building* occupants.

INSIGHTS (2)

[BG] 402.2 Ventilation area required.

The minimum openable area to the outdoors shall be 4 percent of the floor area being ventilated.

[BG] 402.3 Adjoining spaces.

Where rooms and spaces without openings to the outdoors are ventilated through an adjoining room, the opening to the adjoining rooms shall be unobstructed and shall have an area not less than 8 percent of the floor area of the interior room or space, but not less than 25 square feet (2.3 m^2). The minimum openable area to the outdoors shall be based on the total floor area being ventilated.

> **Exception:** Exterior openings required for ventilation shall be permitted to open into a thermally isolated sunroom addition or patio cover, provided that the openable area between the sunroom addition or patio cover and the interior room has an area of not less than 8 percent of the floor area of the interior room or space, but not less than 20 square feet (1.86 m^2). The minimum openable area to the outdoors shall be based on the total floor area being ventilated.

INSIGHTS (2)

[BG] 402.4 Openings below grade.

Where openings below grade provide required *natural ventilation*, the outdoor horizontal clear space measured perpendicular to the opening shall be one and one-half times the depth of the opening. The depth of the opening shall be measured from the average adjoining ground level to the bottom of the opening.

INSIGHTS (1)

Section 403 Mechanical Ventilation

INSIGHTS (2)

403.1 Ventilation system.

Mechanical ventilation shall be provided by a method of supply air and return or *exhaust air* except that mechanical *ventilation air* requirements for Group R-2, R-3 and R-4 *occupancies* shall be provided by an exhaust system, supply system or combination thereof. The amount of supply air shall be approximately equal to the amount of return and *exhaust air*. The system shall not be prohibited from producing negative or positive pressure. The system to convey *ventilation air* shall be designed and installed in accordance with Chapter 6.

INSIGHTS (5)

403.2 Outdoor air required.

The minimum outdoor airflow rate shall be determined in accordance with Section 403.3.

> **Exception:** Where the *registered design professional* demonstrates that an engineered ventilation system design will prevent the maximum concentration of contaminants from exceeding that obtainable by the rate of outdoor air ventilation determined in accordance with Section 403.3, the minimum required rate of outdoor air shall be reduced in accordance with such engineered system design.

403.2.1 Recirculation of air.

The outdoor air required by Section 403.3 shall not be recirculated. Air in excess of that required by Section 403.3 shall not be prohibited from being recirculated as a component of supply air to *building* spaces, except that:

1.

Ventilation air shall not be recirculated from one *dwelling* to another or to dissimilar *occupancies*.

2.

Supply air to a swimming pool and associated deck areas shall not be recirculated unless such air is dehumidified to maintain the relative humidity of the area at 60 percent or less. Air from this area shall not be recirculated to other spaces where more than 10 percent of the resulting supply airstream consists of air recirculated from these spaces. The design and installation of dehumidification systems shall comply with ANSI/ACCA 10 Manual SPS.

3.

Where mechanical exhaust is required by Note b in Table 403.3.1.1, recirculation of air from such spaces shall be prohibited. Recirculation of air that is contained completely within such spaces shall not be prohibited. Where recirculation of air is prohibited, all air supplied to such spaces shall be exhausted, including any air in excess of that required by Table 403.3.1.1.

4.

Where mechanical exhaust is required by Note g in Table 403.3.1.1, mechanical exhaust is required and recirculation from such spaces is prohibited where more than 10 percent of the resulting supply airstream consists of air recirculated from these spaces. Recirculation of air that is contained completely within such spaces shall not be prohibited.

INSIGHTS (2)

403.2.2 Transfer air.

Except where recirculation from such spaces is prohibited by Table 403.3.1.1, air transferred from *occupiable spaces* is not prohibited from serving as *makeup air* for required exhaust systems in such spaces as kitchens, baths, toilet rooms, elevators and smoking lounges. The amount of transfer air and *exhaust air* shall be sufficient to provide the flow rates as specified in Section 403.3.1.1. The required outdoor airflow rates specified in Table 403.3.1.1 shall be introduced directly into such spaces or into the occupied spaces from which air is transferred or a combination of both.

INSIGHTS (1)

403.3 Outdoor air and local exhaust airflow rates.

Group R-2, R-3 and R-4 *occupancies* three stories and less in height above grade plane shall be provided with outdoor air and local exhaust in accordance with Section 403.3.2. Other buildings intended to be occupied shall be provided with outdoor air and local exhaust in accordance with Section 403.3.1.

403.3.1 Other buildings intended to be occupied.

The design of local exhaust systems and ventilation systems for outdoor air for *occupancies* other than Group R-2, R-3 and R-4 three stories and less above grade plane shall comply with Sections 403.3.1.1 through 403.3.1.4.

403.3.1.1 Outdoor airflow rate.

Ventilation systems shall be designed to have the capacity to supply the minimum outdoor airflow rate, determined in accordance with this section. In each *occupiable space*, the ventilation system shall be designed to deliver the required rate of outdoor airflow to the *breathing zone*. The occupant load utilized for design of the ventilation system shall be not less than the number determined from the estimated maximum occupant load rate indicated in Table 403.3.1.1. Ventilation rates for *occupancies* not represented in Table 403.3.1.1 shall be those for a listed *occupancy* classification that is most similar in terms of occupant density, activities and *building* construction; or shall be determined by an *approved* engineering analysis. The ventilation system shall be designed to supply the required rate of *ventilation air* continuously during the period the *building* is occupied, except as otherwise stated in other provisions of the code.

With the exception of smoking lounges, the ventilation rates in Table 403.3.1.1 are based on the absence of smoking in *occupiable spaces*. Where smoking is anticipated in a space other than a smoking lounge, the ventilation system serving the space shall be designed to provide ventilation over and above that required by Table 403.3.1.1 in accordance with accepted engineering practice.

Exception: The occupant load is not required to be determined based on the estimated maximum occupant load rate indicated in Table 403.3.1.1 where *approved* statistical data document the accuracy of an alternative anticipated occupant density.

INSIGHTS (5)

TABLE 403.3.1.1 MINIMUM VENTILATION RATES

OCCUPANCY CLASSIFICATION	OCCUPANT DENSITY #/1000 FT^2 [a]	PEOPLE OUTDOOR AIRFLOW RATE IN BREATHING ZONE, R_p CFM/PERSON	AREA OUTDOOR AIRFLOW RATE IN BREATHING ZONE, R_a CFM/FT^2 [a]	EXHAUST AIRFLOW RATE CFM/FT^2 [a]
Correctional facilities				
Booking/waiting	50	7.5	0.06	—
Cells				
without plumbing fixtures	25	5	0.12	—
with plumbing fixtures[g]	25	5	0.12	1.0
Day room	30	5	0.06	—
Dining halls (see “Food and beverage service”)	—	—	—	—
Guard stations	15	5	0.06	—

Dry cleaners, laundries				
Coin-operated dry cleaner	20	15	—	—
Coin-operated laundries	20	7.5	0.12	—
Commercial dry cleaner	30	30	—	—
Commercial laundry	10	5	0.12	—
Storage, pick up	30	7.5	0.12	—
Education				
Art classroom[g]	20	10	0.18	0.7
Auditoriums	150	5	0.06	—
Classrooms (ages 5–8)	25	10	0.12	—
Classrooms (age 9 plus)	35	10	0.12	—
Computer lab	25	10	0.12	—
Corridors (see “Public spaces”)	—	—	—	—
Day care (through age 4)	25	10	0.18	—
Lecture classroom	65	7.5	0.06	—
Lecture hall (fixed seats)	150	7.5	0.06	—
Locker/dressing rooms[g]	—	—	—	0.25
Media center	25	10	0.12	—
Multiuse assembly	100	7.5	0.06	—
Music/theater/dance	35	10	0.06	—
Science laboratories[g]	25	10	0.18	1.0
Smoking lounges[b]	70	60	—	—
Sports locker rooms[g]	—	—	—	0.5
Wood/metal shops[g]	20	10	0.18	0.5
Food and beverage service				
Bars, cocktail lounges	100	7.5	0.18	—
Cafeteria, fast food	100	7.5	0.18	—

Dining rooms	70	7.5	0.18	—
Kitchens (cooking)[b]	20	7.5	0.12	0.7
Hotels, motels, resorts and dormitories				
Bathrooms/toilet—private[g]	—	—	—	25/50[f]
Bedroom/living room	10	5	0.06	—
Conference/meeting	50	5	0.06	—
Dormitory sleeping areas	20	5	0.06	—
Gambling casinos	120	7.5	0.18	
Lobbies/prefunction	30	7.5	0.06	—
Multipurpose assembly	120	5	0.06	—
Offices				
Conference rooms	50	5	0.06	—
Main entry lobbies	10	5	0.06	—
Office spaces	5	5	0.06	—
Reception areas	30	5	0.06	—
Telephone/data entry	60	5	0.06	
Private dwellings, single and multiple				
Garages, common for multiple units[b]	—	—	—	0.75
Kitchens[b]	—	—	—	50/100[f]
Living areas[c]	Based on number of bedrooms. First bedroom, 2; each additional bedroom, 1	0.35 ACH but not less than 15 cfm/person	—	—
Toilet rooms and bathrooms[g]	—	—	—	25/50[f]
Public spaces				
Corridors	—	—	0.06	—
Courtrooms	70	5	0.06	—
Elevator car	—	—	—	1.0
Legislative chambers	50	5	0.06	—
Libraries	10	5	0.12	—

Museums (children's)	40	7.5	0.12	—
Museums/galleries	40	7.5	0.06	—
Places of religious worship	120	5	0.06	—
Shower room (per shower head)[g]	—	—	—	50/20[f]
Smoking lounges[b]	70	60	—	—
Toilet rooms — public[g]	—	—	—	50/70[e]
Retail stores, sales floors and showroom floors				
Dressing rooms	—	—	—	0.25
Mall common areas	40	7.5	0.06	—
Sales	15	7.5	0.12	—
Shipping and receiving	2	10	0.12	—
Smoking lounges[b]	70	60	—	—
Storage rooms	—	—	0.12	—
Warehouses (see "Storage")	—	10	0.06	—
Specialty shops				
Automotive motor fuel-dispensing stations[b]	—	—	—	1.5
Barber	25	7.5	0.06	0.5
Beauty salons[b]	25	20	0.12	0.6
Embalming room[b]	—	—	—	2.0
Nail salons [b, h]	25	20	0.12	0.6
Pet shops (animal areas)[b]	10	7.5	0.18	0.9
Supermarkets	8	7.5	0.06	—
Sports and amusement				
Bowling alleys (seating areas)	40	10	0.12	—
Disco/dance floors	100	20	0.06	—
Game arcades	20	7.5	0.18	—
Gym, stadium, arena (play area)	7	20	0.18	—

Health club/aerobics room	40	20	0.06	—
Health club/weight room	10	20	0.06	—
Ice arenas without combustion engines	—	—	0.30	0.5
Spectator areas	150	7.5	0.06	—
Swimming pools (pool and deck area)	—	—	0.48	—
Storage				0.75
Refrigerated warehouses/freezers	—	10	—	
Repair garages, enclosed parking garages[b,d]	—	—		0.75
Warehouses	—	10	0.06	—
Theaters				
Auditoriums (see “Education”)	—	—	—	—
Lobbies	150	5	0.06	—
Stages, studios	70	10	0.06	—
Ticket booths	60	5	0.06	—
Transportation				
Platforms	100	7.5	0.06	—
Transportation waiting	100	7.5	0.06	—
Workrooms				
Bank vaults/safe deposit	5	5	0.06	—
Computer (without printing)	4	5	0.06	—
Copy, printing rooms	4	5	0.06	0.5
Darkrooms	—	—	—	1.0
Meat processing[c]	10	15	—	—
Pharmacy (prep. area)	10	5	0.18	—
Photo studios	10	5	0.12	—

For SI: 1 cubic foot per minute = 0.0004719 m^3/s, 1 ton = 908 kg, 1 cubic foot per minute per square foot = 0.00508 $m^3/(s \cdot m^2)$, °C = [(°F) – 32]/1.8, 1 square foot = 0.0929 m^2.

a.
Based on net occupiable floor area.

b.
Mechanical exhaust required and the recirculation of air from such spaces is prohibited. Recirculation of air that is contained completely within such spaces shall not be prohibited (see Section 403.2.1, Item 3).

c.
Spaces unheated or maintained below 50°F are not covered by these requirements unless the occupancy is continuous.

d.
Ventilation systems in enclosed parking garages shall comply with Section 404.

e.
Rates are per water closet or urinal. The higher rate shall be provided where the exhaust system is designed to operate intermittently. The lower rate shall be permitted only where the exhaust system is designed to operate continuously while occupied.

f.
Rates are per room unless otherwise indicated. The higher rate shall be provided where the exhaust system is designed to operate intermittently. The lower rate shall be permitted only where the exhaust system is designed to operate continuously while occupied.

g.
Mechanical exhaust is required and recirculation from such spaces is prohibited. For occupancies other than science laboratories, where there is a wheeltype energy recovery ventilation (ERV) unit in the exhaust system design, the volume of air leaked from the exhaust airstream into the outdoor airstream within the ERV shall be less than 10 percent of the outdoor air volume. Recirculation of air that is contained completely within such spaces shall not be prohibited (see Section 403.2.1, Items 2 and 4).

h.
For nail salons, each manicure and pedicure station shall be provided with a source capture system capable of exhausting not less than 50 cfm per station. Exhaust inlets shall be located in accordance with Section 502.20. Where one or more required source capture systems operate continuously during occupancy, the exhaust rate from such systems shall be permitted to be applied to the exhaust flow rate required by Table 403.3.1.1 for the nail salon.

403.3.1.1.1 Zone outdoor airflow.

The minimum outdoor airflow required to be supplied to each zone shall be determined as a function of *occupancy* classification and space air distribution effectiveness in accordance with Sections 403.3.1.1.1.1 through 403.3.1.1.1.3.

403.3.1.1.1.1 Breathing zone outdoor airflow.

The outdoor airflow rate required in the *breathing zone* (V_{bz}) of the *occupiable space* or spaces in a zone shall be determined in accordance with Equation 4-1.

Equation 4-1 $Vbz=RpPz+RaAz$

where:

A_z =Zone floor area: the net occupiable floor area of the space or spaces in the zone.
P_z =Zone population: the number of people in the space or spaces in the zone.
R_p =People outdoor air rate: the outdoor airflow rate required per person from Table 403.3.1.1.
R_a =Area outdoor air rate: the outdoor airflow rate required per unit area from Table 403.3.1.1.

403.3.1.1.1.2 Zone air distribution effectiveness.

The zone air distribution effectiveness (E_z) shall be determined using Table 403.3.1.1.1.2.

TABLE 403.3.1.1.1.2 ZONE AIR DISTRIBUTION EFFECTIVENESS[a, b, c, d]

AIR DISTRIBUTION CONFIGURATION	E_z
Ceiling or floor supply of cool air	1.0[e]
Ceiling or floor supply of warm air and floor return	1.0
Ceiling supply of warm air and ceiling return	0.8[f]
Floor supply of warm air and ceiling return	0.7
Makeup air drawn in on the opposite side of the room from the exhaust or return	0.8
Makeup air drawn in near to the exhaust or return location	0.5

For SI: 1 foot = 304.8 mm, 1 foot per minute = 0.00506 m/s, °C = [(°F) – 32]/1.8.

a.
"Cool air" is air cooler than space temperature.
b.
"Warm air" is air warmer than space temperature.
c.
"Ceiling" includes any point above the breathing zone.
d.
"Floor" includes any point below the breathing zone.
e.
Zone air distribution effectiveness of 1.2 shall be permitted for systems with a floor supply of cool air and ceiling return, provided that low-velocity displacement ventilation achieves unidirectional flow and thermal stratification.
f.
Zone air distribution effectiveness of 1.0 shall be permitted for systems with a ceiling supply of warm air, provided that supply air temperature is less than 15°F above space temperature and provided that the 150-foot-per-minute supply air jet reaches to within 4 1/2 feet of floor level.

403.3.1.1.1.3 Zone outdoor airflow.

The zone outdoor airflow rate (V_{oz}), shall be determined in accordance with Equation 4-2.

Equation 4-2 $Voz = VbzEz$

403.3.1.1.2 System outdoor airflow.

The outdoor air required to be supplied by each ventilation system shall be determined in accordance with Sections 403.3.1.1.2.1 through 403.3.1.1.2.3.4 as a function of system type and zone outdoor airflow rates.

403.3.1.1.2.1 Single zone systems.

Where one air handler supplies a mixture of outdoor air and recirculated return air to only one zone, the system outdoor air intake flow rate (V_{ot}) shall be determined in accordance with Equation 4-3.

Equation 4-3 $Vot = Voz$

403.3.1.1.2.2 100-percent outdoor air systems.

Where one air handler supplies only outdoor air to one or more zones, the system outdoor air intake flow rate (V_{ot}) shall be determined using Equation 4-4.

Equation 4-4 $Vot = \Sigma allzones Voz$

403.3.1.1.2.3 Multiple zone recirculating systems.

Where one air handler supplies a mixture of outdoor air and recirculated return air to more than one zone, the system outdoor air intake flow rate (V_{ot}) shall be determined in accordance with Sections 403.3.1.1.2.3.1 through 403.3.1.1.2.3.4.

403.3.1.1.2.3.1 Primary outdoor air fraction.

The primary outdoor air fraction (Z_p) shall be determined for each zone in accordance with Equation 4-5.

Equation 4-5 $Z_p = \frac{V_{oz}}{V_{pz}}$

where:

V_{pz} =Primary airflow: The airflow rate supplied to the zone from the airhandling unit at which the outdoor air intake is located. It includes outdoor intake air and recirculated air from that air-handling unit but does not include air transferred or air recirculated to the zone by other means. For design purposes, V_{pz} shall be the zone design primary airflow rate, except for zones with variable air volume supply and V_{pz} shall be the lowest expected primary airflow rate to the zone when it is fully occupied.

403.3.1.1.2.3.2 System ventilation efficiency.

The system ventilation efficiency (E_v) shall be determined using Table 403.3.1.1.2.3.2 or Appendix A of ASHRAE 62.1.

TABLE 403.3.1.1.2.3.2 SYSTEM VENTILATION EFFICIENCY[a, b]

Max (Z_p)	E_v
≤ 0.15	1
≤ 0.25	0.9
≤ 0.35	0.8
≤ 0.45	0.7
≤ 0.55	0.6
≤ 0.65	0.5
≤ 0.75	0.4
> 0.75	0.3

a.
Max (Z_p) is the largest value of Z_p calculated using Equation 4-5 among all the zones served by the system.
b.
Interpolating between table values shall be permitted.

403.3.1.1.2.3.3 Uncorrected outdoor air intake.

The uncorrected outdoor air intake flow rate (V_{ou}) shall be determined in accordance with Equation 4-6.

Equation 4-6 $V_{ou} = D\sum_{all\ zones} R_p P_z + \sum_{all\ zones} R_a A_z$

where:

D =Occupant diversity: the ratio of the system population to the sum of the zone populations, determined in accordance with Equation 4-7.

Equation 4-7 $D = \frac{P_s}{\Sigma_{all\ zones} P_z}$

where:

P_s =System population: The total number of occupants in the area served by the system. For design purposes, P_s shall be the maximum number of occupants expected to be concurrently in all zones served by the system.

403.3.1.1.2.3.4 Outdoor air intake flow rate.

The outdoor air intake flow rate (V_{ot}) shall be determined in accordance with Equation 4-8.

Equation 4-8 $V_{ot} = \frac{V_{ou}}{E_v}$

403.3.1.2 Exhaust ventilation.

Exhaust airflow rate shall be provided in accordance with the requirements of Table 403.3.1.1. Outdoor air introduced into a space by an exhaust system shall be considered as contributing to the outdoor airflow required by Table 403.3.1.1.

403.3.1.3 System operation.

The minimum flow rate of outdoor air that the ventilation system must be capable of supplying during its operation shall be permitted to be based on the rate per person indicated in Table 403.3.1.1 and the actual number of occupants present. Where demand-controlled ventilation is employed to adjust the outdoor airflow rate based on the actual number of occupants present, the minimum quantity of outdoor air shall not fall below that determined from the area outdoor airflow rate column of Table 403.3.1.1 during periods when the *building* is expected to be occupied.

INSIGHTS (3)

403.3.1.4 Variable air volume system control.

Variable air volume air distribution systems, other than those designed to supply only 100-percent outdoor air, shall be provided with controls to regulate the flow of outdoor air. Such control system shall be designed to maintain the flow rate of outdoor air at a rate of not less than that required by Section 403.3 over the entire range of supply air operating rates.

➡

403.3.2 Group R-2, R-3 and R-4 occupancies, three stories and less.

The design of local exhaust systems and ventilation systems for outdoor air in Group R-2, R-3 and R-4 *occupancies* three stories and less in height above grade plane shall comply with Sections 403.3.2.1 through 403.3.2.5.

403.3.2.1 Outdoor air for dwelling units.

An outdoor air ventilation system consisting of a mechanical exhaust system, supply system or combination thereof shall be installed for each *dwelling unit*. Local exhaust or supply systems, including outdoor air ducts connected to the return side of an air handler, are permitted to serve as such a system. The outdoor air ventilation system shall be designed to provide the required rate of outdoor air continuously during the period that the *building* is occupied. The minimum continuous outdoor airflow rate shall be determined in accordance with Equation 4-9.

Equation 4-9 $QOA=0.01Afloor+7.5(Nbr+1)$

where:

Q_{OA} =outdoor airflow rate, cfm
A_{floor} =floor area, ft^2
N_{br} =number of bedrooms; not to be less than one

Exceptions:

1.

The outdoor air ventilation system is not required to operate continuously where the system has controls that enable operation for not less than 1 hour of each 4-hour period. The average outdoor airflow rate over the 4-hour period shall be not less than that prescribed by Equation 4-9.

2.

The minimum mechanical ventilation rate determined in accordance with Equation 4-9 shall be reduced by 30 percent provided that both of the following conditions apply:

2.1.

A ducted system supplies *ventilation air* directly to each bedroom and to one or more of the following rooms:

2.1.1.

Living room.

2.1.2.

Dining room.

2.1.3.

Kitchen.

2.2.

The whole-house ventilation system is a *balanced ventilation system*.

INSIGHTS (1)

403.3.2.2 Outdoor air for other spaces.

Corridors and other common areas within the conditioned space shall be provided with outdoor air at a rate of not less than 0.06 cfm per square foot [0.0003 $m^3/(s \cdot m^2)$] of floor area.

403.3.2.3 Local exhaust.

Local exhaust systems shall be provided in kitchens, bathrooms and toilet rooms and shall have the capacity to exhaust the minimum airflow rate determined in accordance with Table 403.3.2.3.

TABLE 403.3.2.3 MINIMUM REQUIRED LOCAL EXHAUST RATES FOR GROUP R-2, R-3 AND R-4 OCCUPANCIES

AREA TO BE EXHAUSTED	EXHAUST RATE CAPACITY
Kitchens	100 cfm intermittent or 25 cfm continuous
Bathrooms and toilet rooms	50 cfm intermittent or 20 cfm continuous

For SI: 1 cubic foot per minute = 0.0004719 m^3/s.

403.3.2.4 System controls.

Where provided within a *dwelling unit*, controls for outdoor air ventilation systems shall include text or a symbol indicating the system's function.

403.3.2.5 Ventilating equipment.

Fans providing exhaust or outdoor air shall be *listed* and *labeled* to provide the minimum required air flow in accordance with ANSI/AMCA 210-ANSI/ASHRAE 51.

INSIGHTS (2)

Section 404 Enclosed Parking Garages

404.1 Enclosed parking garages.

Mechanical ventilation systems for enclosed parking garages shall operate continuously or shall be automatically operated by means of carbon monoxide detectors applied in conjunction with nitrogen dioxide detectors. Such detectors shall be *listed* in accordance with UL 2075 and installed in accordance with their listing and the manufacturer's instructions. Automatic operation shall cycle the ventilation system between the following two modes of operation:

1.

Full-on at an airflow rate of not less than 0.75 cfm per square foot [0.0038 $m^3/(s \cdot m^2)$] of the floor area served.

2.

Standby at an airflow rate of not less than 0.05 cfm per square foot [0.00025 $m^3/(s \cdot m^2)$] of the floor area served.

INSIGHTS (1)

404.2 Occupied spaces accessory to public garages.

Connecting offices, waiting rooms, ticket booths and similar uses that are accessory to a public garage shall be maintained at a positive pressure and shall be provided with ventilation in accordance with Section 403.3.1.

Section 405 Systems Control

405.1 General.

Mechanical ventilation systems shall be provided with manual or automatic controls that will operate such systems whenever the spaces are occupied. Air-conditioning systems that supply required *ventilation air* shall be provided with controls designed to automatically maintain the required outdoor air supply rate during occupancy.

Section 406 Ventilation of Uninhabited Spaces

406.1 General.

Uninhabited spaces, such as crawl spaces and attics, shall be provided with *natural ventilation* openings as required by the *International Building Code* or shall be provided with a mechanical exhaust and supply air system. The mechanical exhaust rate shall be not less than 0.02 cfm per square foot (0.00001 $m^3/s \cdot m^2$) of horizontal area and shall be automatically controlled to operate when the relative humidity in the space served exceeds 60 percent.

INSIGHTS (1)

Section 407 Ambulatory Care Facilities and Group I-2 Occupancies

407.1 General.

Mechanical ventilation for ambulatory care facilities and Group I-2 *occupancies* shall be designed and installed in accordance with this code, ASHRAE 170 and NFPA 99.

Chapter 5 Exhaust Systems

User note:

About this chapter: *Chapter 5 addresses exhaust systems for, among others, kitchens, laboratories, processes, garages, hazardous systems, clothes dryers and smoke control systems. Many provisions are linked to the International Fire Code®. Exhaust systems mitigate health and fire hazards by removing and diluting contaminants in buildings. Exhaust system discharge location is also addressed as an important concern.*

Section 501 General

501.1 Scope.

This chapter shall govern the design, construction and installation of mechanical exhaust systems, including exhaust systems serving clothes dryers and cooking *appliances*; hazardous exhaust systems; dust, stock and refuse conveyor systems; subslab soil exhaust systems; smoke control systems; energy recovery ventilation systems and other systems specified in Section 502.

501.2 Independent system required.

Single or combined mechanical exhaust systems for *environmental air* shall be independent of all other exhaust systems. Dryer, domestic kitchen and hazardous exhaust shall be independent of all other systems. Type I exhaust systems shall be independent of all other exhaust systems except as provided in Section 506.3.5. Single or combined Type II exhaust systems for food-processing operations shall be independent of all other exhaust systems.

Commercial kitchen exhaust systems shall be constructed in accordance with Sections 506 through 509.

INSIGHTS (3)

501.3 Exhaust discharge.

The air removed by every mechanical exhaust system shall be discharged outdoors at a point where it will not cause a public nuisance and not less than the distances specified in Section 501.3.1. The air shall be discharged to a location from which it cannot again be readily drawn in by a ventilating system. Air shall not be exhausted into an attic or crawl space, or be directed onto walkways.

Exceptions:

1.

Whole-house ventilation-type attic fans shall be permitted to discharge into the attic space of *dwelling units* having private attics.

2.

Commercial cooking recirculating systems.

3.

Where installed in accordance with the manufacturer's instructions and where mechanical or *natural ventilation* is otherwise provided in accordance with Chapter 4, *listed* and *labeled* domestic ductless range hoods shall not be required to discharge to the outdoors.

INSIGHTS (1)

501.3.1 Location of exhaust outlets.

The termination point of exhaust outlets and ducts discharging to the outdoors shall be located with the following minimum distances:

1.

For ducts conveying explosive or flammable vapors, fumes or dusts: 30 feet (9144 mm) from property lines; 10 feet (3048 mm) from operable openings into buildings; 6 feet (1829 mm) from exterior walls and roofs; 30 feet (9144 mm) from combustible walls and operable openings into buildings that are in the direction of the exhaust discharge; 10 feet (3048 mm) above adjoining grade.

2.

For other product-conveying outlets: 10 feet (3048 mm) from the property lines; 3 feet (914 mm) from exterior walls and roofs; 10 feet (3048 mm) from operable openings into buildings; 10 feet (3048 mm) above adjoining grade.

3.

For all *environmental air* exhaust: 3 feet (914 mm) from property lines; 3 feet (914 mm) from operable openings into buildings for all *occupancies* other than Group U; and 10 feet (3048 mm) from mechanical air intakes. Such exhaust shall not be considered hazardous or noxious. Separation is not required between intake air openings and living space *exhaust air* openings of an individual *dwelling unit* or *sleeping unit* where an approved factory-built intake/exhaust combination termination fitting is used to separate the air streams in accordance with the manufacturer's instructions.

4.

Exhaust outlets serving structures in flood hazard areas shall be installed at or above the elevation required by Section 1612 of the *International Building Code* for utilities and attendant equipment.

5.

For specific systems, see the following sections:

5.1.

Clothes dryer exhaust, Section 504.4.

5.2.

Kitchen hoods and other kitchen exhaust *equipment*, Sections 506.3.13, 506.4 and 506.5.

5.3.

Dust, stock and refuse conveying systems, Section 511.2.

5.4.

Subslab soil exhaust systems, Section 512.4.

5.5.

Smoke control systems, Section 513.10.3.

5.6.

Refrigerant discharge, Section 1105.7.

5.7.

Machinery room discharge, Section 1105.6.1.

INSIGHTS (5)

501.3.2 Exhaust opening protection.

Exhaust openings that terminate outdoors shall be protected with corrosion-resistant screens, louvers or grilles. Openings in screens, louvers and grilles shall be sized not less than 1/4 inch (6.4 mm) and not larger than 1/2 inch (12.7 mm). Openings shall be protected against local weather conditions. Louvers that protect exhaust openings in structures located in hurricane-prone regions, as defined in the *International Building Code*, shall comply with AMCA Standard 550. Outdoor openings located in exterior walls shall meet the provisions for exterior wall opening protectives in accordance with the *International Building Code*.

501.4 Pressure equalization.

Mechanical exhaust systems shall be sized to remove the quantity of air required by this chapter to be exhausted. The system shall operate when air is required to be exhausted. Where mechanical exhaust is required in a room or space in other than *occupancies* in Group R-3 and *dwelling units* in Group R-2, such space shall be maintained with a neutral or negative pressure. If a greater quantity of air is supplied by a mechanical ventilating supply system than is removed by a mechanical exhaust for a room, adequate means shall be provided for the natural or mechanical exhaust of the excess air supplied. If only a mechanical exhaust system is installed for a room or if a greater quantity of air is removed by a mechanical exhaust system than is supplied by a mechanical ventilating supply system for a room, adequate *makeup air* shall be provided to satisfy the deficiency.

501.5 Ducts.

Where exhaust duct construction is not specified in this chapter, such construction shall comply with Chapter 6.

Section 502 Required Systems

502.1 General.

An exhaust system shall be provided, maintained and operated as specifically required by this section and for all occupied areas where machines, vats, tanks, furnaces, forges, salamanders and other *appliances*, *equipment* and processes in such areas produce or throw off dust or particles sufficiently light to float in the air, or emit heat, odors, fumes, spray, gas or smoke in such quantities so as to be irritating or injurious to health or safety.

INSIGHTS (1)

502.1.1 Exhaust location.

The inlet to an exhaust system shall be located in the area of heaviest concentration of contaminants.

[F] 502.1.2 Fuel-dispensing areas.

The bottom of an air inlet or exhaust opening in fuel-dispensing areas shall be located not more than 18 inches (457 mm) above the floor.

502.1.3 Equipment, appliance and service rooms.

Equipment, *appliance* and system service rooms that house sources of odors, fumes, noxious gases, smoke, steam, dust, spray or other contaminants shall be designed and constructed so as to prevent spreading of such contaminants to other occupied parts of the *building*.

[F] 502.1.4 Hazardous exhaust.

The mechanical exhaust of high concentrations of dust or hazardous vapors shall conform to the requirements of Section 510.

[F] 502.2 Aircraft fueling and defueling.

Compartments housing piping, pumps, air eliminators, water separators, hose reels and similar *equipment* used in aircraft fueling and defueling operations shall be adequately ventilated at floor level or within the floor itself.

[F] 502.3 Battery-charging areas for powered industrial trucks and equipment.

Ventilation shall be provided in an *approved* manner in battery-charging areas for powered industrial trucks and *equipment* to prevent a dangerous accumulation of flammable gases.

[F] 502.4 Stationary storage battery systems.

Stationary storage battery systems shall be regulated and ventilated in accordance with Section 1207.6.1 of the *International Fire Code* and the general requirements of this chapter.

[F] 502.5 Ventilation of battery systems in cabinets.

Stationary storage battery systems installed in cabinets shall be provided with ventilation in accordance with Section 502.4.

[F] 502.6 Dry cleaning plants.

Ventilation in dry cleaning plants shall be adequate to protect employees and the public in accordance with this section and DOL 29 CFR Part 1910.1000, where applicable.

[F] 502.6.1 Type II systems.

Type II dry cleaning systems shall be provided with a mechanical ventilation system that is designed to exhaust 1 cubic foot of air per minute for each square foot of floor area (1 cfm/ft^2) [0.00508 m^3/ (s • m^2)] in dry cleaning rooms and in drying rooms. The ventilation system shall operate automatically when the dry cleaning *equipment* is in operation and shall have manual controls at an *approved* location.

[F] 502.6.2 Type IV and V systems.

Type IV and V dry cleaning systems shall be provided with an automatically activated exhaust ventilation system to maintain an air velocity of not less than 100 feet per minute (0.51 m/s) through the loading door when the door is opened.

> **Exception:** Dry cleaning units are not required to be provided with exhaust ventilation where an exhaust hood is installed immediately outside of and above the loading door and operates at an airflow rate as follows:

Equation 5-1 $Q = 100 \times A_{LD}$

where:

Q =Flow rate exhausted through the hood, cubic feet per minute.
A_{LD} =Area of the loading door, square feet.

[F] 502.6.3 Spotting and pretreating.

Scrubbing tubs, scouring, brushing or spotting operations shall be located such that solvent vapors are captured and exhausted by the ventilating system.

[F] 502.7 Application of flammable finishes.

Mechanical exhaust as required by this section shall be provided for operations involving the application of flammable finishes.

[F] 502.7.1 During construction.

Ventilation shall be provided for operations involving the application of materials containing flammable solvents in the course of construction, *alteration* or demolition of a structure.

[F] 502.7.2 Limited spraying spaces.

Positive mechanical ventilation that provides not less than six complete air changes per hour shall be installed in limited spraying spaces. Such system shall meet the requirements of the *International Fire Code* for handling flammable vapors. Explosion venting is not required.

[F] 502.7.3 Flammable vapor areas.

Mechanical ventilation of flammable vapor areas shall be provided in accordance with Sections 502.7.3.1 through 502.7.3.6.

[F] 502.7.3.1 Operation.

Mechanical ventilation shall be kept in operation at all times while spraying operations are being conducted and for a sufficient time thereafter to allow vapors from drying coated articles and finishing material residue to be exhausted. Spraying *equipment* shall be interlocked with the ventilation of the flammable vapor area such that spraying operations cannot be conducted unless the ventilation system is in operation.

[F] 502.7.3.2 Recirculation.

Air exhausted from spraying operations shall not be recirculated.

Exceptions:

1.

Air exhausted from spraying operations shall be permitted to be recirculated as *makeup air* for unmanned spray operations provided that:

1.1.

The solid particulate has been removed.

1.2.

The vapor concentration is less than 25 percent of the lower flammable limit (LFL).

1.3.

Approved equipment is used to monitor the vapor concentration.

1.4.

An alarm is sounded and spray operations are automatically shut down if the vapor concentration exceeds 25 percent of the LFL.

1.5.

In the event of shutdown of the vapor concentration monitor, 100 percent of the air volume specified in Section 510 is automatically exhausted.

2.

Air exhausted from spraying operations is allowed to be recirculated as *makeup air* to manned spraying operations where all of the conditions provided in Exception 1 are included in the installation and documents have been prepared to show that the installation does not pose a life safety hazard to personnel inside the spray booth, spraying space or spray room.

[F] 502.7.3.3 Air velocity.

The ventilation system shall be designed, installed and maintained so that the flammable contaminants are diluted in noncontaminated air to maintain concentrations in the exhaust airflow below 25 percent of the contaminant's lower flammable limit (LFL). In addition, the spray booth shall be provided with mechanical ventilation so that the average air velocity through openings is in accordance with Sections 502.7.3.3.1 and 502.7.3.3.2.

[F] 502.7.3.3.1 Open face or open front spray booth.

For spray application operations conducted in an open face or open front spray booth, the ventilation system shall be designed, installed and maintained so that the average air velocity into the spray booth through all openings is not less than 100 feet per minute (0.51 m/s).

Exception: For fixed or automated electrostatic spray application equipment, the average air velocity into the spray booth through all openings shall be not less than 50 feet per minute (0.25 m/s).

[F] 502.7.3.3.2 Enclosed spray booth or spray room with openings for product conveyance.

For spray application operations conducted in an enclosed spray booth or spray room with openings for product conveyance, the ventilation system shall be designed, installed and maintained so that the average air velocity into the spray booth through openings is not less than 100 feet per minute (0.51 m/s).

Exceptions:

1. For fixed or automated electrostatic spray application equipment, the average air velocity into the spray booth through all openings shall be not less than 50 feet per minute (0.25 m/s).

2. Where methods are used to reduce cross drafts that can draw vapors and overspray through openings from the spray booth or spray room, the average air velocity into the spray booth or spray room shall be that necessary to capture and confine vapors and overspray to the spray booth or spray room.

[F] 502.7.3.4 Ventilation obstruction.

Articles being sprayed shall be positioned in a manner that does not obstruct collection of overspray.

[F] 502.7.3.5 Independent ducts.

Each spray booth and spray room shall have an independent exhaust duct system discharging to the outdoors.

Exceptions:

1.

Multiple spray booths having a combined frontal area of 18 square feet (1.67 m^2) or less are allowed to have a common exhaust where identical spray-finishing material is used in each booth. If more than one fan serves one booth, such fans shall be interconnected so that all fans operate simultaneously.

2.

Where treatment of exhaust is necessary for air pollution control or energy conservation, ducts shall be allowed to be manifolded if all of the following conditions are met:

2.1.

The sprayed materials used are compatible and will not react or cause ignition of the residue in the ducts.

2.2.

Nitrocellulose-based finishing material shall not be used.

2.3.

A filtering system shall be provided to reduce the amount of overspray carried into the duct manifold.

2.4.

Automatic sprinkler protection shall be provided at the junction of each booth exhaust with the manifold, in addition to the protection required by this chapter.

[F] 502.7.3.6 Fan motors and belts.

Electric motors driving exhaust fans shall not be placed inside booths or ducts. Fan rotating elements shall be nonferrous or nonsparking or the casing shall consist of, or be lined with, such material. Belts shall not enter the duct or booth unless the belt and pulley within the duct are tightly enclosed.

[F] 502.7.4 Dipping operations.

Flammable vapor areas of dip tank operations shall be provided with mechanical ventilation adequate to prevent the dangerous accumulation of vapors. Required ventilation systems shall be so arranged that the failure of any ventilating fan will automatically stop the dipping conveyor system.

[F] 502.7.5 Electrostatic apparatus.

The flammable vapor area in spray-finishing operations involving electrostatic apparatus and devices shall be ventilated in accordance with Section 502.7.3.

[F] 502.7.6 Powder coating.

Exhaust ventilation for powder-coating operations shall be sufficient to maintain the atmosphere below one-half of the minimum explosive concentration for the material being applied. Nondeposited, air-suspended powders shall be removed through exhaust ducts to the powder recovery system.

[F] 502.7.7 Floor resurfacing operations.

To prevent the accumulation of flammable vapors during floor resurfacing operations, mechanical ventilation at a minimum rate of 1 cfm/ft^2 [0.00508 m^3/(s • m^2)] of area being finished shall be provided. Such exhaust shall be by *approved* temporary or portable means. Vapors shall be exhausted to the outdoors.

[F] 502.8 Hazardous materials—general requirements.

Exhaust ventilation systems for structures containing hazardous materials shall be provided as required in Sections 502.8.1 through 502.8.5.

[F] 502.8.1 Storage in excess of the maximum allowable quantities.

Indoor storage areas and storage buildings for hazardous materials in amounts exceeding the maximum allowable quantity per control area shall be provided with mechanical exhaust ventilation or *natural ventilation* where *natural ventilation* can be shown to be acceptable for the materials as stored.

Exceptions:

1.

Storage areas for flammable solids complying with Section 5904 of the *International Fire Code*.

2.

Storage areas and storage buildings for fireworks and explosives complying with Chapter 56 of the *International Fire Code*.

[F] 502.8.1.1 System requirements.

Exhaust ventilation systems shall comply with all of the following:

1.

The installation shall be in accordance with this code.

2.

Mechanical ventilation shall be provided at a rate of not less than 1 cfm per square foot [0.00508 $m^3/(s \cdot m^2)$] of floor area over the storage area.

3.

The systems shall operate continuously unless alternate designs are *approved*.

4.

A manual shutoff control shall be provided outside of the room in a position adjacent to the access door to the room or in another *approved* location. The switch shall be a break-glass or other *approved* type and shall be *labeled*: VENTILATION SYSTEM EMERGENCY SHUTOFF.

5.

The exhaust ventilation shall be designed to consider the density of the potential fumes or vapors released. For fumes or vapors that are heavier than air, exhaust shall be taken from a point within 12 inches (305 mm) of the floor. For fumes or vapors that are lighter than air, exhaust shall be taken from a point within 12 inches (305 mm) of the highest point of the room.

6.

The location of both the exhaust and inlet air openings shall be designed to provide air movement across all portions of the floor or room to prevent the accumulation of vapors.

7.

The *exhaust air* shall not be recirculated to occupied areas if the materials stored are capable of emitting hazardous vapors and contaminants have not been removed. Air contaminated with explosive or flammable vapors, fumes or dusts; flammable, highly toxic or toxic gases; or radioactive materials shall not be recirculated.

[F] 502.8.2 Gas rooms, exhausted enclosures and gas cabinets.

The ventilation system for gas rooms, exhausted enclosures and gas cabinets for any quantity of hazardous material shall be designed to operate at a negative pressure in relation to the surrounding area. Highly toxic and toxic gases shall comply with Sections 502.9.7.1, 502.9.7.2 and 502.9.8.4.

[F] 502.8.3 Indoor dispensing and use.

Indoor dispensing and use areas for hazardous materials in amounts exceeding the maximum allowable quantity per control area shall be provided with exhaust ventilation in accordance with Section 502.8.1.

> **Exception:** Ventilation is not required for dispensing and use of flammable solids other than finely divided particles.

[F] 502.8.4 Indoor dispensing and use—point sources.

Where gases, liquids or solids in amounts exceeding the maximum allowable quantity per control area and having a hazard ranking of 3 or 4 in accordance with NFPA 704 are dispensed or used, mechanical exhaust ventilation shall be provided to capture gases, fumes, mists or vapors at the point of generation.

> **Exception:** Where it can be demonstrated that the gases, liquids or solids do not create harmful gases, fumes, mists or vapors.

[F] 502.8.5 Closed systems.

Where closed systems for the use of hazardous materials in amounts exceeding the maximum allowable quantity per control area are designed to be opened as part of normal operations, ventilation shall be provided in accordance with Section 502.8.4.

[F] 502.9 Hazardous materials—requirements for specific materials.

Exhaust ventilation systems for specific hazardous materials shall be provided as required in Section 502.8 and Sections 502.9.1 through 502.9.11.

[F] 502.9.1 Compressed gases—medical gas systems.

Rooms for the storage of compressed medical gases in amounts exceeding the permit amounts for compressed gases in the *International Fire Code*, and that do not have an exterior wall, shall be exhausted through a duct to the exterior of the *building*. Both separate airstreams shall be enclosed in a 1-hour-rated shaft enclosure from the room to the exterior. *Approved* mechanical ventilation shall be provided at a minimum rate of 1 cfm/ft^2 [0.00508 m^3/(s • m^2)] of the area of the room.

Gas cabinets for the storage of compressed medical gases in amounts exceeding the permit amounts for compressed gases in the *International Fire Code* shall be connected to an exhaust system. The average velocity of ventilation at the face of access ports or windows shall be not less than 200 feet per minute (1.02 m/s) with a minimum velocity of 150 feet per minute (0.76 m/s) at any point at the access port or window.

[F] 502.9.2 Corrosives.

Where corrosive materials in amounts exceeding the maximum allowable quantity per control area are dispensed or used, mechanical exhaust ventilation in accordance with Section 502.8.4 shall be provided.

[F] 502.9.3 Cryogenics.

Storage areas for stationary or portable containers of cryogenic fluids in any quantity shall be ventilated in accordance with Section 502.8. Indoor areas where cryogenic fluids in any quantity are dispensed shall be ventilated in accordance with the requirements of Section 502.8.4 in a manner that captures any vapor at the point of generation.

Exception: Ventilation for indoor dispensing areas is not required where it can be demonstrated that the cryogenic fluids do not create harmful vapors.

[F] 502.9.4 Explosives.

Squirrel cage blowers shall not be used for exhausting hazardous fumes, vapors or gases in operating buildings and rooms for the manufacture, assembly or testing of explosives. Only nonferrous fan blades shall be used for fans located within the ductwork and through which hazardous materials are exhausted. Motors shall be located outside the duct.

INSIGHTS (1)

[F] 502.9.5 Flammable and combustible liquids.

Exhaust ventilation systems shall be provided as required by Sections 502.9.5.1 through 502.9.5.5 for the storage, use, dispensing, mixing and handling of flammable and combustible liquids. Unless otherwise specified, this section shall apply to any quantity of flammable and combustible liquids.

Exceptions:

1.

This section shall not apply to flammable and combustible liquids that are exempt from the *International Fire Code*.

2.

The storage of beer, distilled spirits and wine in barrels and casks conforming to the requirements of the *International Fire Code*.

INSIGHTS (2)

[F] 502.9.5.1 Vaults.

Vaults that contain tanks of Class I liquids shall be provided with continuous ventilation at a rate of not less than 1 cfm/ft^2 of floor area [0.00508 m^3/(s • m^2)], but not less than 150 cfm (4.25 m^3/min). Failure of the exhaust airflow shall automatically shut down the dispensing system.

The exhaust system shall be designed to provide air movement across all parts of the vault floor. Supply and exhaust ducts shall extend to a point not greater than 12 inches (305 mm) and not less than 3 inches (76 mm) above the floor. The exhaust system shall be installed in accordance with the provisions of NFPA 91. Means shall be provided to automatically detect any flammable vapors and to automatically shut down the dispensing system upon detection of such flammable vapors in the exhaust duct at a concentration of 25 percent of the LFL.

[F] 502.9.5.2 Storage rooms and warehouses.

Liquid storage rooms and liquid storage warehouses for quantities of liquids exceeding those specified in the *International Fire Code* shall be ventilated in accordance with Section 502.8.1.

[F] 502.9.5.3 Cleaning machines.

Areas containing machines used for parts cleaning in accordance with the *International Fire Code* shall be adequately ventilated to prevent accumulation of vapors.

[F] 502.9.5.4 Use, dispensing and mixing.

Continuous mechanical ventilation shall be provided for the use, dispensing and mixing of flammable and combustible liquids in open or closed systems in amounts exceeding the maximum allowable quantity per control area and for bulk transfer and process transfer operations. The ventilation rate shall be not less than 1 cfm/ft^2 [0.00508 m^3/(s • m^2)] of floor area over the design area. Provisions shall be made for the introduction of *makeup air* in a manner that will include all floor areas or pits where vapors can collect. Local or spot ventilation shall be provided where needed to prevent the accumulation of hazardous vapors.

> **Exception:** Where *natural ventilation* can be shown to be effective for the materials used, dispensed or mixed.

[F] 502.9.5.5 Bulk plants or terminals.

Ventilation shall be provided for portions of properties where flammable and combustible liquids are received by tank vessels, pipelines, tank cars or tank vehicles and are stored or blended in bulk for the purpose of distributing such liquids by tank vessels, pipelines, tank cars, tank vehicles or containers as required by Sections 502.9.5.5.1 through 502.9.5.5.3.

[F] 502.9.5.5.1 General.

Ventilation shall be provided for rooms, buildings and enclosures in which Class I liquids are pumped, used or transferred. Design of ventilation systems shall consider the relatively high specific gravity of the vapors. Where *natural ventilation* is used, adequate openings in outside walls at floor level, unobstructed except by louvers or coarse screens, shall be provided. Where *natural ventilation* is inadequate, mechanical ventilation shall be provided.

[F] 502.9.5.5.2 Basements and pits.

Class I liquids shall not be stored or used within a *building* having a basement or pit into which flammable vapors can travel, unless such area is provided with ventilation designed to prevent the accumulation of flammable vapors therein.

[F] 502.9.5.5.3 Dispensing of Class I liquids.

Containers of Class I liquids shall not be drawn from or filled within buildings unless a provision is made to prevent the accumulation of flammable vapors in hazardous concentrations. Where mechanical ventilation is required, it shall be kept in operation while flammable vapors could be present.

[F] 502.9.6 Highly toxic and toxic liquids.

Ventilation exhaust shall be provided for highly toxic and toxic liquids as required by Sections 502.9.6.1 and 502.9.6.2.

[F] 502.9.6.1 Treatment system.

This provision shall apply to indoor and outdoor storage and use of highly toxic and toxic liquids in amounts exceeding the maximum allowable quantities per control area. Exhaust scrubbers or other systems for processing vapors of highly toxic liquids shall be provided where a spill or accidental release of such liquids can be expected to release highly toxic vapors at normal temperature and pressure.

[F] 502.9.6.2 Open and closed systems.

Mechanical exhaust ventilation shall be provided for highly toxic and toxic liquids used in open systems in accordance with Section 502.8.4. Mechanical exhaust ventilation shall be provided for highly toxic and toxic liquids used in closed systems in accordance with Section 502.8.5.

> **Exception:** Liquids or solids that do not generate highly toxic or toxic fumes, mists or vapors.

[F] 502.9.7 Highly toxic and toxic compressed gases—any quantity.

Ventilation exhaust shall be provided for highly toxic and toxic compressed gases in any quantity as required by Sections 502.9.7.1 and 502.9.7.2.

[F] 502.9.7.1 Gas cabinets.

Gas cabinets containing highly toxic or toxic compressed gases in any quantity shall comply with Section 502.8.2 and the following requirements:

1.

The average ventilation velocity at the face of gas cabinet access ports or windows shall be not less than 200 feet per minute (1.02 m/s) with a minimum velocity of 150 feet per minute (0.76 m/s) at any point at the access port or window.

2.

Gas cabinets shall be connected to an exhaust system.

3.

Gas cabinets shall not be used as the sole means of exhaust for any room or area.

[F] 502.9.7.2 Exhausted enclosures.

Exhausted enclosures containing highly toxic or toxic compressed gases in any quantity shall comply with Section 502.8.2 and the following requirements:

1.

The average ventilation velocity at the face of the enclosure shall be not less than 200 feet per minute (1.02 m/s) with a minimum velocity of 150 feet per minute (0.76 m/s).

2.

Exhausted enclosures shall be connected to an exhaust system.

3.

Exhausted enclosures shall not be used as the sole means of exhaust for any room or area.

[F] 502.9.8 Highly toxic and toxic compressed gases—quantities exceeding the maximum allowable quantity per control area.

Ventilation exhaust shall be provided for highly toxic and toxic compressed gases in amounts exceeding the maximum allowable quantities per control area as required by Sections 502.9.8.1 through 502.9.8.6.

[F] 502.9.8.1 Ventilated areas.

The room or area in which indoor gas cabinets or exhausted enclosures are located shall be provided with exhaust ventilation. Gas cabinets or exhausted enclosures shall not be used as the sole means of exhaust for any room or area.

[F] 502.9.8.2 Local exhaust for portable tanks.

A means of local exhaust shall be provided to capture leakage from indoor and outdoor portable tanks. The local exhaust shall consist of portable ducts or collection systems designed to be applied to the site of a leak in a valve or fitting on the tank. The local exhaust system shall be located in a gas room. Exhaust shall be directed to a treatment system where required by the *International Fire Code*.

[F] 502.9.8.3 Piping and controls—stationary tanks.

Filling or dispensing connections on indoor stationary tanks shall be provided with a means of local exhaust. Such exhaust shall be designed to capture fumes and vapors. The exhaust shall be directed to a treatment system where required by the *International Fire Code*.

[F] 502.9.8.4 Gas rooms.

The ventilation system for gas rooms shall be designed to operate at a negative pressure in relation to the surrounding area. The exhaust ventilation from gas rooms shall be directed to an exhaust system.

[F] 502.9.8.5 Treatment system.

The exhaust ventilation from gas cabinets, exhausted enclosures and gas rooms, and local exhaust systems required in Sections 502.9.8.2 and 502.9.8.3 shall be directed to a treatment system where required by the *International Fire Code*.

[F] 502.9.8.6 Process equipment.

Effluent from indoor and outdoor process *equipment* containing highly toxic or toxic compressed gases which could be discharged to the atmosphere shall be processed through an exhaust scrubber or other processing system. Such systems shall be in accordance with the *International Fire Code*.

[F] 502.9.9 Ozone gas generators.

Ozone cabinets and ozone gas-generator rooms for systems having a maximum ozone-generating capacity of 1/2 pound (0.23 kg) or more over a 24-hour period shall be mechanically ventilated at a rate of not less than six air changes per hour. For cabinets, the average velocity of ventilation at *makeup air* openings with cabinet doors closed shall be not less than 200 feet per minute (1.02 m/s).

[F] 502.9.10 LP-gas distribution facilities.

LP-gas distribution facilities shall be ventilated in accordance with NFPA 58.

[F] 502.9.10.1 Portable container use.

Above-grade underfloor spaces or basements in which portable LP-gas containers are used or are stored awaiting use or resale shall be provided with an *approved* means of ventilation.

> **Exception:** Department of Transportation (DOT) specification cylinders with a maximum water capacity of 2.7 pounds (1.2 kg) for use in completely self-contained hand torches and similar applications. The quantity of LP-gas shall not exceed 20 pounds (9 kg).

[F] 502.9.11 Silane gas.

Exhausted enclosures and gas cabinets for the indoor storage of silane gas in amounts exceeding the maximum allowable quantities per control area shall comply with Chapter 64 of the *International Fire Code*.

[F] 502.10 Hazardous production materials (HPM).

Exhaust ventilation systems and materials for ducts utilized for the exhaust of HPM shall comply with this section, other applicable provisions of this code, the *International Building Code* and the *International Fire Code*.

[F] 502.10.1 Where required.

Exhaust ventilation systems shall be provided in the following locations in accordance with the requirements of this section and the *International Building Code*.

1.

Fabrication areas: Exhaust ventilation for fabrication areas shall comply with the *International Building Code*. Additional manual control switches shall be provided where required by the code official.

2.

Workstations: A ventilation system shall be provided to capture and exhaust gases, fumes and vapors at workstations.

3.

Liquid storage rooms: Exhaust ventilation for liquid storage rooms shall comply with Section 502.8.1.1 and the *International Building Code*.

4.

HPM rooms: Exhaust ventilation for HPM rooms shall comply with Section 502.8.1.1 and the *International Building Code*.

5.

Gas cabinets: Exhaust ventilation for gas cabinets shall comply with Section 502.8.2. The gas cabinet ventilation system is allowed to connect to a workstation ventilation system. Exhaust ventilation for gas cabinets containing highly toxic or toxic gases shall also comply with Sections 502.9.7 and 502.9.8.

6.

Exhausted enclosures: Exhaust ventilation for exhausted enclosures shall comply with Section 502.8.2. Exhaust ventilation for exhausted enclosures containing highly toxic or toxic gases shall also comply with Sections 502.9.7 and 502.9.8.

7.

Gas rooms: Exhaust ventilation for gas rooms shall comply with Section 502.8.2. Exhaust ventilation for gas rooms containing highly toxic or toxic gases shall also comply with Sections 502.9.7 and 502.9.8.

8.

Cabinets containing pyrophoric liquids or Class 3 water-reactive liquids: Exhaust ventilation for cabinets in fabrication areas containing pyrophoric liquids shall be as required in Section 2705.2.3.4 of the *International Fire Code*.

[F] 502.10.2 Penetrations.

Exhaust ducts penetrating 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* shall be contained in a shaft of equivalent fire-resistance-rated construction. Exhaust ducts shall not penetrate fire walls. *Fire dampers* shall not be installed in exhaust ducts.

[F] 502.10.3 Treatment systems.

Treatment systems for highly toxic and toxic gases shall comply with the *International Fire Code*.

502.11 Motion picture projectors.

Motion picture projectors shall be exhausted in accordance with Section 502.11.1 or 502.11.2.

502.11.1 Projectors with an exhaust discharge.

Projectors equipped with an exhaust discharge shall be directly connected to a mechanical exhaust system. The exhaust system shall operate at an exhaust rate as indicated by the manufacturer's installation instructions.

502.11.2 Projectors without exhaust connection.

Projectors without an exhaust connection shall have contaminants exhausted through a mechanical exhaust system. The exhaust rate for electric arc projectors shall be not less than 200 cubic feet per minute (cfm) (0.09 m^3/s) per lamp. The exhaust rate for xenon projectors shall be not less than 300 cfm (0.14 m^3/s) per lamp. Xenon projector exhaust shall be at a rate such that the exterior temperature of the lamp housing does not exceed 130°F (54°C). The lamp and projection room exhaust systems, whether combined or independent, shall not be interconnected with any other exhaust or return system within the *building*.

[F] 502.12 Organic coating processes.

Enclosed structures involving organic coating processes in which Class I liquids are processed or handled shall be ventilated at a rate of not less than 1 cfm/ft^2 [0.00508 $m^3/(s \cdot m^2)$] of solid floor area. Ventilation shall be accomplished by exhaust fans that intake at floor levels and discharge to a safe location outside the structure. Noncontaminated intake air shall be introduced in such a manner that all portions of solid floor areas are provided with continuous uniformly distributed air movement.

502.13 Public garages.

Mechanical exhaust systems for public garages, as required in Chapter 4, shall operate continuously or in accordance with Section 404.

502.14 Motor vehicle operation.

In areas where motor vehicles operate, mechanical ventilation shall be provided in accordance with Section 403. Additionally, areas in which stationary motor vehicles are operated shall be provided with a *source capture system* that connects directly to the motor vehicle exhaust systems. Such system shall be engineered by a *registered design professional* or shall be factory-built *equipment* designed and sized for the purpose.

Exceptions:

1.

This section shall not apply where the motor vehicles being operated or repaired are electrically powered.

2.

This section shall not apply to one- and two-family *dwellings*.

3.

This section shall not apply to motor vehicle service areas where engines are operated inside the *building* only for the duration necessary to move the motor vehicles in and out of the *building*.

INSIGHTS (2)

[F] 502.15 Repair garages.

Where Class I liquids or LP-gas are stored or used within a *building* having a basement or pit wherein flammable vapors could accumulate, the basement or pit shall be provided with ventilation designed to prevent the accumulation of flammable vapors therein.

[F] 502.16 Repair garages for vehicles fueled by lighter-than-air fuels.

Repair garages used for the conversion and repair of vehicles that use compressed natural gas, liquefied natural gas, hydrogen or other lighter-than-air motor fuels shall be provided with an *approved* mechanical exhaust ventilation system. The mechanical exhaust ventilation system shall be in accordance with Section 502.16.1 or 502.16.2 as applicable.

Exceptions:

1.

Repair garages where work is not performed on the fuel system and is limited to exchange of parts and maintenance not requiring open flame or welding on the compressed natural gas, liquefied natural gas, hydrogen or other lighter-than-air-fueled motor vehicle.

2.

Repair garages for hydrogen-fueled vehicles where work is not performed on the hydrogen storage tank and is limited to the exchange of parts and maintenance not requiring open flame or welding on the hydrogen-fueled vehicle. During the work, the entire hydrogen fuel system shall contain a quantity of hydrogen that is less than 200 cubic feet (5.6 m^3).

[F] 502.16.1 Repair garages for hydrogen-fueled vehicles.

Repair garages used for the repair of hydrogen-fueled vehicles shall be provided with an *approved* exhaust ventilation system in accordance with this code and Chapter 6 of NFPA 2.

[F] 502.16.2 Exhaust ventilation system.

Repair garages used for the repair of compressed natural gas, liquefied natural gas or other lighter-than-air motor fuel, other than hydrogen, shall be provided with an *approved* mechanical exhaust ventilation system. The mechanical exhaust ventilation system shall be in accordance with this code and Sections 502.16.2.1 and 502.16.2.2.

> **Exception:** Where *approved*, *natural ventilation* shall be an alternative to mechanical exhaust *ventilation*.

[F] 502.16.2.1 Design.

For indoor locations, air supply inlets and exhaust outlets for mechanical ventilation shall be arranged to provide uniformly distributed air movement with inlets uniformly arranged on walls near floor level and outlets located at the high point of the room in walls or the roof.

Failure of the exhaust ventilation system shall cause the fueling system to shut down.

The exhaust ventilation rate shall be not less than 1 cubic foot per minute (0.03 m^3/min) per 12 cubic feet (0.34 m^3) of room volume.

[F] 502.16.2.2 Operation.

The mechanical exhaust ventilation system shall operate continuously.

Exceptions:

1.

Mechanical exhaust ventilation systems that are interlocked with a gas detection system designed in accordance with the *International Fire Code*.

2.

Mechanical exhaust ventilation systems in garages that are used only for the repair of vehicles fueled by liquid fuels or odorized gases, such as compressed natural gas, where the exhaust ventilation system is electrically interlocked with the lighting circuit.

502.17 Tire rebuilding or recapping.

Each room where rubber cement is used or mixed, or where flammable or combustible solvents are applied, shall be ventilated in accordance with the applicable provisions of NFPA 91.

502.17.1 Buffing machines.

Each buffing machine shall be connected to a dust-collecting system that prevents the accumulation of the dust produced by the buffing process.

502.18 Specific rooms.

Specific rooms, including bathrooms, locker rooms, smoking lounges and toilet rooms, shall be exhausted in accordance with the ventilation requirements of Chapter 4.

502.19 Indoor firing ranges.

Ventilation shall be provided in an *approved* manner in areas utilized as indoor firing ranges. Ventilation shall be designed to protect employees and the public in accordance with DOL 29 CFR 1910.1025 where applicable.

502.20 Manicure and pedicure stations.

Manicure and pedicure stations shall be provided with an exhaust system in accordance with Table 403.3.1.1, Note h. Manicure tables and pedicure stations not provided with factory-installed exhaust inlets shall be provided with exhaust inlets located not more than 12 inches (305 mm) horizontally and vertically from the point of chemical application.

INSIGHTS (3)

502.20.1 Operation.

The exhaust system for manicure and pedicure stations shall have controls that operate the system continuously when the space is occupied.

INSIGHTS (2)

Section 503 Motors and Fans

503.1 General.

Motors and fans shall be sized to provide the required air movement. Motors in areas that contain flammable vapors or dusts shall be of a type *approved* for such environments. A manually operated remote control installed at an *approved* location shall be provided to shut off fans or blowers in flammable vapor or dust systems. Electrical *equipment* and *appliances* used in operations that generate explosive or flammable vapors, fumes or dusts shall be interlocked with the ventilation system so that the *equipment* and *appliances* cannot be operated unless the ventilation fans are in operation. Motors for fans used to convey flammable vapors or dusts shall be located outside the duct or shall be protected with *approved* shields and dustproofing. Motors and fans shall be provided with a means of *access* for servicing and maintenance.

503.2 Fans.

Parts of fans in contact with explosive or flammable vapors, fumes or dusts shall be of nonferrous or nonsparking materials, or their casing shall be lined or constructed of such material. Where the size and hardness of materials passing through a fan are capable of producing a spark, both the fan and the casing shall be of nonsparking materials. Where fans are required to be spark resistant, their bearings shall not be within the airstream, and all parts of the fan shall be grounded. Fans in systems-handling materials that are capable of clogging the blades, and fans in buffing or woodworking exhaust systems, shall be of the radial-blade or tube-axial type.

503.3 Equipment and appliance identification plate.

Equipment and *appliances* used to exhaust explosive or flammable vapors, fumes or dusts shall bear an identification plate stating the ventilation rate for which the system was designed.

503.4 Corrosion-resistant fans.

Fans located in systems conveying corrosives shall be of materials that are resistant to the corrosive or shall be coated with corrosion-resistant materials.

Section 504 Clothes Dryer Exhaust

504.1 Installation.

Clothes dryers shall be exhausted in accordance with the manufacturer's instructions. Dryer exhaust systems shall convey the moisture and any products of *combustion* to the outside of the *building*.

> **Exception:** This section shall not apply to *listed* and *labeled* condensing (ductless) clothes dryers.

INSIGHTS (3)

504.2 Exhaust penetrations.

Where a clothes dryer exhaust duct penetrates a wall or ceiling membrane, the annular space shall be sealed with noncombustible material, *approved* fire caulking or a noncombustible dryer exhaust duct wall receptacle. Ducts that exhaust clothes dryers shall not penetrate or be located within any fireblocking, draft-stopping or any wall, floor/ceiling or other assembly required by the *International Building Code* to be fire-resistance rated, unless such duct is constructed of galvanized steel or aluminum of the thickness specified in Section 603.4 and the fire-resistance rating is maintained in accordance with the *International Building Code*. *Fire dampers*, *combination fire/smoke dampers* and any similar devices that will obstruct the exhaust flow shall be prohibited in clothes dryer exhaust ducts.

INSIGHTS (1)

504.3 Cleanout.

Each vertical riser shall be provided with a means for cleanout.

504.4 Exhaust installation.

Dryer exhaust ducts for clothes dryers shall terminate on the outside of the *building* and shall be equipped with a backdraft damper. Screens shall not be installed at the duct termination. Ducts shall not be connected or installed with sheet metal screws or other fasteners that will obstruct the exhaust flow. Clothes dryer exhaust ducts shall not be connected to a vent connector, vent or *chimney*. Clothes dryer exhaust ducts shall not extend into or through ducts or *plenums*. Clothes dryer exhaust ducts shall be sealed in accordance with Section 603.9.

INSIGHTS (1)

504.4.1 Termination location.

Exhaust duct terminations shall be in accordance with the dryer manufacturer's installation instructions. Where the manufacturer's instructions do not specify a termination location, the exhaust duct shall terminate not less than 3 feet (914 mm) in any direction from openings into buildings, including openings in ventilated soffits.

INSIGHTS (3)

504.4.2 Exhaust termination outlet and passageway size.

The passageway of dryer exhaust duct terminals shall be undiminished in size and shall provide an open area of not less than 12.5 square inches (8065 mm^2).

504.5 Dryer exhaust duct power ventilators.

Domestic dryer exhaust duct power ventilators shall be *listed* and *labeled* to UL 705 for use in dryer exhaust duct systems. The dryer exhaust duct power ventilator shall be installed in accordance with the manufacturer's instructions.

INSIGHTS (1)

504.6 Booster fans prohibited.

Domestic booster fans shall not be installed in dryer exhaust systems.

INSIGHTS (2)

504.7 Makeup air.

Installations exhausting more than 200 cfm (0.09 m^3/s) shall be provided with *makeup air*. Where a closet is designed for the installation of a clothes dryer, an opening having an area of not less than 100 square inches (0.0645 m^2) shall be provided in the closet enclosure or *makeup air* shall be provided by other *approved* means.

504.8 Protection required.

Protective shield plates shall be placed where nails or screws from finish or other work are likely to penetrate the clothes dryer exhaust duct. Shield plates shall be placed on the finished face of all framing members where there is less than 1 1/4 inches (32 mm) between the duct and the finished face of the framing member. Protective shield plates shall be constructed of steel, have a thickness of 0.062 inch (1.6 mm) and extend not less than 2 inches (51 mm) above sole plates and below top plates.

504.9 Domestic clothes dryer ducts.

Exhaust ducts for domestic clothes dryers shall conform to the requirements of Sections 504.9.1 through 504.9.6.

504.9.1 Material and size.

Exhaust ducts shall have a smooth interior finish and shall be constructed of metal not less than 0.016 inch (0.4 mm) in thickness. The exhaust duct size shall be 4 inches (102 mm) nominal in diameter.

504.9.2 Duct installation.

Exhaust ducts shall be supported at 4-foot (1219 mm) intervals and secured in place. The insert end of the duct shall extend into the adjoining duct or fitting in the direction of airflow. Ducts shall not be joined with screws or similar fasteners that protrude more than 1/8 inch (3.2 mm) into the inside of the duct.

Where dryer exhaust ducts are enclosed in wall or ceiling cavities, such cavities shall allow the installation of the duct without deformation.

504.9.3 Transition ducts.

Transition ducts used to connect the dryer to the exhaust duct system shall be a single length that is *listed* and *labeled* in accordance with UL 2158A. Transition ducts shall be not greater than 8 feet (2438 mm) in length and shall not be concealed within construction.

504.9.4 Duct length.

The maximum allowable exhaust duct length shall be determined by one of the methods specified in Sections 504.9.4.1 through 504.9.4.3.

504.9.4.1 Specified length.

The maximum length of the exhaust duct shall be 35 feet (10 668 mm) from the connection to the transition duct from the dryer to the outlet terminal. Where fittings are used, the maximum length of the exhaust duct shall be reduced in accordance with Table 504.9.4.1.

TABLE 504.9.4.1 DRYER EXHAUST DUCT FITTING EQUIVALENT LENGTH

DRYER EXHAUST DUCT FITTING TYPE	EQUIVALENT LENGTH
4″ radius mitered 45-degree elbow	2 feet 6 inches
4″ radius mitered 90-degree elbow	5 feet
6″ radius smooth 45-degree elbow	1 foot
6″ radius smooth 90-degree elbow	1 foot 9 inches
8″ radius smooth 45-degree elbow	1 foot
8″ radius smooth 90-degree elbow	1 foot 7 inches
10″ radius smooth 45-degree elbow	9 inches
10″ radius smooth 90-degree elbow	1 foot 6 inches

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 degree = 0.0175 rad.

504.9.4.2 manufacturer's instructions.

The maximum length of the exhaust duct shall be determined by the dryer manufacturer's installation instructions. The code official shall be provided with a copy of the installation instructions for the make and model of the dryer. Where the exhaust duct is to be concealed, the installation instructions shall be provided to the code official prior to the concealment inspection. In the absence of fitting equivalent length calculations from the clothes dryer manufacturer, Table 504.9.4.1 shall be used.

504.9.4.3 Dryer exhaust duct power ventilator length.

The maximum length of the exhaust duct shall be determined by the dryer exhaust duct power ventilator manufacturer's installation instructions.

504.9.5 Length identification.

Where the exhaust duct equivalent length exceeds 35 feet (10 668 mm), the equivalent length of the exhaust duct shall be identified on a permanent label or tag. The label or tag shall be located within 6 feet (1829 mm) of the exhaust duct connection.

504.9.6 Exhaust duct required.

Where space for a clothes dryer is provided, an exhaust duct system shall be installed. Where the clothes dryer is not installed at the time of occupancy, the exhaust duct shall be capped at the location of the future dryer.

> **Exception:** Where a *listed* condensing clothes dryer is installed prior to occupancy of structure.

504.10 Commercial clothes dryers.

The installation of dryer exhaust ducts serving commercial clothes dryers shall comply with the *appliance* manufacturer's installation instructions. Exhaust fan motors installed in exhaust systems shall be located outside of the airstream. In multiple installations, the fan shall operate continuously or be interlocked to operate when any individual unit is operating. Ducts shall have a minimum *clearance* of 6 inches (152 mm) to combustible materials. Clothes dryer transition ducts used to connect the *appliance* to the exhaust duct system shall be limited to single lengths not to exceed 8 feet (2438 mm) in length and shall be *listed* and *labeled* for the application. Transition ducts shall not be concealed within construction.

504.11 Common exhaust systems for clothes dryers located in multistory structures.

Where a common multistory duct system is designed and installed to convey exhaust from multiple clothes dryers, the construction of the system shall be in accordance with all of the following:

1.

The shaft in which the duct is installed shall be constructed and fire-resistance rated as required by the *International Building Code*.

2.

Dampers shall be prohibited in the exhaust duct. Penetrations of the shaft and ductwork shall be protected in accordance with Section 607.5.5, Exception 2.

3.

Rigid metal ductwork shall be installed within the shaft to convey the exhaust. The ductwork shall be constructed of sheet steel having a minimum thickness of 0.0187 inch (0.4712 mm) (No. 26 gage) and in accordance with SMACNA Duct Construction Standards.

4.

The ductwork within the shaft shall be designed and installed without offsets.

5.

The exhaust fan motor design shall be in accordance with Section 503.2.

6.

The exhaust fan motor shall be located outside of the airstream.

7.

The exhaust fan shall run continuously, and shall be connected to a standby power source.

8.

Exhaust fan operation shall be monitored in an *approved* location and shall initiate an audible or visual signal when the fan is not in operation.

9.

Makeup air shall be provided for the exhaust system.

10.

A cleanout opening shall be located at the base of the shaft to provide *access* to the duct to allow for cleaning and inspection. The finished opening shall be not less than 12 inches by 12 inches (305 mm by 305 mm).

11.

Screens shall not be installed at the termination.

12.

The common multistory duct system shall serve only clothes dryers and shall be independent of other exhaust systems.

INSIGHTS (1)

Section 505 Domestic Cooking Exhaust Equipment

505.1 General.

Domestic cooking exhaust *equipment* shall comply with the requirements of this section.

505.2 Domestic cooking exhaust.

Where domestic cooking exhaust *equipment* is provided, it shall comply with the following as applicable:

1.

The fan for overhead range hoods and downdraft exhaust *equipment* not integral with the cooking *appliance* shall be *listed* and *labeled* in accordance with UL 507.

2.

Overhead range hoods and downdraft exhaust *equipment* with integral fans shall comply with UL 507.

3.

Domestic cooking *appliances* with integral downdraft exhaust *equipment* shall be *listed* and *labeled* in accordance with UL 858 or ANSI Z21.1 .

4.

Microwave ovens with integral exhaust for installation over the cooking surface shall be *listed* and *labeled* in accordance with UL 923.

505.3 Exhaust ducts.

Domestic cooking exhaust *equipment* shall discharge to the outdoors through sheet metal ducts constructed of galvanized steel, stainless steel, aluminum or copper. Such ducts shall have smooth inner walls, shall be airtight and shall be equipped with a backdraft damper. Installations in Group I-1 and I-2 *occupancies* shall be in accordance with the *International Building Code* and Section 904.14 of the *International Fire Code.*

Exceptions:

1.

In other than Groups I-1 and I-2, where installed in accordance with the manufacturer's instructions and where mechanical or *natural ventilation* is otherwise provided in accordance with Chapter 4, *listed* and *labeled* ductless range hoods shall not be required to discharge to the outdoors.

2.

Ducts for domestic kitchen cooking *appliances* equipped with downdraft exhaust systems shall be permitted to be constructed of Schedule 40 PVC pipe and fittings provided that the installation complies with all of the following:

2.1.

The duct shall be installed under a concrete slab poured on grade.

2.2.

The underfloor trench in which the duct is installed shall be completely backfilled with sand or gravel.

2.3.

The PVC duct shall extend not more than 1 inch (25 mm) above the indoor concrete floor surface.

2.4.

The PVC duct shall extend not more than 1 inch (25 mm) above grade outside of the *building*.

2.5.

The PVC ducts shall be solvent cemented.

INSIGHTS (2)

505.4 Makeup air required

Exhaust hood systems capable of exhausting in excess of 400 cfm (0.19 m^3/s) shall be provided with *makeup air* at a rate approximately equal to the *exhaust air* rate. Such *makeup air* systems shall be equipped with a means of closure and shall be automatically controlled to start and operate simultaneously with the exhaust system.

505.5 Common exhaust systems for domestic kitchens located in multistory structures.

Where a common multistory duct system is designed and installed to convey exhaust from multiple domestic kitchen exhaust systems, the construction of the system shall be in accordance with all of the following:

1.

The shaft in which the duct is installed shall be constructed and fire-resistance rated as required by the *International Building Code*.

2.

Dampers shall be prohibited in the exhaust duct, except as specified in Section 505.3. Penetrations of the shaft and ductwork shall be protected in accordance with Section 607.5.5, Exception 2.

3.

Rigid metal ductwork shall be installed within the shaft to convey the exhaust. The ductwork shall be constructed of sheet steel having a minimum thickness of 0.0187 inch (0.4712 mm) (No. 26 gage) and in accordance with SMACNA Duct Construction Standards.

4.

The ductwork within the shaft shall be designed and installed without offsets.

5.

The exhaust fan motor design shall be in accordance with Section 503.2.

6.

The exhaust fan motor shall be located outside of the airstream.

7.

The exhaust fan shall run continuously, and shall be connected to a standby power source.

8.

Exhaust fan operation shall be monitored in an *approved* location and shall initiate an audible or visual signal when the fan is not in operation.

9.

Where the exhaust rate for an individual kitchen exceeds 400 cfm (0.19 m^3/s) *makeup air* shall be provided in accordance with Section 505.4.

10.

A cleanout opening shall be located at the base of the shaft to provide *access* to the duct to allow for cleanout and inspection. The finished openings shall be not less than 12 inches by 12 inches (305 mm by 305 mm).

11.

Screens shall not be installed at the termination.

12.

The common multistory duct system shall serve only kitchen exhaust and shall be independent of other exhaust systems.

INSIGHTS (1)

505.6 Other than Group R.

In other than Group R *occupancies*, where domestic cooktops, ranges, and open-top broilers are used for domestic purposes, domestic cooking exhaust systems shall be provided.

Section 506 Commercial Kitchen Hood Ventilation System Ducts and Exhaust Equipment

506.1 General.

Commercial kitchen hood ventilation ducts and exhaust *equipment* shall comply with the requirements of this section. Commercial kitchen grease ducts shall be designed for the type of cooking *appliance* and hood served.

506.2 Corrosion protection.

Ducts exposed to the outside atmosphere or subject to a corrosive environment shall be protected against corrosion in an *approved* manner.

506.3 Ducts serving Type I hoods.

Type I exhaust ducts shall be independent of all other exhaust systems except as provided in Section 506.3.5. Commercial kitchen duct systems serving Type I hoods shall be designed, constructed and installed in accordance with Sections 506.3.1 through 506.3.13.3.

506.3.1 Duct materials.

Ducts serving Type I hoods shall be constructed of materials in accordance with Sections 506.3.1.1 and 506.3.1.2.

506.3.1.1 Grease duct materials.

Grease ducts serving Type I hoods shall be constructed of steel having a minimum thickness of 0.0575 inch (1.463 mm) (No. 16 gage) or stainless steel not less than 0.0450 inch (1.14 mm) (No. 18 gage) in thickness.

> **Exception:** Factory-built commercial kitchen grease ducts listed and labeled in accordance with UL 1978 and installed in accordance with Section 304.1.

506.3.1.2 Makeup air ducts.

Makeup air ducts connecting to or within 18 inches (457 mm) of a Type I hood shall be constructed and installed in accordance with Sections 603.1, 603.3, 603.4, 603.9, 603.10 and 603.12. Duct insulation installed within 18 inches (457 mm) of a Type I hood shall be noncombustible or shall be listed for the application.

506.3.2 Joints, seams and penetrations of grease ducts.

Joints, seams and penetrations of grease ducts shall be made with a continuous liquid-tight weld or braze made on the external surface of the duct system.

Exceptions:

1.

Penetrations shall not be required to be welded or brazed where sealed by devices that are *listed* for the application.

2.

Internal welding or brazing shall not be prohibited provided that the joint is formed or ground smooth and is provided with *ready access* for inspection.

3.

Factory-built commercial kitchen grease ducts *listed* and *labeled* in accordance with UL 1978 and installed in accordance with Section 304.1.

INSIGHTS (1)

506.3.2.1 Duct joint types.

Duct joints shall be butt joints, welded flange joints with a maximum flange depth of 1/2 inch (12.7 mm) or overlapping duct joints of either the telescoping or bell type. Overlapping joints shall be installed to prevent ledges and obstructions from collecting grease or interfering with gravity drainage to the intended collection point. The difference between the inside cross-sectional dimensions of overlapping sections of duct shall not exceed 1/4 inch (6.4 mm). The length of overlap for overlapping duct joints shall not exceed 2 inches (51 mm).

506.3.2.2 Duct-to-hood joints.

Duct-to-hood joints shall be made with continuous internal or external liquid-tight welded or brazed joints. Such joints shall be smooth, accessible for inspection, and without grease traps.

Exceptions: This section shall not apply to:

1.

A vertical duct-to-hood collar connection made in the top plane of the hood in accordance with all of the following:

1.1.

The hood duct opening shall have a 1-inch-deep (25 mm), full perimeter, welded flange turned down into the hood interior at an angle of 90 degrees (1.57 rad) from the plane of the opening.

1.2.

The duct shall have a 1-inch-deep (25 mm) flange made by a 1-inch by 1-inch (25 mm by 25 mm) angle iron welded to the full perimeter of the duct not less than 1 inch (25 mm) above the bottom end of the duct.

1.3.

A gasket rated for use at not less than 1,500°F (816°C) is installed between the duct flange and the top of the hood.

1.4.

The duct-to-hood joint shall be secured by stud bolts not less than 1/4 inch (6.4 mm) in diameter welded to the hood with a spacing not greater than 4 inches (102 mm) on center for the full perimeter of the opening. The bolts and nuts shall be secured with lockwashers.

2.

Listed and *labeled* duct-to-hood collar connections installed in accordance with Section 304.1.

506.3.2.3 Duct-to-exhaust fan connections.

Duct-to-exhaust fan connections shall be flanged and gasketed at the base of the fan for vertical discharge fans; shall be flanged, gasketed and bolted to the inlet of the fan for side-inlet utility fans; and shall be flanged, gasketed and bolted to the inlet and outlet of the fan for in-line fans. Gasket and sealing materials shall be rated for continuous duty at a temperature of not less than 1,500°F (816°C).

506.3.2.4 Vibration isolation.

A vibration isolation connector for connecting a duct to a fan shall consist of noncombustible packing in a metal sleeve joint of *approved* design or shall be a coated-fabric flexible duct connector *listed* and *labeled* for the application. Vibration isolation connectors shall be installed only at the connection of a duct to a fan inlet or outlet.

506.3.2.5 Grease duct test.

Prior to the use or concealment of any portion of a grease duct system, a leakage test shall be performed. Ducts shall be considered to be concealed where installed in shafts or covered by coatings or wraps that prevent the ductwork from being visually inspected on all sides. The permit holder shall be responsible to provide the necessary *equipment* and perform the grease duct leakage test. A light test shall be performed to determine that all welded and brazed joints are liquid tight.

A light test shall be performed by passing a lamp having a power rating of not less than 100 watts through the entire section of ductwork to be tested. The lamp shall be open so as to emit light equally in all directions perpendicular to the duct walls. A test shall be performed for the entire duct system, including the hood-to-duct connection. The duct work shall be permitted to be tested in sections, provided that every joint is tested. For listed factory-built grease ducts, this test shall be limited to duct joints assembled in the field and shall exclude factory welds.

506.3.3 Grease duct supports.

Grease duct bracing and supports shall be of noncombustible material securely attached to the structure and designed to carry gravity and seismic loads within the stress limitations of the *International Building Code*. Bolts, screws, rivets and other mechanical fasteners shall not penetrate duct walls.

INSIGHTS (1)

506.3.4 Air velocity.

Grease duct systems serving a Type I hood shall be designed and installed to provide an air velocity within the duct system of not less than 500 feet per minute (2.5 m/s).

> **Exception:** The velocity limitations shall not apply within duct transitions utilized to connect ducts to differently sized or shaped openings in hoods and fans, provided that such transitions do not exceed 3 feet (914 mm) in length and are designed to prevent the trapping of grease.

506.3.5 Separation of grease duct system.

A separate grease duct system shall be provided for each Type I hood. A separate grease duct system is not required where all of the following conditions are met:

1.

All interconnected hoods are located within the same story.

2.

All interconnected hoods are located within the same room or in adjoining rooms.

3.

Interconnecting ducts do not penetrate assemblies required to be fire-resistance rated.

4.

The grease duct system does not serve solid-fuel-fired *appliances*.

506.3.6 Grease duct clearances.

Where enclosures are not required, grease duct systems and exhaust *equipment* serving a Type I hood shall have a *clearance* to combustible construction of not less than 18 inches (457 mm), and shall have a *clearance* to noncombustible construction and gypsum wallboard attached to noncombustible structures of not less than 3 inches (76 mm).

Exceptions:

1.

Factory-built commercial kitchen grease ducts *listed* and *labeled* in accordance with UL 1978.

2.

Listed and *labeled* exhaust *equipment* installed in accordance with Section 304.1.

3.

Where commercial kitchen grease ducts are continuously covered on all sides with a *listed* and *labeled* field-applied grease duct enclosure material, system, product or method of construction specifically evaluated for such purpose in accordance with ASTM E2336, the required *clearance* shall be in accordance with the listing of such material, system, product or method.

506.3.7 Prevention of grease accumulation in grease ducts.

Duct systems serving a Type I hood shall be constructed and installed so that grease cannot collect in any portion thereof, and the system shall slope not less than 1/4 unit vertical in 12 units horizontal (2-percent slope) toward the hood or toward a grease reservoir designed and installed in accordance with Section 506.3.7.1. Where horizontal ducts exceed 75 feet (22 860 mm) in length, the slope shall be not less than 1 unit vertical in 12 units horizontal (8.3-percent slope).

Exception: Factory-built grease ducts shall be installed at a slope that is in accordance with the listing and manufacturer's installation instructions.

INSIGHTS (4)

506.3.7.1 Grease duct reservoirs.

Grease duct reservoirs shall:

1.

Be constructed as required for the grease duct they serve.

2.

Be located on the bottom of the horizontal duct or the bottommost section of the duct riser.

3.

Extend across the full width of the duct and have a length of not less than 12 inches (305 mm).

4.

Have a depth of not less than 1 inch (25 mm).

5.

Have a bottom that slopes to a drain.

6.

Be provided with a cleanout opening constructed in accordance with Section 506.3.8 and installed to provide direct *access* to the reservoir. The cleanout opening shall be located on a side or on top of the duct so as to permit cleaning of the reservoir.

7.

Be installed in accordance with the manufacturer's instructions where manufactured devices are utilized.

506.3.8 Grease duct cleanouts and openings.

Grease duct cleanouts and openings shall comply with all of the following:

1.

Grease ducts shall not have openings except where required for the operation and maintenance of the system.

2.

Sections of grease ducts that are inaccessible from the hood or discharge openings shall be provided with cleanout openings spaced not more than 20 feet (6096 mm) apart and not more than 10 feet (3048 mm) from changes in direction greater than 45 degrees (0.79 rad).

3.

Cleanouts and openings shall be equipped with tight-fitting doors constructed of steel having a thickness not less than that required for the duct.

4.

Cleanout doors shall be installed liquid tight.

5.

Door assemblies including any frames and gaskets shall be *approved* for the application and shall not have fasteners that penetrate the duct.

6.

Gasket and sealing materials shall be rated for not less than 1,500°F (816°C).

7.

Listed door assemblies shall be installed in accordance with the manufacturer's instructions.

506.3.8.1 Personnel entry.

Where ductwork is large enough to allow entry of personnel, not less than one *approved* or *listed* opening having dimensions not less than 22 inches by 20 inches (559 mm by 508 mm) shall be provided in the horizontal sections, and in the top of vertical risers. Where such entry is provided, the duct and its supports shall be capable of supporting the additional load, and the cleanouts specified in Section 506.3.8 are not required.

506.3.8.2 Cleanouts serving in-line fans.

A cleanout shall be provided for both the inlet side and outlet side of an in-line fan except where a duct does not connect to the fan. Such cleanouts shall be located within 3 feet (914 mm) of the fan duct connections.

506.3.9 Grease duct horizontal cleanouts.

Cleanouts serving horizontal sections of grease ducts shall:

1.

Be spaced not more than 20 feet (6096 mm) apart.

2.

Be located not more than 10 feet (3048 mm) from changes in direction that are greater than 45 degrees (0.79 rad).

3.

Be located on the bottom only where other locations are not available and shall be provided with internal damming of the opening such that grease will flow past the opening without pooling. Bottom cleanouts and openings shall be *approved* for the application and installed liquid tight.

4.

Not be closer than 1 inch (25 mm) from the edges of the duct.

5.

Have opening dimensions of not less than 12 inches by 12 inches (305 mm by 305 mm). Where such dimensions preclude installation, the opening shall be not less than 12 inches (305 mm) on one side and shall be large enough to provide *access* for cleaning and maintenance.

6.

Be located at grease reservoirs.

7.

Be located within 3 feet (914 mm) of horizontal discharge fans.

INSIGHTS (2)

506.3.10 Underground grease duct installation.

Underground grease duct installations shall comply with all of the following:

1.

Underground grease ducts shall be constructed of steel having a minimum thickness of 0.0575 inch (1.463 mm) (No. 16 gage) and shall be coated to provide protection from corrosion or shall be constructed of stainless steel having a minimum thickness of 0.0450 inch (1.140 mm) (No. 18 gage).

2.

The underground duct system shall be tested and approved in accordance with Section 506.3.2.5 prior to coating or placement in the ground.

3.

The underground duct system shall be completely encased in concrete with a minimum thickness of 4 inches (102 mm).

4.

Ducts shall slope toward grease reservoirs.

5.

A grease reservoir with a cleanout to allow cleaning of the reservoir shall be provided at the base of each vertical duct riser.

6.

Cleanouts shall be provided with *access* to permit cleaning and inspection of the duct in accordance with Section 506.3.

7.

Cleanouts in horizontal ducts shall be installed on the topside of the duct.

8.

Cleanout locations shall be legibly identified at the point of *access* from the interior space.

506.3.11 Grease duct enclosures.

A commercial kitchen grease duct serving a Type I hood that penetrates a ceiling, wall, floor or any concealed space shall be enclosed from the point of penetration to the outlet terminal. In-line exhaust fans not located outdoors shall be enclosed as required for grease ducts. A duct shall penetrate exterior walls only at locations where unprotected openings are permitted by the *International Building Code*. The duct enclosure shall serve a single grease duct and shall not contain other ducts, piping or wiring systems. Duct enclosures shall be a shaft enclosure in accordance with Section 506.3.11.1, a field-applied enclosure assembly in accordance with Section 506.3.11.2 or a factory-built enclosure assembly in accordance with Section 506.3.11.3. Duct enclosures shall have a fire-resistance rating of not less than that of the assembly penetrated and not less than 1 hour. Fire dampers and smoke dampers shall not be installed in grease ducts.

> **Exception:** A duct enclosure shall not be required for a grease duct that penetrates only a nonfire-resistance-rated roof/ceiling assembly.

506.3.11.1 Shaft enclosure.

Grease ducts constructed in accordance with Section 506.3.1 shall be permitted to be enclosed in accordance with the *International Building Code* requirements for shaft construction. Such grease duct systems and exhaust *equipment* shall have a *clearance* to combustible construction of not less than 18 inches (457 mm), and shall have a *clearance* to noncombustible construction and gypsum wallboard attached to noncombustible structures of not less than 6 inches (152 mm). Duct enclosures shall be sealed around the duct at the point of penetration and vented to the outside of the building through the use of weather-protected openings.

INSIGHTS (1)

506.3.11.2 Field-applied grease duct enclosure.

Grease ducts constructed in accordance with Section 506.3.1 shall be enclosed by a *listed* and *labeled* field-applied grease duct enclosure material, systems, product, or method of construction specifically evaluated for such purpose in accordance with ASTM E2336. The surface of the duct shall be continuously covered on all sides from the point at which the duct originates to the outlet terminal. Duct penetrations shall be protected with a through-penetration firestop system tested and *listed* in accordance with ASTM E814 or UL 1479 and having a “F” and “T” rating equal to the fire-resistance rating of the assembly being penetrated. The grease duct enclosure and firestop system shall be installed in accordance with the listing and the manufacturer’s instructions. Partial application of a field-applied grease duct enclosure shall not be installed for the sole purpose of reducing *clearances* to combustibles at isolated sections of grease duct. Exposed duct-wrap systems shall be protected where subject to physical damage.

506.3.11.3 Factory-built grease duct enclosure assemblies.

Factory-built grease ducts incorporating integral enclosure materials shall be *listed* and *labeled* for use as grease duct enclosure assemblies specifically evaluated for such purpose in accordance with UL 2221. Duct penetrations shall be protected with a through-penetration firestop system tested and *listed* in accordance with ASTM E814 or UL 1479 and having an “F” and “T” rating equal to the fire-resistance rating of the assembly being penetrated. The grease duct enclosure assembly and firestop system shall be installed in accordance with the listing and the manufacturer’s instructions.

506.3.12 Grease duct fire-resistive access opening.

Where cleanout openings are located in ducts within a fire-resistance-rated enclosure, access openings shall be provided in the enclosure at each cleanout point. Access openings shall be equipped with tight-fitting sliding or hinged doors that are equal in fire-resistive protection to that of the shaft or enclosure. An *approved* sign shall be placed on access opening panels with wording as follows: “ACCESS PANEL. DO NOT OBSTRUCT.”

506.3.13 Exhaust outlets serving Type I hoods.

Exhaust outlets for grease ducts serving Type I hoods shall conform to the requirements of Sections 506.3.13.1 through 506.3.13.3.

506.3.13.1 Termination above the roof.

Exhaust outlets that terminate above the roof shall have the discharge opening located not less than 40 inches (1016 mm) above the roof surface.

506.3.13.2 Termination through an exterior wall.

Exhaust outlets shall be permitted to terminate through exterior walls where the smoke, grease, gases, vapors and odors in the discharge from such terminations do not create a public nuisance or a fire hazard. Such terminations shall not be located where protected openings are required by the *International Building Code*. Such terminations shall be located in accordance with Section 506.3.13.3 and shall not be located within 3 feet (914 mm) of any opening in the exterior wall.

INSIGHTS (1)

506.3.13.3 Termination location.

Exhaust outlets shall be located not less than 10 feet (3048 mm) horizontally from parts of the same or contiguous buildings, adjacent buildings and adjacent property lines and shall be located not less than 10 feet (3048 mm) above the adjoining grade level. Exhaust outlets shall be located not less than 10 feet (3048 mm) horizontally from or not less than 3 feet (914 mm) above air intake openings into any building.

Exception: Exhaust outlets shall terminate not less than 5 feet (1524 mm) horizontally from parts of the same or contiguous building, an adjacent building, adjacent property line and air intake openings into a building where air from the exhaust outlet discharges away from such locations.

INSIGHTS (1)

506.4 Ducts serving Type II hoods.

Commercial kitchen exhaust systems serving Type II hoods shall comply with Sections 506.4.1 and 506.4.2.

506.4.1 Ducts.

Ducts and *plenums* serving Type II hoods shall be constructed of rigid metallic materials. Duct construction, installation, bracing and supports shall comply with Chapter 6. Ducts subject to positive pressure and ducts conveying moisture-laden or waste-heat-laden air shall be constructed, joined and sealed in an *approved* manner.

506.4.2 Type II terminations.

Exhaust outlets serving Type II hoods shall terminate in accordance with the hood manufacturer's installation instructions and shall comply with all of the following:

1.

Exhaust outlets shall terminate not less than 3 feet (914 mm) in any direction from openings into the *building*.

2.

Outlets shall terminate not less than 10 feet (3048 mm) from property lines or buildings on the same lot.

3.

Outlets shall terminate not less than 10 feet (3048 mm) above grade.

4.

Outlets that terminate above a roof shall terminate not less than 30 inches (762 mm) above the roof surface.

5.

Outlets shall terminate not less than 30 inches (762 mm) from exterior vertical walls.

6.

Outlets shall be protected against local weather conditions.

7.

Outlets shall not be directed onto walkways.

8.

Outlets shall meet the provisions for exterior wall opening protectives in accordance with the *International Building Code*.

506.5 Exhaust equipment.

Exhaust *equipment*, including fans and grease reservoirs, shall comply with Sections 506.5.1 through 506.5.6 and shall be of an *approved* design or shall be *listed* for the application.

506.5.1 Exhaust fans.

Exhaust fan housings serving a Type I hood shall be constructed as required for grease ducts in accordance with Section 506.3.1.1.

Exception: Fans *listed* and *labeled* in accordance with UL 762.

506.5.1.1 Fan motor.

Exhaust fan motors shall be located outside of the exhaust airstream.

506.5.1.2 In-line fan location.

Where enclosed duct systems are connected to in-line fans not located outdoors, the fan shall be located in a room or space having the same fire-resistance rating as the duct enclosure. *Access* shall be provided for servicing and cleaning of fan components. Such rooms or spaces shall be ventilated in accordance with the fan manufacturer's installation instructions.

506.5.2 Pollution-control units.

The installation of pollution-control units shall be in accordance with all of the following:

1.

Pollution-control units shall be *listed* and *labeled* in accordance with UL 8782.

2.

Fans serving pollution-control units shall be *listed* and *labeled* in accordance with UL 762.

3.

Bracing and supports for pollution-control units shall be of noncombustible material securely attached to the structure and designed to carry gravity and seismic loads within the stress limitations of the *International Building Code*.

4.

Pollution-control units located indoors shall be *listed* and *labeled* for such use. Where enclosed duct systems, as required by Section 506.3.11, are connected to a pollution control unit, such unit shall be listed and labeled, in accordance with UL 2221 or ASTM E2336, for location in an enclosure having the same fire-resistance rating as the duct enclosure. Access shall be provided for servicing and cleaning of the unit. The space or enclosure shall be ventilated in accordance with the manufacturer’s installation instructions.

5.

Clearances shall be maintained between the pollution-control unit and combustible material in accordance with the listing.

6.

Roof-mounted pollution-control units shall be *listed* for outdoor installation and shall be mounted not less than 18 inches (457 mm) above the roof.

7.

Exhaust outlets for pollution-control units shall be in accordance with Section 506.3.13.

8.

An airflow differential pressure control shall be provided to monitor the pressure drop across the filter sections of a pollution-control unit. When the airflow is reduced below the design velocity, the airflow differential pressure control shall activate a visual alarm located in the area where cooking operations occur.

9.

Pollution-control units shall be provided with a factory-installed fire suppression system.

10.

Service space shall be provided in accordance with the manufacturer’s instructions for the pollution control unit and the requirements of Section 306.

11.

Wash-down drains shall discharge through a grease interceptor and shall be sized for the flow. Drains shall be sealed with a trap or other *approved* means to prevent air bypass. Where a trap is utilized it shall have a seal depth that accounts for the system pressurization and evaporation between cleanings.

12.

Protection from freezing shall be provided for the water supply and fire suppression systems where such systems are subject to freezing.

13.

Duct connections to pollution-control units shall be in accordance with Section 506.3.2.3. Where water splash or carryover can occur in the transition duct as a result of a washing operation, the transition duct shall slope downward toward the cabinet drain pan for a length not less than 18 inches (457 mm). Ducts shall transition to the full size of the unit's inlet and outlet openings.

14.

Extra-heavy-duty *appliance* exhaust systems shall not be connected to pollution-control units except where such units are specifically designed and listed for use with solid fuels.

15.

Pollution-control units shall be maintained in accordance with the manufacturer's instructions.

INSIGHTS (2)

506.5.3 Exhaust fan discharge.

Exhaust fans shall be positioned so that the discharge will not impinge on the roof, other *equipment* or *appliances* or parts of the structure. A vertical discharge fan shall be manufactured with an *approved* drain outlet at the lowest point of the housing to permit drainage of grease to an *approved* grease reservoir.

506.5.4 Exhaust fan mounting.

Upblast fans serving Type I hoods and installed in a vertical or horizontal position shall be hinged, supplied with a flexible weatherproof electrical cable to permit inspection and cleaning and shall be equipped with a means of restraint to limit the swing of the fan on its hinge. The ductwork shall extend not less than 18 inches (457 mm) above the roof surface.

506.5.5 Clearances.

Exhaust *equipment* serving a Type I hood shall have a *clearance* to combustible construction of not less than 18 inches (457 mm).

> **Exception:** Factory-built exhaust *equipment* installed in accordance with Section 304.1 and *listed* for a lesser *clearance*.

506.5.6 Termination location.

The outlet of exhaust *equipment* serving Type I hoods shall be in accordance with Section 506.3.13.

> **Exception:** The minimum horizontal distance between vertical discharge fans and parapet-type *building* structures shall be 2 feet (610 mm), provided that such structures are not higher than the top of the fan discharge opening.

Section 507 Commercial Kitchen Hoods

507.1 General.

Commercial kitchen exhaust hoods shall comply with the requirements of this section. Hoods shall be Type I or II and shall be designed to capture and confine cooking vapors and residues.

A Type I or Type II hood shall be installed at or above *appliances* in accordance with Sections 507.2 and 507.3. Where any cooking *appliance* under a single hood requires a Type I hood, a Type I hood shall be installed. Where a Type II hood is required, a Type I or Type II hood shall be installed. Where a Type I hood is installed, the installation of the entire system, including the hood, ducts, exhaust equipment and makeup air system shall comply with the requirements of Sections 506, 507, 508 and 509.

Exceptions:

1.

Factory-built commercial exhaust hoods that are *listed* and *labeled* in accordance with UL 710, and installed in accordance with Section 304.1, shall not be required to comply with Sections 507.1.5, 507.2.3, 507.2.5, 507.2.8, 507.3.1, 507.3.3, 507.4 and 507.5.

2.

Factory-built commercial cooking recirculating systems that are *listed* and *labeled* in accordance with UL 710B, and installed in accordance with Section 304.1, shall not be required to comply with Sections 507.1.5, 507.2.3, 507.2.5, 507.2.8, 507.3.1, 507.3.3, 507.4 and 507.5. Spaces in which such systems are located shall be considered to be kitchens and shall be ventilated in accordance with Table 403.3.1.1. For the purpose of determining the floor area required to be ventilated, each individual *appliance* shall be considered as occupying not less than 100 square feet (9.3 m^2).

3.

Where cooking *appliances* are equipped with integral down-draft exhaust systems and such *appliances* and exhaust systems are *listed* and *labeled* for the application in accordance with NFPA 96, a hood shall not be required at or above them.

4.

Smoker ovens with integral exhaust systems, provided that the *appliance* is installed in accordance with the manufacturer's installation instructions, is listed and tested for the application, and complies with Chapter 5.

INSIGHTS (5)

507.1.1 Operation.

Commercial kitchen exhaust hood systems shall operate during the cooking operation. The hood exhaust rate shall comply with the listing of the hood or shall comply with Section 507.5 .The exhaust fan serving a Type I hood shall have automatic controls that will activate the fan when any *appliance* that requires such Type I hood is turned on, or a means of interlock shall be provided that will prevent operation of such *appliances* when the exhaust fan is not turned on. Where one or more temperature or radiant energy sensors are used to activate a Type I hood exhaust fan, the fan shall activate not more than 15 minutes after the first *appliance* served by that hood has been turned on. A method of interlock between an exhaust hood system and *appliances* equipped with standing pilot burners shall not cause the pilot burners to be extinguished. A method of interlock between an exhaust hood system and cooking *appliances* shall not involve or depend on any component of a fire-extinguishing system.

The net exhaust volumes for hoods shall be permitted to be reduced during part-load cooking conditions, where engineered or *listed* multispeed or variable speed controls automatically operate the exhaust system to maintain capture and removal of cooking effluents as required by this section. Reduced volumes shall not be below that required to maintain capture and removal of effluents from the idle cooking *appliances* that are operating in a standby mode.

507.1.1.1 Multiple hoods utilizing a single exhaust system.

Where heat or radiant energy sensors are utilized in hood systems consisting of multiple hoods served by a single exhaust system, such sensors shall be provided in each hood. Sensors shall be capable of being accessed from the hood outlet or from a cleanout location.

507.1.2 Domestic cooking appliances used for commercial purposes.

Domestic cooking *appliances* utilized for commercial purposes shall be provided with Type I or Type II hoods as required for the type of *appliances* and processes in accordance with Sections 507.2 and 507.3. Domestic cooking *appliances* utilized for domestic cooking shall comply with Section 505.

507.1.3 Fuel-burning appliances.

Where vented fuel-burning *appliances* are located in the same room or space as the hood, provisions shall be made to prevent the hood system from interfering with normal operation of the *appliance* vents.

507.1.4 Cleaning.

A hood shall be designed to provide for thorough cleaning of the entire hood.

507.1.5 Exhaust outlets.

Exhaust outlets located within the hood shall be located so as to optimize the capture of particulate matter. Each outlet shall serve not more than a 12-foot (3658 mm) section of hood.

507.2 Type I hoods.

Type I hoods shall be installed where cooking *appliances* produce grease or smoke as a result of the cooking process. Type I hoods shall be installed over *medium-duty, heavy-duty* and *extra-heavy-duty cooking appliances*.

Exception: A Type I hood shall not be required for an electric cooking *appliance* where an approved testing agency provides documentation that the *appliance* effluent contains 5 mg/m3 or less of grease when tested at an exhaust flow rate of 500 cfm (0.236 m3/s) in accordance with UL 710B.

INSIGHTS (2)

507.2.1 Type I exhaust flow rate label.

Type I hoods shall bear a label indicating the minimum exhaust flow rate in cfm per linear foot (1.55 L/s per linear meter) of hood that provides for capture and containment of the exhaust effluent for the cooking *appliances* served by the hood, based on the cooking *appliance* duty classifications defined in this code.

507.2.2 Type I extra-heavy-duty.

Type I hoods for use over *extra-heavy-duty cooking appliances* shall not cover *heavy-, medium-* or *light-duty appliances*. Such hoods shall discharge to an exhaust system that is independent of other exhaust systems.

507.2.3 Type I materials.

Type I hoods shall be constructed of steel having a minimum thickness of 0.0466 inch (1.181 mm) (No. 18 gage) or stainless steel not less than 0.0335 inch [0.8525 mm (No. 20 MSG)] in thickness.

507.2.4 Type I supports.

Type I hoods shall be secured in place by noncombustible supports. Type I hood supports shall be adequate for the applied load of the hood, the unsupported ductwork, the effluent loading and the possible weight of personnel working in or on the hood.

507.2.5 Type I hoods.

External hood joints, seams and penetrations for Type I hoods shall be made with a continuous external liquid-tight weld or braze to the lowest outermost perimeter of the hood. Internal hood joints, seams, penetrations, filter support frames and other appendages attached inside the hood shall not be required to be welded or brazed but shall be otherwise sealed to be grease tight.

Exceptions:

1.

Penetrations shall not be required to be welded or brazed where sealed by devices that are *listed* for the application.

2.

Internal welding or brazing of seams, joints and penetrations of the hood shall not be prohibited provided that the joint is formed smooth or ground so as to not trap grease, and is readily cleanable.

507.2.6 Clearances for Type I hood.

A Type I hood shall be installed with a *clearance* to combustibles of not less than 18 inches (457 mm).

Exceptions:

1.

Clearance shall not be required from gypsum wallboard or 1/2-inch (12.7 mm) or thicker cementitious wallboard attached to noncombustible structures provided that a smooth, cleanable, nonabsorbent and noncombustible material is installed between the hood and the gypsum or cementitious wallboard over an area extending not less than 18 inches (457 mm) in all directions from the hood.

2.

Type I hoods *listed* and *labeled* for *clearances* less than 18 inches (457 mm) in accordance with UL 710 shall be installed with the *clearances* specified by such listings.

INSIGHTS (1)

507.2.7 Type I hoods penetrating a ceiling.

Type I hoods or portions thereof penetrating a ceiling, wall or furred space shall comply with Section 506.3.11. Field-applied grease duct enclosure systems, as addressed in Section 506.3.11.2, shall not be utilized to satisfy the requirements of this section.

507.2.8 Type I grease filters.

Type I hoods shall be equipped with grease filters *listed* and *labeled* in accordance with UL 1046. Grease filters shall be provided with *access* for cleaning or replacement. The lowest edge of a grease filter located above the cooking surface shall be not less than the height specified in Table 507.2.8.

TABLE 507.2.8 MINIMUM DISTANCE BETWEEN THE LOWEST EDGE OF A GREASE FILTER AND THE COOKING SURFACE OR THE HEATING SURFACE

TYPE OF COOKING APPLIANCES	HEIGHT ABOVE COOKING SURFACE (feet)
Without exposed flame	0.5
Exposed flame and burners	2
Exposed charcoal and charbroil type	3.5

For SI: 1 foot = 304.8 mm.

507.2.8.1 Criteria.

Filters shall be of such size, type and arrangement as will permit the required quantity of air to pass through such units at rates not exceeding those for which the filter or unit was designed or *approved*. Filter units shall be installed in frames or holders so as to be readily removable without the use of separate tools, unless designed and installed to be cleaned in place and the system is equipped for such cleaning in place. Where filters are designed and required to be cleaned, removable filter units shall be of a size that will allow them to be cleaned in a dishwashing machine or pot sink. Filter units shall be arranged in place or provided with drip-intercepting devices to prevent grease or other condensate from dripping into food or on food preparation surfaces.

507.2.8.2 Mounting position of grease filters.

Filters shall be installed at an angle of not less than 45 degrees (0.79 rad) from the horizontal and shall be equipped with a drip tray beneath the lower edge of the filters.

507.2.9 Grease gutters for Type I hood.

Grease gutters shall drain to an *approved* collection receptacle that is fabricated, designed and installed to allow *access* for cleaning.

507.3 Type II hoods.

Type II hoods shall be installed above dishwashers and *appliances* that produce heat or moisture and do not produce grease or smoke as a result of the cooking process, except where the heat and moisture loads from such *appliances* are incorporated into the HVAC system design or into the design of a separate removal system. Type II hoods shall be installed above all *appliances* that produce products of combustion and do not produce grease or smoke as a result of the cooking process. Spaces containing cooking *appliances* that do not require Type

II hoods shall be provided with exhaust at a rate of 0.70 cfm per square foot (0.00356 m3/(s • m2). For the purpose of determining the floor area required to be exhausted, each individual appliance that is not required to be installed under a Type II hood shall be considered as occupying not less than 100 square feet (9.3 m2). Such additional square footage shall be provided with exhaust at a rate of 0.70 cfm per square foot [0.00356 m3/(s • m2)].

INSIGHTS (1)

507.3.1 Type II hood materials.

Type II hoods shall be constructed of steel having a minimum thickness of 0.0296 inch (0.7534 mm) (No. 22 gage) or stainless steel not less than 0.0220 inch (0.5550 mm) (No. 24 gage) in thickness, copper sheets weighing not less than 24 ounces per square foot (7.3 kg/m^2) or of other *approved* material and gage.

507.3.2 Type II supports.

Type II hood supports shall be adequate for the applied load of the hood, the unsupported ductwork, the effluent loading and the possible weight of personnel working in or on the hood.

507.3.3 Type II hoods joint, seams and penetrations.

Joints, seams and penetrations for Type II hoods shall be constructed as set forth in Chapter 6, shall be sealed on the interior of the hood and shall provide a smooth surface that is readily cleanable and watertight.

507.4 Hood size and location.

Hoods shall comply with the overhang, setback and height requirements in accordance with Sections 507.4.1 and 507.4.2, based on the type of hood.

507.4.1 Canopy size and location.

The inside lower edge of canopy-type Type I and II commercial hoods shall overhang or extend a horizontal distance of not less than 6 inches (152 mm) beyond the edge of the top horizontal surface of the *appliance* on all open sides. The vertical distance between the front lower lip of the hood and such surface shall not exceed 4 feet (1219 mm).

> **Exception:** The hood shall be permitted to be flush with the outer edge of the cooking surface where the hood is closed to the *appliance* side by a noncombustible wall or panel.

INSIGHTS (1)

507.4.2 Noncanopy size and location.

Noncanopy-type hoods shall be located not greater than 3 feet (914 mm) above the cooking surface. The edge of the hood shall be set back not greater than 1 foot (305 mm) from the edge of the cooking surface.

507.5 Capacity of hoods.

Commercial food service hoods shall exhaust a minimum net quantity of air determined in accordance with this section and Sections 507.5.1 through 507.5.5. The net quantity of *exhaust air* shall be calculated by subtracting any airflow supplied directly to a hood cavity from the total exhaust flow rate of a hood. Where any combination of *heavy-duty*, *medium-duty* and *light-duty cooking appliances* are utilized under a single hood, the exhaust rate required by this section for the heaviest duty appliance covered by the hood shall be used for the entire hood.

INSIGHTS (1)

507.5.1 Extra-heavy-duty cooking appliances.

The minimum net airflow for hoods, as determined by Section 507.1, used for extra-heavy-duty cooking appliances shall be determined as follows:

TYPE OF HOOD	CFM PER LINEAR FOOT OF HOOD
Backshelf/pass-over	Not allowed
Double island canopy (per side)	550
Eyebrow	Not allowed
Single island canopy	700
Wall-mounted canopy	550

For SI: 1 cfm per linear foot = 1.55 L/s per linear meter.

507.5.2 Heavy-duty cooking appliances.

The minimum net airflow for hoods, as determined by Section 507.1, used for heavy-duty cooking appliances shall be determined as follows:

TYPE OF HOOD	CFM PER LINEAR FOOT OF HOOD
Backshelf/pass-over	400
Double island canopy (per side)	400
Eyebrow	Not allowed
Single island canopy	600
Wall-mounted canopy	400

For SI: 1 cfm per linear foot = 1.55 L/s per linear meter.

507.5.3 Medium-duty cooking appliances.

The minimum net airflow for hoods, as determined by Section 507.1, used for medium-duty cooking appliances shall be determined as follows:

TYPE OF HOOD	CFM PER LINEAR FOOT OF HOOD
Backshelf/pass-over	300
Double island canopy (per side)	300
Eyebrow	250
Single island canopy	500
Wall-mounted canopy	300

For SI: 1 cfm per linear foot = 1.55 L/s per linear meter.

507.5.4 Light-duty cooking appliances.

The minimum net airflow for hoods, as determined by Section 507.1, used for light-duty cooking appliances and food service preparation shall be determined as follows:

TYPE OF HOOD	CFM PER LINEAR FOOT OF HOOD
Backshelf/pass-over	*250*
Double island canopy (per side)	*250*
Eyebrow	*250*
Single island canopy	*400*
Wall-mounted canopy	*200*

For SI: 1 cfm per linear foot = 1.55 L/s per linear meter.

507.5.5 Dishwashing appliances.

The minimum net airflow for Type II hoods used for dishwashing *appliances* shall be 100 cfm per linear foot (155 L/s per linear meter) of hood length.

> **Exception:** Dishwashing *appliances* and *equipment* installed in accordance with Section 507.3.

507.6 Performance test.

A performance test shall be conducted upon completion and before final approval of the installation of a ventilation system serving *commercial cooking appliances*. The test shall verify the rate of exhaust airflow required by Section 507.5, makeup airflow required by Section 508 and proper operation as specified in this chapter. The permit holder shall furnish the necessary test *equipment* and devices required to perform the tests.

507.6.1 Capture and containment test.

The permit holder shall verify capture and containment performance of the exhaust system. This field test shall be conducted with all *appliances* under the hood at operating temperatures, with all sources of outdoor air providing *makeup air* for the hood operating and with all sources of recirculated air providing conditioning for the space in which the hood is located operating. Capture and containment shall be verified visually by observing smoke or steam produced by actual or simulated cooking, such as that provided by smoke generators.

Section 508 Commercial Kitchen Makeup Air

508.1 Makeup air.

Makeup air shall be supplied during the operation of commercial kitchen exhaust systems that are provided for *commercial cooking appliances*. The amount of *makeup air* supplied to the building from all sources shall be approximately equal to the amount of *exhaust air* for all exhaust systems for the building. The *makeup air* shall not reduce the effectiveness of the exhaust system. *Makeup air* shall be provided by gravity or mechanical means or both. Mechanical *makeup air* systems shall be automatically controlled to start and operate simultaneously with the exhaust system. *Makeup air* intake opening locations shall comply with Section 401.4.

INSIGHTS (1)

508.1.1 Makeup air temperature.

The temperature differential between *makeup air* and the air in the conditioned space shall not exceed 10°F (6°C) except where the added heating and cooling loads of the *makeup air* do not exceed the capacity of the HVAC system.

508.1.2 Air balance.

Design plans for a facility with a commercial kitchen ventilation system shall include a schedule or diagram indicating the design outdoor air balance. The design outdoor air balance shall indicate all exhaust and replacement air for the facility, plus the net exfiltration if applicable. The total replacement air airflow rate shall equal the total exhaust airflow rate plus the net exfiltration.

508.2 Compensating hoods.

Manufacturers of compensating hoods shall provide a label indicating the minimum exhaust flow, the maximum makeup airflow or both that provides capture and containment of the exhaust effluent.

> **Exception:** Compensating hoods with makeup air supplied only from the front face discharge and side face discharge openings shall not be required to be labeled with the maximum makeup airflow.

Section 509 Fire Suppression Systems

509.1 Where required.

Cooking appliances required by Section 507.2 to have a Type I hood shall be provided with an *approved* automatic fire suppression system complying with the International Building Code and the International Fire Code.

INSIGHTS (1)

Section 510 Hazardous Exhaust Systems

510.1 General.

This section shall govern the design and construction of duct systems for hazardous exhaust and shall determine where such systems are required. Hazardous exhaust systems are systems designed to capture and control hazardous emissions generated from product handling or processes, and convey those emissions to the outdoors. Hazardous emissions include flammable vapors, gases, fumes, mists or dusts, and volatile or airborne materials posing a health hazard, such as toxic or corrosive materials. For the purposes of this section, the health-hazard rating of materials shall be as specified in NFPA 704.

For the purposes of the provisions of Section 510, a laboratory shall be defined as a facility where the use of chemicals is related to testing, analysis, teaching, research or developmental activities. Chemicals are used or synthesized on a nonproduction basis, rather than in a manufacturing process.

INSIGHTS (1)

510.2 Where required.

A hazardous exhaust system shall be required wherever operations involving the handling or processing of hazardous materials, in the absence of such exhaust systems and under normal operating conditions, have the potential to create one of the following conditions:

1.

A flammable vapor, gas, fume, mist or dust is present in concentrations exceeding 25 percent of the lower flammability limit of the substance for the expected room temperature.

2.

A vapor, gas, fume, mist or dust with a health-hazard rating of 4 is present in any concentration.

3.

A vapor, gas, fume, mist or dust with a health-hazard rating of 1, 2 or 3 is present in concentrations exceeding 1 percent of the median lethal concentration of the substance for acute inhalation toxicity.

Exception: Laboratories, as defined in Section 510.1, except where the concentrations listed in Item 1 are exceeded or a vapor, gas, fume, mist or dust with a health-hazard rating of 1, 2, 3 or 4 is present in concentrations exceeding 1 percent of the median lethal concentration of the substance for acute inhalation toxicity.

[F] 510.2.1 Lumber yards and woodworking facilities.

Equipment or machinery located inside buildings at lumber yards and woodworking facilities that generates or emits combustible dust shall be provided with an *approved* dust-collection and exhaust system installed in accordance with this section and the *International Fire Code*. *Equipment* and systems that are used to collect, process or convey combustible dusts shall be provided with an *approved* explosion-control system.

INSIGHTS (1)

[F] 510.2.2 Combustible fibers.

Equipment or machinery within a *building* that generates or emits combustible fibers shall be provided with an *approved* dust-collecting and exhaust system. Such systems shall comply with this code and the *International Fire Code*.

510.3 Design and operation.

The design and operation of the exhaust system shall be such that flammable contaminants are diluted in noncontaminated air to maintain concentrations in the exhaust flow below 25 percent of the contaminant's lower flammability limit.

➡

510.4 Incompatible materials and common shafts.

Incompatible materials, as defined in the *International Fire Code*, shall not be exhausted through the same hazardous exhaust system. Hazardous exhaust systems shall not share common shafts with other duct systems, except where such systems are hazardous exhaust systems originating in the same fire area.

Exception: The provisions of this section shall not apply to laboratory exhaust systems where all of the following conditions apply:

1.

All of the hazardous exhaust ductwork and other laboratory exhaust within both the occupied space and the shafts are under negative pressure while in operation.

2.

The hazardous exhaust ductwork manifolded together within the occupied space must originate within the same fire area.

3.

Hazardous exhaust ductwork originating in different fire areas and manifolded together in a common shaft shall meet the provisions of Section 717.5.3, Exception 1, Item 1.1 of the *International Building Code*.

4.

Each control branch has a flow-regulating device.

5.

Perchloric acid hoods and connected exhaust shall be prohibited from manifolding.

6.

Radioisotope hoods are equipped with filtration, carbon beds or both where required by the *registered design professional*.

7.

Biological safety cabinets are filtered.

8.

Each hazardous exhaust duct system shall be served by redundant exhaust fans that comply with either of the following:

8.1.

The fans shall operate simultaneously in parallel and each fan shall be individually capable of providing the required exhaust rate.

8.2.

Each of the redundant fans is controlled so as to operate when the other fan has failed or is shut down for servicing.

INSIGHTS (3)

510.5 Design.

Systems for removal of vapors, gases and smoke shall be designed by the constant velocity or equal friction methods. Systems conveying particulate matter shall be designed employing the constant velocity method.

510.5.1 Balancing.

Systems conveying explosive or radioactive materials shall be prebalanced by duct sizing. Other systems shall be balanced by duct sizing with balancing devices, such as dampers. Dampers provided to balance airflow shall have securely fixed minimum-position blocking devices to prevent restricting the flow below the required volume or velocity.

510.5.2 Emission control.

The design of the system shall be such that the emissions are confined to the area in which they are generated by air currents, hoods or enclosures and shall be exhausted by a duct system to a safe location or treated by removing contaminants.

510.5.3 Hoods required.

Hoods or enclosures shall be used where contaminants originate in a limited area of a space. The design of the hood or enclosure shall be such that air currents created by the exhaust systems will capture the contaminants and transport them directly to the exhaust duct.

INSIGHTS (1)

510.5.4 Contaminant capture and dilution.

The velocity and circulation of air in work areas shall be such that contaminants are captured by an airstream at the area where the emissions are generated and conveyed into a product-conveying duct system. Contaminated air from work areas where hazardous contaminants are generated shall be diluted below the thresholds specified in Section 510.2 with air that does not contain other hazardous contaminants.

510.5.5 Makeup air.

Makeup air from all sources shall be provided during operations at a rate approximately equal to the rate that air is exhausted by the hazardous exhaust system. *Makeup air* shall be provided by gravity or mechanical means or both. Mechanical *makeup air* systems shall be automatically controlled to start and operate simultaneously with the exhaust system. The *makeup air* shall not reduce the effectiveness of the exhaust system. *Makeup air* intakes shall be located in accordance with Section 401.4.

INSIGHTS (2)

510.5.6 Clearances.

The minimum *clearance* between hoods and combustible construction shall be the *clearance* required by the duct system.

510.5.7 Ducts.

Hazardous exhaust duct systems shall extend directly to the exterior of the *building* and shall not extend into or through ducts and *plenums*.

510.6 Penetrations.

Penetrations of structural elements by a hazardous exhaust system shall conform to Sections 510.6.1 through 510.6.4.

> **Exception:** Duct penetrations within Group H-5 *occupancies* as allowed by the *International Building Code*.

510.6.1 Fire dampers and smoke dampers.

Fire dampers and *smoke dampers* are prohibited in hazardous exhaust ducts.

510.6.1.1 Shaft penetrations.

Hazardous exhaust ducts that penetrate fire-resistance-rated shafts shall comply with Section 714.4.1 or 714.4.1.2 of the *International Building Code*.

510.6.2 Floors.

Hazardous exhaust systems that penetrate a floor/ceiling assembly shall be enclosed in a fire-resistance-rated shaft constructed in accordance with the *International Building Code*.

INSIGHTS (1)

510.6.3 Wall assemblies.

Hazardous exhaust duct systems that penetrate fire-resistance-rated wall assemblies shall be enclosed in fire-resistance-rated construction from the point of penetration to the outlet terminal, except where the interior of the duct is equipped with an *approved* automatic fire suppression system. Ducts shall be enclosed in accordance with the *International Building*

Code requirements for shaft construction and such enclosure shall have a minimum fire-resistance rating of not less than the highest fire-resistance-rated wall assembly penetrated.

INSIGHTS (1)

510.6.4 Fire walls.

Ducts shall not penetrate a fire wall.

INSIGHTS (1)

510.7 Suppression required.

Ducts shall be protected with an *approved* automatic fire suppression system installed in accordance with the *International Building Code*.

Exceptions:

1.

An *approved* automatic fire suppression system shall not be required in ducts conveying materials, fumes, mists and vapors that are nonflammable and noncombustible under all conditions and at any concentrations.

2.

Automatic fire suppression systems shall not be required in metallic and noncombustible, nonmetallic exhaust ducts in semiconductor fabrication facilities.

3.

An *approved* automatic fire suppression system shall not be required in ducts where the largest cross-sectional diameter of the duct is less than 10 inches (254 mm).

4.

For laboratories, as defined in Section 510.1, automatic fire protection systems shall not be required in laboratory hoods or exhaust systems.

510.7.1 Duct cleanout.

Ducts conveying combustible dust as part of a dust collection system shall be equipped with cleanouts that are provided with *approved access*, predesigned to be disassembled for cleaning, or engineered for automatic cleanouts. Where provided, cleanouts shall be located at the base of each vertical duct riser and at intervals not exceeding 20 feet (6096 mm) in horizontal sections of duct.

510.8 Duct construction.

Ducts used to convey hazardous exhaust shall be constructed of materials *approved* for installation in such an exhaust system and shall comply with one of the following:

1.

Ducts shall be constructed of *approved* G90 galvanized sheet steel, with a minimum nominal thickness as specified in Table 510.8.

2.

Ducts used in systems exhausting nonflammable corrosive fumes or vapors shall be constructed of nonmetallic materials that exhibit a flame spread index of 25 or less and a smoke-developed index of 50 or less when tested in accordance with ASTM E84 or UL 723 and that are *listed* and *labeled* for the application.

Where the products being exhausted are detrimental to the duct material, the ducts shall be constructed of alternative materials that are compatible with the exhaust.

TABLE 510.8 MINIMUM DUCT THICKNESS

DIAMETER OF DUCT OR MAXIMUM SIDE DIMENSION	MINIMUM NOMINAL THICKNESS		
	Nonabrasive materials	Nonabrasive/abrasive materials	Abrasive materials

0–8 inches	0.028 inch (No. 24 gage)	0.034 inch (No. 22 gage)	0.040 inch (No. 20 gage)
9–18 inches	0.034 inch (No. 22 gage)	0.040 inch (No. 20 gage)	0.052 inch (No. 18 gage)
19–30 inches	0.040 inch (No. 20 gage)	0.052 inch (No. 18 gage)	0.064 inch (No. 16 gage)
Over 30 inches	0.052 inch (No. 18 gage)	0.064 inch (No. 16 gage)	0.079 inch (No. 14 gage)

For SI: 1 inch = 25.4 mm.

510.8.1 Duct joints.

Ducts shall be made tight with lap joints having a minimum lap of 1 inch (25 mm). Joints used in ANSI/SMACNA Round Industrial Duct Construction Standards and ANSI/SMACNA Rectangular Industrial Duct Construction Standards are also acceptable.

510.8.2 Clearance to combustibles.

Ducts shall have a *clearance* to combustibles in accordance with Table 510.8.2. Exhaust gases having temperatures in excess of 600°F (316°C) shall be exhausted to a *chimney* in accordance with Section 511.2.

TABLE 510.8.2 CLEARANCE TO COMBUSTIBLES

TYPE OF EXHAUST OR TEMPERATURE OF EXHAUST (°F)	CLEARANCE TO COMBUSTIBLES (inches)
Less than 100	1
100–600	12
Flammable vapors	6

For SI: 1 inch = 25.4 mm, °C = [(°F) – 32]/1.8.

510.8.3 Explosion relief.

Systems exhausting potentially explosive mixtures shall be protected with an *approved* explosion relief system or by an *approved* explosion prevention system designed and installed in accordance with NFPA 69. An explosion relief system shall be designed to minimize the structural and mechanical damage resulting from an explosion or deflagration within the exhaust system. An explosion prevention system shall be designed to prevent an explosion or deflagration from occurring.

510.9 Supports.

Ducts shall be supported at intervals not exceeding 10 feet (3048 mm). Supports shall be constructed of noncombustible material.

Section 511 Dust, Stock and Refuse Conveying Systems

INSIGHTS (2)

511.1 Dust, stock and refuse conveying systems.

Dust, stock and refuse conveying systems shall comply with the provisions of Section 510, Sections 511.1.1 through 511.2 and the *International Fire Code*.

INSIGHTS (2)

511.1.1 Collectors and separators.

Collectors and separators involving such systems as centrifugal separators, bag filter systems and similar devices, and associated supports shall be constructed of noncombustible materials and shall be located on the exterior of the *building* or structure. A collector or separator shall not be located nearer than 10 feet (3048 mm) to combustible construction or to an unprotected wall or floor opening, unless the collector is provided with a metal vent pipe that extends above the highest part of any roof with a distance of 30 feet (9144 mm).

Exceptions:

1.

Collectors such as “Point of Use” collectors, close extraction weld fume collectors, spray finishing booths, stationary grinding tables, sanding booths, and integrated or machine-mounted collectors shall be permitted to be installed indoors provided that the installation is in accordance with the *International Fire Code* and NFPA 70.

2.

Collectors in independent exhaust systems handling combustible dusts shall be permitted to be installed indoors provided that such collectors are installed in compliance with the *International Fire Code* and NFPA 70.

INSIGHTS (2)

511.1.2 Discharge pipe.

Discharge piping shall conform to the requirements for ducts, including *clearances* required for high-heat *appliances*, as contained in this code. A delivery pipe from a cyclone collector shall not convey refuse directly into the firebox of a boiler, furnace, Dutch oven, refuse burner, incinerator or other *appliance*.

511.1.3 Conveying systems exhaust discharge.

An exhaust system shall discharge to the outside of the *building* either directly by flue or indirectly through the bin or vault into which the system discharges except where the contaminants have been removed. Exhaust system discharge shall be permitted to be recirculated provided that the solid particulate has been removed at a minimum efficiency of 99.9 percent at 10 microns (10.01 mm), vapor concentrations are less than 25 percent of the LFL, and *approved equipment* is used to monitor the vapor concentration.

511.1.4 Spark protection.

The outlet of an open-air exhaust terminal shall be protected with an *approved* metal or other noncombustible screen to prevent the entry of sparks.

511.1.5 Explosion control.

Explosion control shall be provided in accordance with the requirements of the *International Fire Code* on all systems that convey combustible dust or combustible refuse or stock that produces combustible dusts in such a manner that the concentration and conditions could create a fire or explosion hazard. Determination of concentrations or conditions that are deemed to not create a fire or explosion hazard shall be based on a Dust Hazard Analysis prepared in accordance with Section 2203.2 of the *International Fire Code*.

INSIGHTS (2)

511.1.5.1 Screens.

Where a screen is installed in a safety relief vent, the screen shall be attached so as to permit ready release under the explosion pressure.

511.1.5.2 Hoods.

The relief vent shall be provided with an *approved* noncombustible cowl or hood, or with a counterbalanced relief valve or cover arranged to prevent the escape of hazardous materials, gases or liquids.

511.2 Exhaust outlets.

Outlets for exhaust that exceed 600°F (315°C) shall be designed as a *chimney* in accordance with Table 511.2.

TABLE 511.2 CONSTRUCTION, CLEARANCE AND TERMINATION REQUIREMENTS FOR SINGLE-WALL METAL CHIMNEYS

CHIMNEYS SERVING	MINIMUM THICKNESS	TERMINATION	CLEARANCE

	Walls (inch)	Lining	Above roof opening (feet)	Above any part of building within (feet)			Combustible construction (inches)		Noncombustible construction	
				10	25	50	Interior inst.	Exterior inst.	Interior inst.	Exterior inst.
High-heat appliances (Over 2,000°F)[a]	0.127 (No. 10 MSG)	4 1/2″ laid on 4 1/2″ bed	20	—	—	20	See Note c			
Low-heat appliances (1,000°F normal operation)	0.127 (No. 10 MSG)	None	3	2	—	—	18	6	Up to 18″ diameter, 2″ Over 18″ diameter, 4″	
Medium-heat appliances (2,000°F maximum)[b]	0.127 (No. 10 MSG)	Up to 18″ dia.—2 1/2″ Over 18″—4 1/2″ on 4 1/2″ bed	10	—	10	—	36	24		

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, °C = [(°F) – 32]/1.8.

a.
Lining shall extend from bottom to top of outlet.

b.
Lining shall extend from 24 inches below connector to 24 feet above.

c.
Clearance shall be as specified by the design engineer and shall have sufficient clearance from buildings and structures to avoid overheating combustible materials (maximum 160°F).

Section 512 Subslab Soil Exhaust Systems

INSIGHTS (1)

512.1 General.

Where a subslab soil exhaust system is provided, the duct shall conform to the requirements of this section.

512.2 Materials.

Subslab soil exhaust system duct material shall be air duct material *listed* and *labeled* to the requirements of UL 181 for Class 0 air ducts, or any of the following piping materials that comply with the *International Plumbing Code* as *building* sanitary drainage and vent pipe: cast iron; galvanized steel; copper or copper-alloy pipe and tube of a weight not less than type DWV; and plastic piping.

512.3 Grade.

Exhaust system ducts shall not be trapped and shall have a minimum slope of 1/8 unit vertical in 12 units horizontal (1-percent slope).

512.4 Termination.

Subslab soil exhaust system ducts shall extend through the roof and terminate not less than 6 inches (152 mm) above the roof and not less than 10 feet (3048 mm) from any operable openings or air intake.

512.5 Identification.

Subslab soil exhaust ducts shall be permanently identified within each floor level by means of a tag, stencil or other *approved* marking.

Section 513 Smoke Control Systems

[F] 513.1 Scope and purpose.

This section applies to mechanical and passive smoke control systems that are required by the *International Building Code* or the *International Fire Code*. The purpose of this section is to establish minimum requirements for the design, installation and acceptance testing of smoke control systems that are intended to provide a tenable environment for the evacuation or relocation of occupants. These provisions are not intended for the preservation of contents, the timely restoration of operations, or for assistance in fire suppression or overhaul activities. Smoke control systems regulated by this section serve a different purpose than the smoke and heat removal provisions found in Section 910 of the *International Building Code* or the *International Fire Code*.

[F] 513.2 General design requirements.

Buildings, structures, or parts thereof required by the *International Building Code* or the *International Fire Code* to have a smoke control system or systems shall have such systems designed in accordance with the applicable requirements of Section 909 of the *International Building Code* and the generally accepted and well-established principles of engineering relevant to the design. The *construction documents* shall include sufficient information and detail to describe adequately the elements of the design necessary for the proper implementation of the smoke control systems. These documents shall be accompanied with sufficient information and analysis to demonstrate compliance with these provisions.

[F] 513.3 Special inspection and test requirements.

In addition to the ordinary inspection and test requirements that buildings, structures and parts thereof are required to undergo, smoke control systems subject to the provisions of

Section 909 of the *International Building Code* shall undergo special inspections and tests sufficient to verify the proper commissioning of the smoke control design in its final installed condition. The design submission accompanying the *construction documents* shall clearly detail procedures and methods to be used and the items subject to such inspections and tests. Such commissioning shall be in accordance with generally accepted engineering practice and, where possible, based on published standards for the particular testing involved. The special inspections and tests required by this section shall be conducted under the same terms as found in Section 1704 of the *International Building Code*.

[F] 513.4 Analysis.

A rational analysis supporting the types of smoke control systems to be employed, their methods of operation, the systems supporting them and the methods of construction to be utilized shall accompany the submitted *construction documents* and shall include, but not be limited to, the items indicated in Sections 513.4.1 through 513.4.7.

[F] 513.4.1 Stack effect.

The system shall be designed such that the maximum probable normal or reverse stack effects will not adversely interfere with the system's capabilities. In determining the maximum probable stack effects, altitude, elevation, weather history and interior temperatures shall be used.

[F] 513.4.2 Temperature effect of fire.

Buoyancy and expansion caused by the design fire in accordance with Section 513.9 shall be analyzed. The system shall be designed such that these effects do not adversely interfere with its capabilities.

[F] 513.4.3 Wind effect.

The design shall consider the adverse effects of wind. Such consideration shall be consistent with the wind-loading provisions of the *International Building Code*.

[F] 513.4.4 HVAC systems.

The design shall consider the effects of the heating, ventilating and air-conditioning (HVAC) systems on both smoke and fire transport. The analysis shall include all permutations of systems' status. The design shall consider the effects of fire on the HVAC systems.

[F] 513.4.5 Climate.

The design shall consider the effects of low temperatures on systems, property and occupants. Air inlets and exhausts shall be located so as to prevent snow or ice blockage.

[F] 513.4.6 Duration of operation.

All portions of active or engineered smoke control systems shall be capable of continued operation after detection of the fire event for a period of not less than either 20 minutes or 1.5 times the calculated egress time, whichever is greater.

[F] 513.4.7 Smoke control system interaction.

The design shall consider the interaction effects of the operation of multiple smoke control systems for all design scenarios.

[F] 513.5 Smoke barrier construction.

Smoke barriers required for passive smoke control and a smoke control system using the pressurization method shall comply with Section 709 of the *International Building Code*. The maximum allowable leakage area shall be the aggregate area calculated using the following leakage area ratios:

1.

Walls: $A/A_w = 0.00100$

2.

Interior exit stairways and ramps and exit passageways: $A/A_w = 0.00035$

3.

Enclosed exit access stairways and ramps and all other shafts: $A/A_w = 0.00150$

4.

Floors and roofs: $A/A_F = 0.00050$

where:

A=Total leakage area, square feet (m^2).
A_F=Unit floor or roof area of barrier, square feet (m^2).
A_w =Unit wall area of barrier, square feet (m^2).

The leakage area ratios shown do not include openings created by gaps around doors and operable windows. The total leakage area of the smoke barrier shall be determined in accordance with Section 513.5.1 and tested in accordance with Section 513.5.2.

[F] 513.5.1 Total leakage area.

Total leakage area of the barrier is the product of the smoke barrier gross area times the allowable leakage area ratio, plus the area of other openings such as gaps around doors and operable windows.

[F] 513.5.2 Testing of leakage area.

Compliance with the maximum total leakage area shall be determined by achieving the minimum air pressure difference across the barrier with the system in the smoke control mode for mechanical smoke control systems utilizing the pressurization method. Compliance with the maximum total leakage area of passive smoke control systems shall be verified through methods such as door fan testing or other methods, as *approved* by the fire code official.

[F] 513.5.3 Opening protection.

Openings in smoke barriers shall be protected by automatic-closing devices actuated by the required controls for the mechanical smoke control system. Door openings shall be protected by door assemblies complying with the requirements of the *International Building Code* for doors in smoke barriers.

Exceptions:

1.

Passive smoke control systems with automatic-closing devices actuated by spot-type smoke detectors *listed* for releasing service installed in accordance with the *International Building Code*.

2.

Fixed openings between smoke zones that are protected utilizing the airflow method.

3.

In Group I-1 Condition 2, Group I-2 and ambulatory care facilities, where a pair of opposite-swinging doors are installed across a corridor in accordance with Section 513.5.3.1, the doors shall not be required to be protected in accordance with Section 716 of the *International Building Code*. The doors shall be close-fitting within operational tolerances and shall not have a center mullion or undercuts in excess of 3/4 inch (19.1 mm), louvers or grilles. The doors shall have head and jamb stops and astragals or rabbets at meeting edges and, where permitted by the door manufacturer's listing, positive-latching devices are not required.

4. In Group I-2 and *ambulatory care facilities*, where such doors are special-purpose horizontal sliding, accordion or folding door assemblies installed in accordance with Section 1010.1.4.3 of the *International Building Code* and are automatic closing by smoke detection in accordance with Section 716.2.6.5 of the *International Building Code*.

5. Group I-3.

6. Openings between smoke zones with clear ceiling heights of 14 feet (4267 mm) or greater and bank down capacity of greater than 20 minutes as determined by the design fire size.

[F] 513.5.3.1 Group I-1 Condition 2, Group I-2 and ambulatory care facilities.

In Group I-1 Condition 2, Group I-2 and *ambulatory care facilities*, where doors are installed across a *corridor*, the doors shall be automatic closing by smoke detection in accordance with Section 716.2.6.5 of the *International Building Code* and shall have a vision panel with fire-protection-rated glazing materials in fire-protection-rated frames, the area of which shall not exceed that tested.

[F] 513.5.3.2 Ducts and air transfer openings.

Ducts and air transfer openings are required to be protected with a minimum Class II, 250°F (121°C) smoke damper complying with the *International Building Code*.

[F] 513.6 Pressurization method.

The primary mechanical means of controlling smoke shall be by pressure differences across smoke barriers. Maintenance of a tenable environment is not required in the smoke control zone of fire origin.

[F] 513.6.1 Minimum pressure difference.

The pressure difference across a smoke barrier used to separate smoke zones shall be not less than 0.05-inch water gage (12.4 Pa) in fully sprinklered buildings.

In buildings permitted to be other than fully sprinklered, the smoke control system shall be designed to achieve pressure differences not less than two times the maximum calculated pressure difference produced by the design fire.

[F] 513.6.2 Maximum pressure difference.

The maximum air pressure difference across a smoke barrier shall be determined by required door-opening or closing forces. The actual force required to open exit doors when the system is in the smoke control mode shall be in accordance with the *International Building Code*. Opening and closing forces for other doors shall be determined by standard engineering methods for the resolution of forces and reactions. The calculated force to set a side-hinged, swinging door in motion shall be determined by:

Equation 5-2 $F = F_{dc} + K(WA\Delta P)/2(W-d)$

where:

A =Door area, square feet (m^2).
d =Distance from door handle to latch edge of door, feet (m).
F =Total door opening force, pounds (N).
F_{dc} =Force required to overcome closing device, pounds (N).
K =Coefficient 5.2 (1.0).
W =Door width, feet (m).
ΔP =Design pressure difference, inches (Pa) water gage.

[F] 513.6.3 Pressurized stairways and elevator hoistways.

Where stairways or elevator hoistways are pressurized, such pressurization systems shall comply with Section 513 as smoke control systems, in addition to the requirements of Sections 909.20 of the *International Building Code* and 909.21 of the *International Fire Code*.

[F] 513.7 Airflow design method.

Where *approved* by the code official, smoke migration through openings fixed in a permanently open position, which are located between smoke control zones by the use of the airflow method, shall be permitted. The design airflows shall be in accordance with this section. Airflow shall be directed to limit smoke migration from the fire zone. The geometry of openings shall be considered to prevent flow reversal from turbulent effects. Smoke control systems using the airflow method shall be designed in accordance with NFPA 92.

[F] 513.7.1 Prohibited conditions.

This method shall not be employed where either the quantity of air or the velocity of the airflow will adversely affect other portions of the smoke control system, unduly intensify the fire, disrupt plume dynamics or interfere with exiting. Airflow toward the fire shall not exceed 200 feet per minute (1.02 m/s). Where the calculated airflow exceeds this limit, the airflow method shall not be used.

[F] 513.8 Exhaust method.

Where *approved* by the building official, mechanical smoke control for large enclosed volumes, such as in atriums or malls, shall be permitted to utilize the exhaust method. Smoke control systems using the exhaust method shall be designed in accordance with NFPA 92.

[F] 513.8.1 Exhaust rate.

The height of the lowest horizontal surface of the accumulating smoke layer shall be maintained not less than 6 feet (1829 mm) above any walking surface that forms a portion of a required egress system within the smoke zone.

[F] 513.9 Design fire.

The design fire shall be based on a rational analysis performed by the *registered design professional* and *approved* by the code official. The design fire shall be based on the analysis in accordance with Section 513.4 and this section.

[F] 513.9.1 Factors considered.

The engineering analysis shall include the characteristics of the fuel, fuel load, effects included by the fire and whether the fire is likely to be steady or unsteady.

[F] 513.9.2 Design fire fuel.

Determination of the design fire shall include consideration of the type of fuel, fuel spacing and configuration.

[F] 513.9.3 Heat-release assumptions.

The analysis shall make use of the best available data from *approved* sources and shall not be based on excessively stringent limitations of combustible material.

[F] 513.9.4 Sprinkler effectiveness assumptions.

A documented engineering analysis shall be provided for conditions that assume fire growth is halted at the time of sprinkler activation.

[F] 513.10 Equipment.

Equipment such as, but not limited to, fans, ducts, automatic dampers and balance dampers shall be suitable for their intended use, suitable for the probable exposure temperatures that the rational analysis indicates, and as *approved* by the code official.

[F] 513.10.1 Exhaust fans.

Components of exhaust fans shall be rated and certified by the manufacturer for the probable temperature rise to which the components will be exposed. This temperature rise shall be computed by:

Equation 5-3 $Ts=(Qc/mc)+(Ta)$

where:

c =Specific heat of smoke at smoke-layer temperature, Btu/lb°F (kJ/kg • K).
m =Exhaust rate, pounds per second (kg/s).
Q_c =Convective heat output of fire, Btu/s (kW).
T_a =Ambient temperature, °F (K).
T_s =Smoke temperature, °F (K).

Exception: Reduced T_s as calculated based on the assurance of adequate dilution air.

[F] 513.10.2 Ducts.

Duct materials and joints shall be capable of withstanding the probable temperatures and pressures to which they are exposed as determined in accordance with Section 513.10.1. Ducts shall be constructed and supported in accordance with Chapter 6. Ducts shall be leak tested to 1.5 times the maximum design pressure in accordance with nationally accepted practices. Measured leakage shall not exceed 5 percent of design flow. Results of such testing shall be a part of the documentation procedure. Ducts shall be supported directly from fire-resistance-rated structural elements of the *building* by substantial, noncombustible supports.

Exception: Flexible connections, for the purpose of vibration isolation, that are constructed of *approved* fire-resistance-rated materials.

[F] 513.10.3 Equipment, inlets and outlets.

Equipment shall be located so as to not expose uninvolved portions of the *building* to an additional fire hazard. Outdoor air inlets shall be located so as to minimize the potential for introducing smoke or flame into the *building*. Exhaust outlets shall be so located as to minimize reintroduction of smoke into the *building* and to limit exposure of the *building* or adjacent buildings to an additional fire hazard.

[F] 513.10.4 Automatic dampers.

Automatic dampers, regardless of the purpose for which they are installed within the smoke control system, shall be *listed* and conform to the requirements of *approved* recognized standards.

[F] 513.10.5 Fans.

In addition to other requirements, belt-driven fans shall have 1.5 times the number of belts required for the design duty with the minimum number of belts being two. Fans shall be selected for stable performance 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 Standby power.

The smoke control system shall be supplied with standby power in accordance with Section 2702 of the *International Building Code*.

[F] 513.11.1 Equipment room.

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.

[F] 513.11.2 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 the requirements of Section 907 of the *International Building Code*. Such systems shall be equipped with a control unit complying with UL 864 and *listed* as smoke control *equipment*.

[F] 513.12.1 Verification.

Control systems for mechanical smoke control systems shall include provisions for verification. Verification shall include positive confirmation of actuation, testing, manual override and the presence of power downstream of all disconnects. A preprogrammed weekly test sequence shall report abnormal conditions audibly, visually and by printed report. The preprogrammed weekly test shall operate all devices, *equipment* and components used for smoke control.

> **Exception:** Where verification of individual components tested through the preprogrammed weekly testing sequence will interfere with, and produce unwanted effects to, normal *building* operation, such individual components are permitted to be bypassed from the preprogrammed weekly testing, where *approved* by the building official and in accordance with both of the following:
>
> 1.
>
> Where the operation of components is bypassed from the preprogrammed weekly test, presence of power downstream of all disconnects shall be verified weekly by a *listed* control unit.
>
> 2.
>
> Testing of all components bypassed from the preprogrammed weekly test shall be in accordance with Section 909.20.6 of the *International Fire Code*.

[F] 513.12.2 Wiring.

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

[F] 513.12.3 Activation.

Smoke control systems shall be activated in accordance with the *International Building Code* or the *International Fire Code*.

[F] 513.12.4 Automatic control.

Where complete 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 provided with *ready access* for 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 B42, ASTM B43, ASTM B68, ASTM B88, ASTM B251 and ASTM B280. Fittings shall be wrought copper or copper alloy, solder type in accordance with ASME B16.18 or ASME B16.22. Changes in direction shall be made with appropriate tool bends. Copper-alloy 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 liquidus below 1,500°F (816°C). Brazing flux shall be used on copper-to-copper alloy joints only.

> **Exception:** Nonmetallic tubing used within control panels and at the final connection to devices provided that 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 movable devices shall be of sufficient length to avoid tension and excessive stress. Tubing shall be protected against abrasion. Tubing connected to 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.

Control-air tubing shall be tested 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 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 hoods.

5.

Clothes dryer exhaust systems covered in Section 504.

> **Exception:** The application of ERV *equipment* that recovers sensible heat only utilizing coil-type heat exchangers shall not be limited by this section.

INSIGHTS (5)

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

User note:

About this chapter: *Chapter 6 addresses duct systems used in HVAC systems and some exhaust systems. Some exhaust system ducts are addressed in Chapter 5, such as kitchen exhaust ducts and clothes dryer exhaust ducts. This chapter addresses air plenums such as above-ceiling and below-floor plenums. Section 607 covers fire and smoke dampers, consistent with the requirements of the* International Building Code®.

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.

[BE] 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.

Transfer air movement required to maintain pressurization difference within health care facilities in accordance with ASHRAE 170.

INSIGHTS (1)

[BE] 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.

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.

INSIGHTS (1)

[BE] 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.

601.5 Return air openings.

Return air openings for heating, ventilation and air-conditioning systems shall comply with all of the following:

1.

Openings shall not be located less than 10 feet (3048 mm) measured in any direction from an open combustion chamber or draft hood of another *appliance* located in the same room or space.

2.

Return air shall not be taken from a hazardous or insanitary location or a refrigeration room as defined in this code.

3.

The amount of return air taken from any room or space shall be not greater than the flow rate of supply air delivered to such room or space.

4.

Return and transfer openings shall be sized in accordance with the *appliance* or *equipment* manufacturer's installation instructions, ACCA Manual D or the design of the *registered design professional*.

5.

Return air taken from one *dwelling unit* shall not be discharged into another *dwelling unit*.

6.

Taking return air from a crawl space shall not be accomplished through a direct connection to the return side of a forced air furnace. Transfer openings in the crawl space enclosure shall not be prohibited.

7.

Return air shall not be taken from a closet, bathroom, toilet room, kitchen, garage, boiler room, furnace room or unconditioned attic.

8.

Return air shall not be taken from indoor swimming pool enclosures and associated deck areas.

Exceptions:

1.

Where the air from such spaces is dehumidified in accordance with Section 403.2.1, Item 2.

2.

Dedicated HVAC systems serving only such spaces.

Exceptions:

1.

Taking return air from a kitchen is not prohibited where such return air openings serve the kitchen and are located not less than 10 feet (3048 mm) from the cooking *appliances*.

2.

Taking return air from a kitchen is not prohibited in a *dwelling unit* where the kitchen and living spaces are in a single room and the cooking *appliance* is electric and located not less than 5 feet (1524 mm) in any direction from the return air intake opening.

3.

Dedicated forced air systems serving only the garage shall not be prohibited from obtaining return air from the garage.

INSIGHTS (3)

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, mechanical equipment rooms and the framing cavities addressed in Section 602.3. Plenums shall be limited to one fire area. Air systems shall be ducted from the boundary of the fire area served directly to the air-handling equipment. Fuel-fired appliances shall not be installed within a plenum.

INSIGHTS (2)

602.2 Construction.

Plenum enclosure construction materials that are exposed to the airflow shall comply with the requirements of Section 703.5 of the *International Building Code* or such materials shall have 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 E84 or UL 723.

The use of gypsum boards to form *plenums* shall be limited to systems where the air temperatures do not exceed 125°F (52°C) 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. Supply air *plenums* formed by gypsum boards shall not be incorporated in air-handling systems utilizing *direct evaporative cooling* systems.

INSIGHTS (3)

602.2.1 Materials within plenums.

Except as required by Sections 602.2.1.1 through 602.2.1.8, 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 E84 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* and *listed* for the application.

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.

INSIGHTS (1)

602.2.1.1 Wiring.

Combustible electrical wires and cables and optical fiber cables exposed within a *plenum* shall be *listed* and *labeled* as having a peak optical density not greater than 0.50, an average optical density not greater than 0.15, and a flame spread distance not greater than 5 feet (1524 mm) 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* and *labeled* as having a peak optical density not greater than 0.5, an average optical density not greater than 0.15, and a flame spread distance not greater than 5 feet (1524 mm) when tested in accordance with UL 2024. Only *plenum*-rated wires and cables shall be installed in *plenum*-rated raceways.

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 be *listed* and *labeled* as having a peak optical density not greater than 0.50, an average optical density not greater than 0.15, and a flame spread distance not greater than 5 feet (1524 mm) when tested in accordance with UL 1887.

INSIGHTS (1)

602.2.1.3 Pneumatic tubing.

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

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 Discrete plumbing and mechanical products in plenums.

Where discrete plumbing and mechanical products and appurtenances are located in a *plenum* and have exposed combustible material, they shall be *listed* and *labeled* for such use in accordance with UL 2043.

602.2.1.6 Foam plastic in plenums as interior finish or interior trim.

Foam plastic in *plenums* used as interior wall or ceiling finish or interior trim 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 E84 or UL 723 at the maximum thickness and density intended for use, and shall be tested in accordance with NFPA 286 and meet the acceptance criteria of Section 803.1.2 of the *International Building Code*. As an alternative to testing to NFPA 286, the foam plastic shall be *approved* based on tests conducted in accordance with Section 2603.9 of the *International Building Code*.

Exceptions:

1.

Foam plastic in *plenums* used as interior wall or ceiling finish or interior trim 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 E84 or UL 723 at the maximum thickness and density intended for use, where it is separated from the airflow in the *plenum* by a thermal barrier complying with Section 2603.4 of the *International Building Code*.

2.

Foam plastic in *plenums* used as interior wall or ceiling finish or interior trim, 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 E84 or UL 723 at the maximum thickness and density intended for use, where it is separated from the airflow in the *plenum* by corrosion-resistant steel having a base metal thickness of not less than 0.0160 inch (0.4 mm).

3.

Foam plastic in *plenums* used as interior wall or ceiling finish or interior trim, 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 E84 or UL 723 at the maximum thickness and density intended for use, where it is separated from the airflow in the *plenum* by not less than a 1-inch (25 mm) thickness of masonry or concrete.

602.2.1.7 Plastic plumbing piping and tubing.

Plastic piping and tubing used in plumbing systems shall be *listed* and *labeled* as having a flame spread index not greater than 25 and a smoke-developed index not greater than 50 when tested in accordance with ASTM E84 or UL 723.

> **Exception:** Plastic water distribution piping and tubing *listed* and *labeled* in accordance with UL 2846 as having a peak optical density not greater than 0.50, an average optical density not greater than 0.15, and a flame spread distance not greater than 5 feet (1524 mm), and installed in accordance with its listing.

602.2.1.8 Pipe and duct insulation within plenums.

Pipe and duct insulation contained within *plenums*, including insulation adhesives, shall have 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 E84 or UL 723, using the specimen preparation and mounting procedures of ASTM E2231. Pipe and duct insulation shall not flame, glow, smolder or smoke when tested in accordance with ASTM C411 at the temperature to which they are exposed in service. The test temperature shall not fall below 250°F (121°C). Pipe and duct insulation shall be *listed* and *labeled*. Pipe and duct insulation shall not be used to reduce the maximum flame spread and smoke-developed indices except where the pipe or duct and its related insulation, coatings, and adhesives are tested as a composite assembly in accordance with Section 602.2.1.7.

INSIGHTS (3)

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.

Stud wall cavities in the outside walls of building envelope assemblies shall not be utilized as air *plenums*.

INSIGHTS (2)

[BS] 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.

INSIGHTS (1)

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, the *appliance* manufacturer's installation instructions 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.

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.

TABLE 603.4 DUCT CONSTRUCTION MINIMUM SHEET METAL THICKNESS FOR SINGLE DWELLING UNITS[a]

ROUND DUCT DIAMETER (inches)	STATIC PRESSURE			
	1/2-inch water gauge		1-inch water gauge	
	Thickness (inches)		Thickness (inches)	
	Galvanized	Aluminum	Galvanized	Aluminum
< 12	0.013	0.018	0.013	0.018
12 to14	0.013	0.018	0.016	0.023
15 to 17	0.016	0.023	0.019	0.027
18	0.016	0.023	0.024	0.034
19 to 20	0.019	0.027	0.024	0.034
RECTANGULAR DUCT DIMENSION (inches)	STATIC PRESSURE			
	1/2-inch water gauge		1-inch water gauge	
	Thickness (inches)		Thickness (inches)	
	Galvanized	Aluminum	Galvanized	Aluminum
≤ 8	0.013	0.018	0.013	0.018
9 to 10	0.013	0.018	0.016	0.023
11 to 12	0.016	0.023	0.019	0.027
13 to 16	0.019	0.027	0.019	0.027
17 to 18	0.019	0.027	0.024	0.034
19 to 20	0.024	0.034	0.024	0.034

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

a.
Ductwork that exceeds 20 inches by dimension or exceeds a pressure of 1-inch water gauge shall be constructed in accordance with SMACNA *HVAC Duct Construction Standards—Metal and Flexible.*

603.4.1 Minimum fasteners.

Round metallic ducts shall be mechanically fastened by means of not less than 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.

603.4.2 Duct lap.

Crimp joints for round and oval metal ducts shall be lapped not less than 1 inch (25 mm) and the male end of the duct shall extend into the adjoining duct in the direction of airflow.

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 250°F (121°C).

INSIGHTS (1)

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 125°F (52°C) and the gypsum board surface temperature is maintained above the airstream dew-point temperature. Supply air ducts formed by gypsum boards shall not be incorporated in air-handling systems utilizing *direct evaporative cooling* systems.

INSIGHTS (2)

603.5.2 Phenolic ducts.

Nonmetallic phenolic ducts shall be constructed and installed in accordance with the SMACNA *Phenolic Duct Construction Standards*.

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 250°F (121°C).

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 not less than 2 inches (51 mm) of concrete.

INSIGHTS (1)

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, secured and tested prior to concrete encasement or direct burial. Ducts shall be leak tested as required by Section C403 of the *International Energy Conservation Code*.

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 D2412. 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.

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. 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. Tapes and mastics used to seal fibrous glass ductwork shall be *listed* and *labeled* in accordance with UL 181A and shall be marked “181 A-P” for pressure-sensitive tape, “181 A-M” for mastic or “181 A-H” for heat-sensitive tape. Tapes and mastics used to seal metallic and flexible air ducts and flexible air connectors shall comply with UL 181B and shall be marked “181 B-FX” for pressure-sensitive tape or “181 B-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 “181 B-C.” Closure systems used to seal all ductwork shall be installed in accordance with the manufacturer’s instructions.

> **Exception:** For ducts having a static pressure classification of less than 2 inches of water column (500 Pa), additional closure systems shall not be required for continuously welded joints and seams and locking-type joints and seams. This exception shall not apply to snaplock and button-lock type joints and seams located outside of conditioned spaces.

603.10 Supports.

Ducts shall be supported 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.

[BS] 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.

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 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).

INSIGHTS (1)

604.3 Coverings and linings.

Duct coverings and linings, including adhesives where 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 E84 or UL 723, using the specimen preparation and mounting procedures of ASTM E2231. Duct coverings and linings shall not flame, glow, smolder or smoke when tested in accordance with ASTM C411 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*.

Exception: Polyurethane foam insulation that is spray applied to the exterior of ducts in attics and crawl spaces shall be subject to all of the following requirements:

1. The foam plastic insulation shall have a flame spread index not greater than 25 and a smoke–developed index not greater than 450, when tested in accordance with ASTM E84 or UL 723, using the specimen preparation and mounting procedures of ASTM E2231.

2. The foam plastic insulation shall not flame, glow, smolder or smoke when tested in accordance with ASTM C411 at the temperature to which they are exposed in service. The test temperature shall not fall below 250°F (121°C).

3. The foam plastic insulation complies with the requirements of Section 2603 of the *International Building Code*.

4. The foam plastic insulation is protected against ignition in accordance with the requirements of Section 2603.4.1.6 of the *International Building Code*.

INSIGHTS (4)

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 indices of the composite materials. 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 75°F (24°C) 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 (mm), 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 not less than 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. Joints and seams shall be sealed to maintain the continuity of the vapor retarder.

> **Exception:** A vapor retarder is not required for spray polyurethane foam insulation having a water vapor permeance of not greater than 3 perms per inch [1722 ng/(s • m^2 • Pa)] at the installed thickness.

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 shall be provided with *approved* air filters. Filters shall be installed such that all return air, outdoor air and *makeup air* is filtered upstream from any heat exchanger or coil. Filters shall be installed in an *approved* convenient location. Liquid adhesive coatings used on filters shall have a flash point not lower than 325°F (163°C).

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.

INSIGHTS (1)

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. In facilities that are required to be monitored by a supervising station, duct smoke detectors shall report only as a supervisory signal, not as a fire alarm.

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.

Section 607 Duct and Transfer Openings

[BF] 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.

[BF] 607.1.1 Ducts between shafts.

Ducts transitioning horizontally between shafts shall not require a shaft enclosure provided that the duct penetration into each associated shaft is protected with dampers complying with this section.

[BF] 607.1.2 Ducts that penetrate fire-resistance-rated assemblies without dampers.

Ducts that penetrate fire-resistance-rated walls and are not required by this section to have dampers shall comply with the requirements of Sections 714.3 through 714.4.3 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 *fire dampers* shall comply with the requirements of Section 714.5 of the *International Building Code*.

[BF] 607.1.2.1 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*.

[BF] 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 manufacturer's instructions, the dampers' listing and Sections 607.2.1 through 607.2.3.

INSIGHTS (2)

[BF] 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.

[BF] 607.2.3 Static dampers.

Fire dampers and ceiling radiation dampers that are listed for use in static systems shall be installed only in heating, ventilation and airconditioning systems that are automatically shut down in the event of a fire.

[BF] 607.3 Damper testing, ratings and actuation.

Damper testing, ratings and actuation shall be in accordance with Sections 607.3.1 through 607.3.3.5.

[BF] 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. *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. Corridor dampers shall comply with requirements of both UL 555 and UL 555S. Corridor dampers shall demonstrate acceptable closure performance when subjected to 150 feet per minute (0.76 m/s) velocity across the face of the damper using the UL 555 fire exposure test.

INSIGHTS (3)

[BF] 607.3.2 Damper rating.

Damper ratings shall be in accordance with Sections 607.3.2.1 through 607.3.2.4.

[BF] 607.3.2.1 Fire damper ratings.

Fire dampers shall have the minimum rating specified in Table 607.3.2.1.

[BF] 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

[BF] 607.3.2.2 Smoke damper ratings.

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

[BF] 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 607.3.2.1 and shall have the minimum rating specified for smoke dampers in Section 607.3.2.2.

[BF] 607.3.2.4 Corridor damper ratings.

Corridor dampers shall have the following minimum ratings:

1.

One-hour fire-resistance rating.

2.

Class I or II leakage rating as specified in Section 607.3.2.2.

[BF] 607.3.3 Damper actuation.

Damper actuation shall be in accordance with Sections 607.3.3.1 through 607.3.3.5 as applicable.

[BF] 607.3.3.1 Fire damper actuation.

Primary heat–responsive devices used to actuate fire dampers 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*.

[BF] 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 inside the duct or outside the duct with sampling tubes protruding into the duct. The detector or tubes within the duct shall be within 5 feet (1524 mm) of the damper. Air outlets and inlets shall not be located between the detector or tubes 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 shall be installed on either side of the smoke barrier door opening. The detector shall be *listed* for releasing service if used for direct interface with the damper.

3.

Where a smoke damper is installed within an unducted opening in a wall, a spot-type detector shall be installed within 5 feet (1524 mm) horizontally of the damper. The detector shall be *listed* for releasing service if used for direct interface with 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 smoke detection system is installed in all areas served by the duct in which the damper will be located, the smoke dampers shall be permitted to be controlled by the smoke detection system.

[BF] 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.

[BF] 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).

[BF] 607.3.3.5 Corridor damper actuation.

Corridor damper actuation shall be in accordance with Sections 607.3.3.1 and 607.3.3.2.

[BF] 607.4 Access and identification.

Access and identification of fire and *smoke dampers* shall comply with Sections 607.4.1 through 607.4.2.

INSIGHTS (2)

[BF] 607.4.1 Access.

Fire and *smoke dampers* shall be provided with an *approved* means of *access* that is large enough to permit inspection and maintenance of the damper and its operating parts. Dampers equipped with fusible links, internal operators or both shall be provided with an access door that is not less than 12 inches (305 mm) square or provided with a removable duct section.

INSIGHTS (1)

[BF] 607.4.1.1 Fire-resistance rating.

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 doors in ducts shall be tight fitting and suitable for the required duct construction.

[BF] 607.4.1.2 Restricted access.

Where space constraints or physical barriers restrict *access* to a damper for periodic inspection and testing, the damper shall be a single- or multi-blade damper and shall comply with the remote inspection requirements of NFPA 80 or NFPA 105.

[BF] 607.4.2 Identification.

Access points shall be permanently identified on the exterior by a label having letters not less than 1/2 inch (12.7 mm) in height reading: FIRE/SMOKE DAMPER, SMOKE DAMPER or FIRE DAMPER.

INSIGHTS (1)

[BF] 607.5 Where required.

Fire dampers, *smoke dampers*, combination fire/*smoke dampers*, *ceiling radiation dampers* and corridor 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 provided.

[BF] 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.

[BF] 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.*

[BF] 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 enclosures for interior exit stairways and ramps and exit passageways except as permitted by Sections 1023.5 and 1024.6, 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 E119 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 fully 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 fully 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. Flexible air connectors shall be permitted in a fully ducted system, limited to the following installations:

3.1.

Nonmetallic flexible connections that connect a duct to an air handling unit or *equipment* located within a mechanical room in accordance with Section 603.9.

3.2.

Nonmetallic flexible air connectors in accordance with Section 603.6.2 that connect an overhead metal duct to a ceiling diffuser where the metal duct and ceiling diffuser are located within the same room.

INSIGHTS (3)

[BF] 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*.

[BF] 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 not less than 0.0217 inch (0.55 mm) in thickness.

3.3.

The duct shall not have openings that communicate the corridor with adjacent spaces or rooms.

3.4.

The duct shall be installed above a ceiling.

3.5.

The duct shall not terminate at a wall register in the fire-resistance-rated wall.

3.6.

A minimum 12-inch-long (305 mm) by 0.060-inch-thick (1.52 mm) steel sleeve shall be centered in each duct opening. The sleeve shall be secured to both sides of the wall and all four sides of the sleeve with minimum 1 1/2-inch by 1 1/2-inch by 0.060-inch (38 mm by 38 mm by 1.52 mm) steel retaining angles. The retaining angles shall be secured to the sleeve and the wall with No. 10 (M5) screws. The annular space between the steel sleeve and the wall opening shall be filled with rock (mineral) wool batting on all sides.

4.

Such walls are penetrated by ducted HVAC systems, have a required fire-resistance rating of 1 hour or less, and 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 conveying supply, return or *exhaust air* as part of the structure's HVAC system. Such a duct system shall be constructed of sheet steel not less than 26 gage in thickness and shall be continuous from the air-handling *appliance* or *equipment* to the air outlet and inlet terminals.

[BF] 607.5.4 Corridors/smoke barriers.

A *listed* smoke damper designed to resist the passage of smoke shall be provided at each point a duct or air transfer opening penetrates a smoke barrier wall or a corridor enclosure required to have smoke and draft control doors in accordance with the *International Building Code*.

A corridor damper shall be provided where corridor ceilings, constructed as required for the corridor walls as permitted in Section 708.4, Exception 3, of the *International Building Code*, are penetrated.

A *ceiling radiation damper* shall be provided where the ceiling membrane of a fire-resistance-rated floor/ceiling or roof/ceiling assembly, constructed as permitted in Section 708.4, Exception 2, of the *International Building Code*, is penetrated.

Smoke dampers and smoke damper actuation methods shall comply with Section 607.5.4.1.

Exceptions:

1.

Smoke dampers are not required in corridor penetrations where the *building* is equipped throughout with an *approved* smoke control system in accordance with Section 513 and *smoke dampers* are not necessary for the operation and control of the system.

2.

Smoke dampers are not required in smoke barrier penetrations where the openings in ducts are limited to a single smoke compartment and the ducts are constructed of steel.

3.

Smoke dampers are not required in corridor penetrations where the duct is constructed of steel not less than 0.019 inch (0.48 mm) in thickness and there are no openings serving the corridor.

4.

Smoke dampers are not required in smoke barriers required by Section 407.5 of the *International Building Code* for Group I-2, Condition 2 where the HVAC system is fully ducted in accordance with Section 603 and where *buildings* are equipped throughout with an automatic sprinkler system in accordance with Section 903.3.1.1 of the *International Building Code* and equipped with quick-response sprinklers in accordance with Section 903.3.2 of the *International Building Code*.

INSIGHTS (1)

[BF] 607.5.4.1 Smoke damper.

Smoke dampers shall close as required by Section 607.3.3.2.

[BF] 607.5.5 Shaft enclosures.

Shaft enclosures that are permitted to be penetrated by ducts and air transfer openings shall be protected with *listed* fire and *smoke dampers* installed in accordance with their listing.

Exceptions:

1.

Fire dampers are not required at penetrations of shafts where any of the following apply:

1.1.

Steel exhaust subducts having a wall thickness of not less than 0.0187 inch (0.4712 mm) extend not less than 22 inches (559 mm) vertically in exhaust shafts and an exhaust fan is installed at the upper terminus of the shaft that is powered continuously, in accordance with Section 909.11 of the *International Building Code*, so as to maintain a continuous airflow upward to the outdoors.

1.2.

Penetrations are tested in accordance with ASTM E119 or UL 263 as part of the fire-resistance-rated assembly.

1.3.

Ducts are used as part of an *approved* smoke control system in accordance with Section 909 of the *International Building Code*, and where the fire damper will interfere with the operation of the smoke control system.

1.4.

The penetrations are in parking garage exhaust or supply shafts that are separated from other *building* shafts by not less than 2-hour fire-resistance-rated construction.

2.

In Group B and R *occupancies* equipped throughout with an automatic sprinkler system in accordance with Section 903.3.1.1 of the *International Building Code*, *smoke dampers* are not required at penetrations of shafts where kitchen, clothes dryer, bathroom and toilet room exhaust openings with steel exhaust subducts, having a wall thickness of not less than 0.0187 inch (0.4712 mm), extend not less than 22 inches (559 mm) vertically and the exhaust fan at the upper terminus is powered continuously in accordance with the provisions of Section 909.11 of the *International Building Code*, and maintains airflow upward to the outdoors.

3.

Smoke dampers are not required at penetrations of exhaust or supply shafts in parking garages that are separated from other *building* shafts by not less than 2-hour fire-resistance-rated construction.

4.

Smoke dampers are not required at penetrations of shafts where ducts are used as part of an *approved* mechanical smoke control system designed in accordance with Section 909 of the *International Building Code* and where the smoke damper will interfere with the operation of the smoke control system.

5. Fire dampers and combination fire/*smoke dampers* are not required in kitchen and clothes dryer exhaust systems where dampers are prohibited by this code.

INSIGHTS (3)

[BF] 607.5.5.1 Continuous upward flow.

Fire dampers and *smoke dampers* shall not be installed in shafts that are required to maintain continuous airflow upward where closure of the damper would result in the loss of airflow.

[BF] 607.5.5.2 Enclosure at the bottom.

Shaft enclosures that do not extend to the bottom of the *building* or structure shall be protected in accordance with Section 713.11 of the *International Building Code*.

[BF] 607.5.6 Exterior walls.

Ducts and air transfer openings in fire-resistance-rated exterior walls required to have protected openings in accordance with Section 705.10 of the *International Building Code* shall be protected with *listed* fire dampers installed in accordance with their listing.

[BF] 607.5.7 Smoke partitions.

A *listed smoke damper* designed to resist the passage of smoke shall be provided at each point where an air transfer opening penetrates a smoke partition. *Smoke dampers* and smoke damper actuation methods shall comply with Section 607.3.3.2.

> **Exception:** Where the installation of a smoke damper will interfere with the operation of a required smoke control system in accordance with Section 513, *approved* alternative protection shall be used.

[BF] 607.6 Horizontal assemblies.

Penetrations by air ducts of a floor, floor/ceiling assembly or the ceiling membrane of a roof/ceiling assembly shall be protected by a shaft enclosure that complies with Section 713 and Sections 717.6.1 through 717.6.3 of the *International Building Code* or shall comply with Sections 607.6.1 through 607.6.3.

[BF] 607.6.1 Through penetrations.

In *occupancies* other than Groups I-2 and I-3, a duct constructed of *approved* materials in accordance with Section 603 that penetrates a fire-resistance-rated floor/ceiling assembly that connects not more than two stories is permitted without shaft enclosure protection provided that a *listed* fire damper is installed at the floor line or the duct is protected in accordance with Section 714.5 of the *International Building Code*. For air transfer openings, see Item 6, Section 712.1.9 of the *International Building Code*.

> **Exception:** A duct is permitted to penetrate three floors or less without a fire damper at each floor provided that it meets all of the following requirements:
>
> 1.
>
> The duct shall be contained and located within the cavity of a wall and shall be constructed of steel having a minimum thickness of 0.0187 inch (0.4712 mm) (No. 26 gage).
>
> 2.
>
> The duct shall open into only one *dwelling unit* or *sleeping unit* and the duct system shall be continuous from the unit to the exterior of the *building*.
>
> 3.

The duct shall not exceed a 4-inch (102 mm) nominal diameter and the total area of such ducts shall not exceed 100 square inches for any 100 square feet (64 516 mm^2 per 9.3 m^2) of the floor area.

4.

The annular space around the duct is protected with materials that prevent the passage of flame and hot gases sufficient to ignite cotton waste when subjected to ASTM E119 or UL 263 time-temperature conditions under a minimum positive pressure differential of 0.01 inch (2.49 Pa) of water at the location of the penetration for the time period equivalent to the fire-resistance rating of the construction penetrated.

5.

Grille openings located in a ceiling of a fire-resistance-rated floor/ceiling or roof/ceiling assembly shall be protected with a *listed ceiling radiation damper* installed in accordance with Section 607.6.2.1.

INSIGHTS (1)

[BF] 607.6.2 Membrane penetrations.

Ducts and air transfer openings constructed of *approved* materials, in accordance with Section 603, that penetrate the ceiling membrane of a fire-resistance-rated floor/ceiling or roof/ceiling assembly shall be protected with one of the following:

1.

A shaft enclosure in accordance with Section 713 of the *International Building Code*.

2.

A *listed ceiling radiation damper* installed at the ceiling line where a duct penetrates the ceiling of a fire-resistance-rated floor/ceiling or roof/ceiling assembly.

Exceptions:

1.

A fire-resistance-rated assembly tested in accordance with ASTM E119 or UL 263 showing that ceiling radiation dampers are not required in order to maintain the fire-resistance rating of the assembly.

2.

Where exhaust duct or outdoor air duct penetrations are protected in accordance with Section 714.5.1.2 of the *International Building Code*, are located within the cavity of a wall and do not pass through another *dwelling unit* or tenant space.

3.

Where duct and air transfer openings are protected with a duct outlet penetration system tested as part of a fire-resistance-rated assembly in accordance with ASTM E119 or UL 263.

3.

A *listed* ceiling radiation damper installed at the ceiling line where a diffuser with no duct attached penetrates the ceiling of a fire-resistance-rated floor/ceiling or roof/ceiling assembly.

Exceptions:

1.

A fire-resistance-rated assembly tested in accordance with ASTM E119 or UL 263 showing that ceiling radiation dampers are not required in order to maintain the fire-resistance rating of the assembly.

2.

Where duct and air transfer openings are protected with a duct outlet penetration system tested as part of a fire-resistance-rated assembly in accordance with ASTM E119 or UL 263.

[BF] 607.6.2.1 Ceiling radiation dampers testing and installation.

Ceiling radiation dampers shall be tested in accordance with Section 607.3.1. *Ceiling radiation dampers* shall be installed in accordance with the details listed in the fire-resistance-rated assembly and the manufacturer's installation instructions and the listing.

[BF] 607.6.2.1.1 Dynamic systems.

Ceiling radiation dampers installed in heating, ventilation and air-conditioning systems designed to operate with fans on during a fire shall be labeled for use in dynamic systems.

[BF] 607.6.2.1.2 Static systems.

Static *ceiling radiation dampers* shall be installed only in systems that are not designed to operate during a fire.

Exceptions:

1.

Where a static *ceiling radiation damper* is installed at the opening of a duct, a smoke detector shall be installed inside the duct or outside the duct with sampling tubes protruding into the duct. The detector or tubes within the duct shall be within 5 feet (1524 mm) of the damper. Air outlets and inlets shall not be located between the detector or tubes 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 static *ceiling radiation damper* is installed in a ceiling, the *ceiling radiation damper* shall be permitted to be controlled by a smoke detection system installed within the same room or area as the *ceiling radiation damper*.

3.

A static *ceiling radiation damper* shall be permitted to be installed within a room where an occupant sensor is provided within the room that will shut down the system.

[BF] 607.6.3 Nonfire-resistance-rated floor assemblies.

Duct systems constructed of *approved* materials in accordance with Section 603 that penetrate nonfire-resistance-rated floor assemblies shall be protected by any of the following methods:

1.

A shaft enclosure in accordance with Section 713 of the *International Building Code*.

2.

The duct connects not more than two stories, and the annular space around the penetrating duct is protected with an *approved* noncombustible material that resists the free passage of flame and the products of *combustion*.

3.

In floor assemblies composed of noncombustible materials, a shaft shall not be required where the duct connects not more than three stories, and the annular space around the penetrating duct is protected with an *approved* noncombustible material that resists the free passage of flame and the products of *combustion* and a fire damper is installed at each floor line.

Exception: Fire dampers are not required in ducts within individual residential *dwelling units*.

INSIGHTS (1)

[BF] 607.7 Flexible ducts and air connectors.

Flexible ducts and air connectors shall not pass through any fire-resistance-rated assembly.

Section 608 Balancing

608.1 Balancing.

Air distribution, ventilation and exhaust systems shall be provided with means to adjust the system to achieve the design airflow rates and shall be balanced by an *approved* method. *Ventilation air* distribution shall be balanced by an *approved* method and such balancing shall verify that the air distribution system is capable of supplying and exhausting the airflow rates required by Chapter 4.

Chapter 7 Combustion Air

User note:

About this chapter: *Chapter 7 defers to the International Fuel Gas Code® for combustion air provisions for gas-fired appliances. This code addresses oil-fired and solid-fuel-fired appliances; therefore, Chapter 7 is brief, referring to the manufacturer for solid-fuel appliances and NFPA 31 for oil-fired appliances. Combustion air must be provided to appliances to prevent poor combustion that can create multiple health and safety hazards.*

Section 701 General

701.1 Scope.

Solid fuel-burning *appliances* shall be provided with *combustion air* in accordance with the *appliance* manufacturer's installation instructions. Oil-fired *appliances* shall be provided with *combustion air* in accordance with NFPA 31. The methods of providing *combustion air* in this chapter do not apply to fireplaces, fireplace stoves and direct-vent *appliances*. The requirements for combustion and dilution air for gas-fired *appliances* shall be in accordance with the *International Fuel Gas Code.*

701.2 Dampered openings.

Where combustion air openings are provided with volume, smoke or fire dampers, the dampers shall be interlocked with the firing cycle of the *appliances* served, so as to prevent operation of any *appliance* that draws combustion air from the room or space when any of the dampers are closed. Manual dampers shall not be installed in combustion air ducts. Ducts not provided with dampers and that pass through rated construction shall be enclosed in a shaft in accordance with the *International Building Code.*

Chapter 8 Chimneys and Vents

User note:

About this chapter: *Chapter 8 addresses venting means for fuel-fired appliances other than gas-fired. The* International Fuel Gas Code® *addresses gas-fired appliances. Chimneys include masonry and factory built; vents include Type L and pellet vents.*

Section 801 General

801.1 Scope.

This chapter shall govern the installation, maintenance, repair and approval of factory-built *chimneys*, *chimney* liners, vents and connectors. This chapter shall govern the utilization of masonry *chimneys*. Gas-fired *appliances* shall be vented in accordance with the *International Fuel Gas Code.*

801.2 General.

Every fuel-burning *appliance* shall discharge the products of *combustion* to a vent, factory-built *chimney* or masonry *chimney*, except for *appliances* vented in accordance with Section 804. The *chimney* or vent shall be designed for the type of *appliance* being vented.

> **Exception:** Commercial cooking *appliances* vented by a Type I hood installed in accordance with Section 507.

801.2.1 Oil-fired appliances.

Oil-fired *appliances* shall be vented in accordance with this code and NFPA 31.

801.3 Masonry chimneys.

Masonry *chimneys* shall be constructed in accordance with the *International Building Code.*

801.4 Positive flow.

Venting systems shall be designed and constructed so as to develop a positive flow adequate to convey all *combustion products* to the outside atmosphere.

801.5 Design.

Venting systems shall be designed in accordance with this chapter or shall be *approved* engineered systems.

801.6 Minimum size of chimney or vent.

Except as otherwise provided for in this chapter, the size of the *chimney* or vent, serving a single *appliance*, except engineered systems, shall have a minimum area equal to the area of the *appliance* connection.

801.7 Solid fuel appliance flues.

The cross-sectional area of a flue serving a solid-fuel-burning *appliance* shall be not greater than three times the cross-sectional area of the *appliance* flue collar or flue outlet.

801.8 Abandoned inlet openings.

Abandoned inlet openings in *chimneys* and vents shall be closed by an *approved* method.

801.9 Positive pressure.

Where an *appliance* equipped with a forced or induced draft system creates a positive pressure in the venting system, the venting system shall be designed and *listed* for positive pressure applications.

801.10 Connection to fireplace.

Connection of *appliances* to *chimney* flues serving fireplaces shall be in accordance with Sections 801.10.1 through 801.10.3.

801.10.1 Closure and access.

A noncombustible seal shall be provided below the point of connection to prevent entry of room air into the flue. Means shall be provided for *access* to the flue for inspection and cleaning.

801.10.2 Connection to factory-built fireplace flue.

An *appliance* shall not be connected to a flue serving a factory-built fireplace unless the *appliance* is specifically *listed* for such installation. The connection shall be made in accordance with the *appliance* manufacturer's installation instructions.

801.10.3 Connection to masonry fireplace flue.

A connector shall extend from the *appliance* to the flue serving a masonry fireplace such that the flue gases are exhausted directly into the flue. The connector shall be provided with *access* or shall be removable for inspection and cleaning of both the connector and the flue. *Listed* direct connection devices shall be installed in accordance with their listing.

801.11 Multiple solid fuel prohibited.

A solid fuel-burning *appliance* or fireplace shall not connect to a *chimney* passageway venting another *appliance*.

801.12 Chimney entrance.

Connectors shall connect to a *chimney* flue at a point not less than 12 inches (305 mm) above the lowest portion of the interior of the *chimney* flue.

801.13 Cleanouts.

Masonry *chimney* flues shall be provided with a cleanout opening having a minimum height of 6 inches (152 mm). The upper edge of the opening shall be located not less than 6 inches (152 mm) below the lowest *chimney* inlet opening. The cleanout shall be provided with a tight-fitting, noncombustible cover.

> **Exception:** Cleanouts shall not be required for *chimney* flues serving masonry fireplaces, if such flues are provided with *access* through the fireplace opening.

801.14 Connections to exhauster.

Appliance connections to a *chimney* or vent equipped with a power exhauster shall be made on the inlet side of the exhauster. Joints and piping on the positive pressure side of the exhauster shall be *listed* for positive pressure applications as specified by the manufacturer's installation instructions for the exhauster.

INSIGHTS (1)

801.15 Fuel-fired appliances.

Masonry *chimneys* utilized to vent fuel-fired *appliances* shall be located, constructed and sized as specified in the manufacturer's installation instructions for the *appliances* being vented.

801.16 Flue lining.

Masonry chimneys shall be lined. The lining material shall be compatible with the type of *appliance* connected, in accordance with the *appliance* listing and manufacturer's installation instructions. *Listed* materials used as flue linings shall be installed in accordance with their listings and the manufacturer's instructions.

INSIGHTS (1)

801.16.1 Residential and low-heat appliances (general).

Flue lining systems for use with residential-type and low-heat *appliances* shall be limited to the following:

1.

Clay flue lining complying with the requirements of ASTM C315 or equivalent. Clay flue lining shall be installed in accordance with the *International Building Code*.

2.

Listed and *labeled chimney* lining systems complying with UL 1777.

3.

Other *approved* materials that will resist, without cracking, softening or corrosion, flue gases and condensate at temperatures up to 1,800°F (982°C).

801.17 Space around lining.

The space surrounding a flue lining system or other vent installed within a *masonry chimney* shall not be used to vent any other *appliance*. This shall not prevent the installation of a separate flue lining in accordance with the manufacturer's installation instructions and this code.

801.18 Existing chimneys and vents.

Where an *appliance* is permanently disconnected from an existing *chimney* or vent, or where an *appliance* is connected to an existing *chimney* or vent during the process of a new installation, the *chimney* or vent shall comply with Sections 801.18.1 through 801.18.4.

INSIGHTS (1)

801.18.1 Size.

The *chimney* or vent shall be resized as necessary to control flue gas condensation in the interior of the *chimney* or vent and to provide the *appliance* or *appliances* served with the required draft. For the venting of oil-fired *appliances* to masonry *chimneys*, the resizing shall be in accordance with NFPA 31.

INSIGHTS (1)

801.18.2 Flue passageways.

The flue gas passageway shall be free from obstructions and combustible deposits and shall be cleaned if previously used for venting a solid or liquid fuel-burning *appliance* or fireplace. The flue liner, *chimney* inner wall or vent inner wall shall be continuous and shall be free from cracks, gaps, perforations or other damage or deterioration that would allow the escape of *combustion products*, including gases, moisture and creosote. Where an oil-fired *appliance* is connected to an existing masonry *chimney*, such *chimney* flue shall be repaired or relined in accordance with NFPA 31.

801.18.3 Cleanout.

Masonry *chimneys* shall be provided with a cleanout opening complying with Section 801.13.

801.18.4 Clearances.

Chimneys and vents shall have airspace *clearance* to combustibles in accordance with the *International Building Code* and the *chimney* or vent manufacturer's installation instructions.

> **Exception:** Masonry *chimneys* without the required airspace *clearances* shall be permitted to be used if lined or relined with a *chimney* lining system *listed* for use in *chimneys* with reduced *clearances* in accordance with UL 1777. The *chimney clearance* shall be not less than permitted by the terms of the *chimney* liner listing and the manufacturer's instructions.

801.18.4.1 Fireblocking.

Noncombustible fireblocking shall be provided in accordance with the *International Building Code*.

801.19 Multistory prohibited.

Common venting systems for *appliances* located on more than one floor level shall be prohibited, except where all of the *appliances* served by the common vent are located in rooms or spaces that are accessed only from the outdoors. The *appliance* enclosures shall not communicate with the occupiable areas of the *building*.

801.20 Plastic vent joints.

Plastic pipe and fittings used to vent *appliances* shall be installed in accordance with the *appliance* manufacturer's installation instructions.

INSIGHTS (1)

801.21 Blocked vent switch.

Oil-fired *appliances* shall be equipped with a device that will stop burner operation in the event that the venting system is obstructed. Such device shall have a manual reset and shall be installed in accordance with the manufacturer's instructions.

INSIGHTS (3)

Section 802 Vents

802.1 General.

Vent systems shall be *listed* and *labeled*. Type L vents and pellet vents shall be tested in accordance with UL 641.

INSIGHTS (1)

802.2 Vent application

The application of vents shall be in accordance with Table 802.2.

INSIGHTS (1)

TABLE 802.2 VENT APPLICATION

VENT TYPES	APPLIANCE TYPES
Type L oil vents	Oil-burning appliances listed and labeled for venting with Type L vents; gas appliances listed and labeled for venting with Type B vents.
Pellet vents	Pellet fuel-burning appliances listed and labeled for venting with pellet vents.

802.3 Installation.

Vent systems shall be sized, installed and terminated in accordance with the vent and *appliance* manufacturer's installation instructions.

INSIGHTS (1)

802.4 Vent termination caps required.

Type L vents shall terminate with a *listed* and *labeled* cap in accordance with the vent manufacturer's installation instructions.

802.5 Type L vent terminations.

Type L vents shall terminate not less than 2 feet (610 mm) above the highest point of the roof penetration and not less than 2 feet (610 mm) higher than any portion of a building within 10 feet (3048 mm).

802.6 Minimum vent heights.

Vents shall terminate not less than 5 feet (1524 mm) in vertical height above the highest connected *appliance* flue collar.

Exceptions:

1.

Venting systems of direct vent *appliances* shall be installed in accordance with the *appliance* and the vent manufacturer's instructions.

2.

Appliances listed for outdoor installations incorporating integral venting means shall be installed in accordance with their listings and the manufacturer's installation instructions.

3.

Pellet vents shall be installed in accordance with the *appliance* and the vent manufacturer's installation instructions.

INSIGHTS (1)

802.7 Support of vents.

All portions of vents shall be adequately supported for the design and weight of the materials employed.

802.8 Insulation shield.

Where vents pass through insulated assemblies, an insulation shield constructed of not less than No. 26 gage sheet metal shall be installed to provide *clearance* between the vent and the insulation material. The *clearance* shall be not less than the *clearance* to combustibles specified by the vent manufacturer's installation instructions. Where vents pass through attic space, the shield shall terminate not less than 2 inches (51 mm) above the insulation materials and shall be secured in place to prevent displacement. Insulation shields provided as part of a *listed* vent system shall be installed in accordance with the manufacturer's installation instructions.

INSIGHTS (1)

802.9 Door swing.

Appliance and *equipment* vent terminals shall be located such that doors cannot swing within 12 inches (305 mm) horizontally of the vent terminals. Door stops or closers shall not be installed to obtain this clearance.

Section 803 Connectors

803.1 Connectors required.

Connectors shall be used to connect *appliances* to the vertical *chimney* or vent, except where the *chimney* or vent is attached directly to the *appliance*.

803.2 Location.

Connectors shall be located entirely within the room in which the connecting *appliance* is located, except as provided for in Section 803.10.4. Where passing through an unheated space, a connector shall not be constructed of single-wall pipe.

803.3 Size.

The connector shall not be smaller than the size of the flue collar supplied by the manufacturer of the *appliance*. Where the *appliance* has more than one flue outlet, and in the absence of the manufacturer's specific instructions, the connector area shall be not less than the combined area of the flue outlets for which it acts as a common connector.

803.4 Branch connections.

Branch connections to the vent connector shall be made in accordance with the vent manufacturer's instructions.

803.5 Manual dampers.

Manual dampers shall not be installed in connectors except in *chimney* connectors serving solid fuel-burning *appliances*.

803.6 Automatic dampers.

Automatic dampers shall be *listed* and *labeled* in accordance with UL 17 for oil-fired heating *appliances*. The dampers shall be installed in accordance with the manufacturer's instructions. An automatic vent damper device shall not be installed on an existing *appliance* unless the *appliance* is *listed* and *labeled* and the device is installed in accordance with the terms of its listing. The name of the installer and date of installation shall be marked on a label affixed to the damper device.

803.7 Connectors serving two or more appliances.

Where two or more connectors enter a common vent or *chimney*, the smaller connector shall enter at the highest level consistent with available headroom or *clearance* to combustible material.

803.8 Vent connector construction.

Vent connectors shall be constructed of metal. The minimum thickness of the connector shall be 0.0136 inch (0.345 mm) (No. 28 gage) for galvanized steel, 0.022 inch (0.6 mm) (No. 26 B & S gage) for copper, and 0.020 inch (0.5 mm) (No. 24 B & S gage) for aluminum.

803.9 Chimney connector construction.

Chimney connectors for low-heat *appliances* shall be of sheet steel pipe having resistance to corrosion and heat not less than that of galvanized steel specified in Table 803.9(1). Connectors for medium-heat *appliances* and high-heat *appliances* shall be of sheet steel not less than the thickness specified in Table 803.9(2).

INSIGHTS (1)

TABLE 803.9(1) MINIMUM CHIMNEY CONNECTOR THICKNESS FOR LOW-HEAT APPLIANCES

DIAMETER OF CONNECTOR (inches)	MINIMUM NOMINAL THICKNESS (galvanized) (inches)
5 and smaller	0.022 (No. 26 gage)
Larger than 5 and up to 10	0.028 (No. 24 gage)
Larger than 10 and up to 16	0.034 (No. 22 gage)
Larger than 16	0.064 (No. 16 gage)

For SI: 1 inch = 25.4 mm.

TABLE 803.9(2) MINIMUM CHIMNEY CONNECTOR THICKNESS FOR MEDIUM- AND HIGH-HEAT APPLIANCES

AREA (square inches)	EQUIVALENT ROUND DIAMETER (inches)	MINIMUM THICKNESS (inches)
0–154	0–14	0.0575 (No. 16 gage)
155–201	15–16	0.075 (No. 14 gage)
202–254	17–18	0.0994 (No. 12 gage)
Greater than 254	Greater than 18	0.1292 (No. 10 gage)

For SI: 1 inch = 25.4 mm, 1 square inch = 645.16 mm^2.

803.10 Installation.

Connectors shall be installed in accordance with Sections 803.10.1 through 803.10.6.

803.10.1 Supports and joints.

Connectors shall be supported in an *approved* manner, and joints shall be fastened with sheet metal screws, rivets or other *approved* means.

803.10.2 Length.

The maximum horizontal length of a single-wall connector shall be 75 percent of the height of the *chimney* or vent.

803.10.3 Connection.

The connector shall extend to the inner face of the *chimney* or vent liner, but not beyond. A connector entering a masonry *chimney* shall be cemented to masonry in an *approved* manner. Where thimbles are installed to facilitate removal of the connector from the masonry *chimney*, the thimble shall be permanently cemented in place with high-temperature cement.

INSIGHTS (1)

803.10.4 Connector pass-through.

Chimney connectors shall not pass through any floor or ceiling, nor through a fire-resistance-rated wall assembly. *Chimney* connectors for domestic-type *appliances* shall not pass through walls or partitions constructed of combustible material to reach a masonry *chimney* except where one of the following applies:

1.

The connector is *labeled* for wall pass-through and is installed in accordance with the manufacturer's instructions.

2.

The connector is put through a device *labeled* for wall pass-through.

3.

The connector has a diameter not larger than 10 inches (254 mm) and is installed in accordance with one of the methods in Table 803.10.4. Concealed metal parts of the pass-through system in contact with flue gases shall be of stainless steel or equivalent material that resists corrosion, softening or cracking up to 1,800°F (980°C).

INSIGHTS (1)

TABLE 803.10.4 CHIMNEY CONNECTOR SYSTEMS AND CLEARANCES TO COMBUSTIBLE WALL MATERIALS FOR DOMESTIC HEATING APPLIANCES[a, b, c, d]

System A (12-inch clearance)	A 3.5-inch-thick brick wall shall be framed into the combustible wall. An 0.625-inch-thick fire-clay liner (ASTM C315 or equivalent)[e] shall be firmly cemented in the center of the brick wall maintaining a 12-inch clearance to combustibles. The clay liner shall run from the outer surface of the bricks to the inner surface of the chimney liner.
System B (9-inch clearance)	A labeled solid-insulated factory-built chimney section (1-inch insulation) the same inside diameter as the connector shall be utilized. Sheet steel supports cut to maintain a 9-inch clearance to combustibles shall be fastened to the wall surface and to the chimney section. Fasteners shall not penetrate the chimney flue liner. The chimney length shall be

	flush with the masonry chimney liner and sealed to the masonry with water-insoluble refractory cement. Chimney manufacturers' parts shall be utilized to securely fasten the chimney connector to the chimney section.
System C (6-inch clearance)	A steel ventilated thimble having a minimum thickness of 0.0236 inch (No. 24 gage) having two 1-inch air channels shall be installed with a steel chimney connector. Steel supports shall be cut to maintain a 6-inch clearance between the thimble and combustibles. The chimney connector and steel supports shall have a minimum thickness of 0.0236 inch (No. 24 gage). One side of the support shall be fastened to the wall on all sides. Glass-fiber insulation shall fill the 6-inch space between the thimble and the supports.
System D (2-inch clearance)	A labeled solid-insulated factory-built chimney section (1-inch insulation) with a diameter 2 inches larger than the chimney connector shall be installed with a steel chimney connector having a minimum thickness of 0.0236 inch (No. 24 gage). Sheet steel supports shall be positioned to maintain a 2-inch clearance to combustibles and to hold the chimney connector to ensure that a 1-inch airspace surrounds the chimney connector through the chimney section. The steel support shall be fastened to the wall on all sides and the chimney section shall be fastened to the supports. Fasteners shall not penetrate the liner of the chimney section.

For SI: 1 inch = 25.4 mm, 1.0 Btu • in/ft^2 • h • °F = 0.144 W/m^2 • K.

a.
Insulation material that is part of the wall pass-through system shall be noncombustible and shall have a thermal conductivity of 1.0 Btu • in/ft^2 • h • °F or less.

b.
All clearances and thicknesses are minimums.

c.
Materials utilized to seal penetrations for the connector shall be noncombustible.

d.
Connectors for all systems except System B shall extend through the wall pass-through system to the inner face of the flue liner.

e.
ASTM C315.

803.10.5 Pitch.

Connectors shall rise vertically to the *chimney* or vent with a minimum pitch equal to 1/4 unit vertical in 12 units horizontal (2-percent slope).

803.10.6 Clearances.

Connectors shall have a minimum *clearance* to combustibles in accordance with Table 803.10.6. The *clearances* specified in Table 803.10.6 apply, except where the *listing* and *labeling* of an *appliance* specifies a different *clearance*, in which case the *labeled clearance* shall apply. The *clearance* to combustibles for connectors shall be reduced only in accordance with Section 308.

INSIGHTS (1)

TABLE 803.10.6 CONNECTOR CLEARANCES TO COMBUSTIBLES

TYPE OF APPLIANCE	MINIMUM CLEARANCE (inches)
Domestic-type appliances	
Chimney and vent connectors	
Electric and oil incinerators	18
Oil and solid-fuel appliances	18
Oil appliances labeled for venting with Type L vents	9
Commercial, industrial-type appliances	
Low-heat appliances	
Chimney connectors	
Oil and solid-fuel boilers, furnace and water heaters	18
Oil unit heaters	18
Other low-heat industrial appliances	18
Medium-heat appliances	
Chimney connectors	
All oil and solid-fuel appliances	36
High-heat appliances	(As determined by the code official)
Masonry or metal connectors	
All oil and solid-fuel appliances	

For SI: 1 inch = 25.4 mm.

Section 804 Direct-Vent, Integral Vent and Mechanical Draft Systems

804.1 Direct-vent terminations.

Vent terminals for *direct-vent appliances* shall be installed in accordance with the manufacturer’s instructions.

804.2 Appliances with integral vents.

Appliances incorporating integral venting means shall be installed in accordance with their listings and the manufacturer’s installation instructions.

804.2.1 Terminal clearances.

Appliances designed for natural draft venting and incorporating integral venting means shall be located so that a minimum *clearance* of 9 inches (229 mm) is maintained between vent terminals and from any openings through which *combustion* products enter the building. *Appliances* using forced draft venting shall be located so that a minimum *clearance* of 12 inches (305 mm) is maintained between vent terminals and from any openings through which *combustion* products enter the building.

804.3 Mechanical draft systems.

Mechanical draft systems of either forced or induced draft design shall be *listed* and *labeled* in accordance with UL 378 and shall comply with Sections 804.3.1 through 804.3.8.

804.3.1 Forced draft systems.

Forced draft systems and all portions of induced draft systems under positive pressure during operation shall be designed and installed so as to be gas tight to prevent leakage of *combustion products* into a *building*.

INSIGHTS (1)

804.3.2 Automatic shutoff.

Power exhausters serving automatically fired *appliances* shall be electrically connected to each *appliance* to prevent operation of the *appliance* when the power exhauster is not in operation.

804.3.3 Termination.

The termination of *chimneys* or vents equipped with power exhausters shall be located not less than 10 feet (3048 mm) from the lot line or from adjacent *buildings*. The exhaust shall be directed away from the *building*.

804.3.4 Horizontal terminations.

Horizontal terminations shall comply with the following requirements:

1.

Where located adjacent to walkways, the termination of mechanical draft systems shall be not less than 7 feet (2134 mm) above the level of the walkway.

2.

Vents shall terminate not less than 3 feet (914 mm) above any forced air inlet located within 10 feet (3048 mm).

3.

The vent system shall terminate not less than 4 feet (1219 mm) below, 4 feet (1219 mm) horizontally from or 1 foot (305 mm) above any door, window or gravity air inlet into the building.

4.

The vent termination point shall not be located closer than 3 feet (914 mm) to an interior corner formed by two walls perpendicular to each other.

5.

The vent termination shall not be mounted directly above or within 3 feet (914 mm) horizontally from an oil tank vent or gas meter.

6.

The bottom of the vent termination shall be located not less than 12 inches (305 mm) above finished grade.

INSIGHTS (1)

804.3.5 Vertical terminations.

Vertical terminations shall comply with the following requirements:

1.

Where located adjacent to walkways, the termination of mechanical draft systems shall be not less than 7 feet (2134 mm) above the level of the walkway.

2.

Vents shall terminate not less than 3 feet (914 mm) above any forced air inlet located within 10 feet (3048 mm) horizontally.

3.

Where the vent termination is located below an adjacent roof structure, the termination point shall be located not less than 3 feet (914 mm) from such structure.

4.

The vent shall terminate not less than 4 feet (1219 mm) below, 4 feet (1219 mm) horizontally from or 1 foot (305 mm) above any door, window or gravity air inlet for the *building*.

5.

A vent cap shall be installed to prevent rain from entering the vent system.

6.

The vent termination shall be located not less than 3 feet (914 mm) horizontally from any portion of the roof structure.

INSIGHTS (1)

804.3.6 Exhauster connections.

An *appliance* vented by natural draft shall not be connected into a vent, *chimney* or vent connector on the discharge side of a mechanical flue exhauster.

804.3.7 Exhauster sizing.

Mechanical flue exhausters and the vent system served shall be sized and installed in accordance with the manufacturer's installation instructions.

804.3.8 Mechanical draft systems for manually fired appliances and fireplaces.

A mechanical draft system shall be permitted to be used with manually fired *appliances* and fireplaces where such system complies with all of the following requirements:

1.

The mechanical draft device shall be *listed* and *labeled* in accordance with UL 378, and shall be installed in accordance with the manufacturer's instructions.

2.

A device shall be installed that produces visible and audible warning upon failure of the mechanical draft device or loss of electrical power, at any time that the mechanical draft device is turned on. This device shall be equipped with a battery backup if it receives power from the *building* wiring.

3.

A smoke detector shall be installed in the room with the *appliance* or fireplace. This device shall be equipped with a battery backup if it receives power from the *building* wiring.

Section 805 Factory-Built Chimneys

805.1 Listing.

Factory-built *chimneys* shall be *listed* and *labeled* and shall be installed and terminated in accordance with the manufacturer's installation instructions.

INSIGHTS (1)

805.2 Solid fuel appliances.

Factory-built *chimneys* installed in *dwelling units* with solid fuel-burning *appliances* shall comply with the Type HT requirements of UL 103 and shall be marked "Type HT" and "Residential Type and Building Heating *Appliance Chimney*."

> **Exception:** *Chimneys* for use with open *combustion* chamber fireplaces shall comply with the requirements of UL 103 and shall be marked "Residential Type and Building Heating *Appliance Chimney*."

Chimneys for use with open *combustion* chamber *appliances* installed in *buildings* other than *dwelling units* shall comply with the requirements of UL 103 and shall be marked "Building Heating *Appliance Chimney*" or "Residential Type and Building Heating *Appliance Chimney*."

805.3 Factory-built fireplaces.

Chimneys for use with factory-built fireplaces shall comply with the requirements of UL 127.

805.4 Factory-built chimney offsets.

Where a factory-built *chimney* assembly incorporates offsets, no part of the *chimney* shall be at an angle of more than 30 degrees (0.52 rad) from vertical at any point in the assembly and the *chimney* assembly shall not include more than four elbows.

805.5 Support.

Where factory-built *chimneys* are supported by structural members, such as joists and rafters, such members shall be designed to support the additional load.

805.6 Medium-heat appliances.

Factory-built *chimneys* for medium-heat *appliances* producing flue gases having a temperature above 1,000°F (538°C) measured at the entrance to the *chimney* shall comply with UL 959.

805.7 Decorative shrouds.

Decorative shrouds shall not be installed at the termination of factory-built *chimneys* except where such shrouds are *listed* and *labeled* for use with the specific *factory-built chimney* system and are installed in accordance with Section 304.1.

805.8 Insulation shield.

Where factory-built *chimneys* pass through insulated assemblies, an insulation shield constructed of steel having a thickness of not less than 0.0187 inch (0.4712 mm) (No. 26 gage) shall be installed to provide *clearance* between the *chimney* and the insulation material. The *clearance* shall be not less than the *clearance* to combustibles specified by the *chimney* manufacturer's installation instructions. Where *chimneys* pass through attic space, the shield shall terminate not less than 2 inches (51 mm) above the insulation materials and shall be secured in place to prevent displacement. Insulation shields provided as part of a *listed chimney* system shall be installed in accordance with the manufacturer's instructions.

Section 806 Metal Chimneys

806.1 General.

Metal *chimneys* shall be constructed and installed in accordance with NFPA 211.

Chapter 10 Boilers, Water Heaters and Pressure Vessels

User note:

About this chapter: *Chapter 10 addresses boilers, water heaters, expansion tanks and pressure vessels in general, such as compressed air vessels. This chapter includes requirements for components of hydronic HVAC systems, with the focus being on safety, maintenance, testing and safety control devices.*

Section 1001 General

1001.1 Scope.

This chapter shall govern the installation, *alteration* and repair of boilers, water heaters and pressure vessels.

Exceptions:

1.

Pressure vessels used for unheated water supply.

2.

Portable unfired pressure vessels and Interstate Commerce Commission containers.

3.

Containers for bulk oxygen and medical gas.

4.

Unfired pressure vessels having a volume of 5 cubic feet (0.14 m^3) or less operating at pressures not exceeding 250 pounds per square inch (psi) (1724 kPa) and located within *occupancies* of Groups B, F, H, M, R, S and U.

5.

Pressure vessels used in refrigeration systems that are regulated by Chapter 11 of this code.

6.

Pressure tanks used in conjunction with coaxial cables, telephone cables, power cables and other similar humidity control systems.

7.

Any boiler or pressure vessel subject to inspection by federal or state inspectors.

INSIGHTS (1)

Section 1002 Water Heaters

1002.1 General.

Potable water heaters and hot water storage tanks shall be *listed* and *labeled* and installed in accordance with the manufacturer's instructions, the *International Plumbing Code* and this code. Water heaters shall be capable of being removed without first removing a permanent portion of the *building* structure. The potable water connections and relief valves for all water heaters shall conform to the requirements of the *International Plumbing Code*. Domestic electric water heaters shall comply with UL 174 or UL 1453. Commercial electric water heaters shall comply with UL 1453. Oil-fired water heaters shall comply with UL 732. Solid-fuel-fired water heaters shall comply with UL 2523. Solar thermal water heating systems shall comply with Chapter 14 and ICC 900/SRCC 300.

INSIGHTS (1)

1002.2 Water heaters utilized for space heating.

Water heaters utilized both to supply potable hot water and provide hot water for space-heating applications shall be *listed* and *labeled* for such applications by the manufacturer and shall be installed in accordance with the manufacturer's instructions and the *International Plumbing Code*.

INSIGHTS (1)

1002.2.1 Sizing.

Water heaters utilized for both potable water heating and space-heating applications shall be sized to prevent the space-heating load from diminishing the required potable water-heating capacity.

1002.2.2 Temperature limitation.

Where a combination potable water-heating and space-heating system requires water for space heating at temperatures higher than 140°F (60°C), a temperature-actuated mixing valve that conforms to ASSE 1017 shall be provided to temper the water supplied to the potable hot water distribution system to a temperature of 140°F (60°C) or less.

1002.3 Supplemental water-heating devices.

Potable water-heating devices that utilize refrigerant-to-water heat exchangers shall be *approved* and installed in accordance with the *International Plumbing Code* and the manufacturer's instructions.

Section 1003 Pressure Vessels

1003.1 General.

All pressure vessels, unless otherwise *approved*, shall be constructed and certified in accordance with the ASME *Boiler and Pressure Vessel Code*, and shall be installed in accordance with the manufacturer's instructions and nationally recognized standards. Directly fired pressure vessels shall meet the requirements of Section 1004.

1003.2 Piping.

All piping materials, fittings, joints, connections and devices associated with systems utilized in conjunction with pressure vessels shall be designed for the specific application and shall be *approved*.

INSIGHTS (1)

1003.3 Welding.

Welding on pressure vessels shall be performed by an R-Stamp holder in accordance with the National Board Inspection Code, Part 3 or in accordance with an *approved* standard.

INSIGHTS (1)

Section 1004 Boilers

1004.1 Standards.

Boilers shall be designed, constructed and certified in accordance with the ASME *Boiler and Pressure Vessel Code*, Section I or IV. Controls and safety devices for boilers with fuel input ratings of less than 12,500,000 Btu/hr (3,662,500 W) shall meet the requirements of ASME CSD-1. Controls and safety devices for boilers with inputs greater than or equal to 12,500,000 Btu/hr (3,662,500 W) shall meet the requirements of NFPA 85. Packaged oil-fired boilers shall be *listed* and *labeled* in accordance with UL 726. Packaged electric boilers shall be *listed* and *labeled* in accordance with UL 834. Solid-fuel-fired boilers shall be *listed* and *labeled* in accordance with UL 2523.

INSIGHTS (2)

1004.2 Installation.

In addition to the requirements of this code, the installation of boilers shall conform to the manufacturer's instructions. Operating instructions of a permanent type shall be attached to the boiler. Boilers shall have all controls set, adjusted and tested by the installer. The manufacturer's rating data and the nameplate shall be attached to the boiler.

INSIGHTS (1)

1004.3 Working clearance.

Clearances shall be maintained around boilers, generators, heaters, tanks and related *equipment* and *appliances* so as to permit inspection, servicing, repair, replacement and visibility of all gauges. Where boilers are installed or replaced, *clearance* shall be provided to allow *access* for inspection, maintenance and repair. Passageways around all sides of boilers shall have an unobstructed width of not less than 18 inches (457 mm), unless otherwise *approved*.

INSIGHTS (1)

1004.3.1 Top clearance.

Clearances from the tops of boilers to the ceiling or other overhead obstruction shall be in accordance with Table 1004.3.1.

TABLE 1004.3.1 BOILER TOP CLEARANCES

BOILER TYPE	MINIMUM CLEARANCES FROM TOP OF BOILER TO CEILING OR OTHER OVERHEAD OBSTRUCTION (feet)
All boilers with manholes on top of the boiler except where a greater clearance is required in this table.	3
All boilers without manholes on top of the boiler except high-pressure steam boilers and where a greater clearance is required in this table.	2
High-pressure steam boilers with steam generating capacity not exceeding 5,000 pounds per hour.	3
High-pressure steam boilers with steam generating capacity exceeding 5,000 pounds per hour.	7
High-pressure steam boilers having heating surface not exceeding 1,000 square feet.	3

High-pressure steam boilers having heating surface in excess of 1,000 square feet.	7
High-pressure steam boilers with input not exceeding 5,000,000 Btu/h.	3
High-pressure steam boilers with input in excess of 5,000,000 Btu/h.	7
Steam-heating boilers and hot water-heating boilers with input exceeding 5,000,000 Btu/h.	3
Steam-heating boilers exceeding 5,000 pounds of steam per hour.	3
Steam-heating boilers and hot water-heating boilers having heating surface exceeding 1,000 square feet.	3

For SI: 1 foot = 304.8 mm, 1 square foot = 0.0929 m^2, 1 pound per hour = 0.4536 kg/h, 1 Btu/h = 0.293 W.

1004.4 Mounting.

Equipment shall be set or mounted on a level base capable of supporting and distributing the weight contained thereon. Boilers, tanks and *equipment* shall be secured in accordance with the manufacturer's installation instructions.

1004.5 Floors.

Boilers shall be mounted on floors of noncombustible construction, unless *listed* for mounting on combustible flooring.

1004.6 Boiler rooms and enclosures.

Boiler rooms and enclosures and *access* thereto shall comply with the *International Building Code* and Chapter 3 of this code. Boiler rooms shall be equipped with a floor drain or other *approved* means for disposing of liquid waste.

INSIGHTS (1)

1004.7 Operating adjustments and instructions.

Hot water and steam boilers shall have all operating and safety controls set and operationally tested by the installing contractor. A complete control diagram and boiler operating instructions shall be furnished by the installer for each installation.

Section 1005 Boiler Connections

1005.1 Valves.

Every boiler or modular boiler shall have a shutoff valve in the supply and return piping. For multiple boiler or multiple modular boiler installations, each boiler or modular boiler shall have individual shutoff valves in the supply and return piping.

> **Exception:** Shutoff valves are not required in a system having a single low-pressure steam boiler.

INSIGHTS (1)

1005.2 Potable water supply.

The water supply to all boilers shall be connected in accordance with the *International Plumbing Code*.

Section 1006 Safety and Pressure Relief Valves and Controls

1006.1 Safety valves for steam boilers.

Steam boilers shall be protected with a safety valve.

1006.2 Safety relief valves for hot water boilers.

Hot water boilers shall be protected with a safety relief valve.

1006.3 Pressure relief for pressure vessels.

Pressure vessels shall be protected with a pressure relief valve or pressure-limiting device as required by the manufacturer's installation instructions for the pressure vessel.

1006.4 Approval of safety and safety relief valves.

Safety and safety relief valves shall be *listed* and *labeled*, and shall have a minimum rated capacity for the *equipment* or *appliances* served. Safety and safety relief valves shall be set at not greater than the nameplate pressure rating of the boiler or pressure vessel.

1006.5 Installation.

Safety or relief valves shall be installed directly into the safety or relief valve opening on the boiler or pressure vessel. Valves shall not be located on either side of a safety or relief valve connection. The relief valve shall discharge by gravity.

1006.6 Safety and relief valve discharge.

Safety and relief valve discharge pipes shall be of rigid pipe that is *approved* for the temperature of the system. High-pressure-steam safety valves shall be vented to the outside of the structure. The discharge piping serving pressure relief valves, temperature relief valves and combinations of such valves shall:

1.

Not be directly connected to the drainage system.

2.

Discharge through an air break located in the same room as the *appliance*.

3.

Not be smaller than the diameter of the outlet of the valve served and shall discharge full size to the air break.

4.

Serve a single relief device and shall not connect to piping serving any other relief device or *equipment*.

5.

Discharge to the floor, to the pan serving the boiler or storage tank, to a waste receptor or to the outdoors.

6.

Discharge in a manner that does not cause personal injury or structural damage.

7.

Discharge to a termination point that is readily observable by the building occupants.

8.

Not be trapped.

9.

Be installed so as to flow by gravity.

10.

Not terminate more than 6 inches (152 mm) above the floor or waste receptor.

11.

Not have a threaded connection at the end of such piping.

12.

Not have valves or tee fittings.

13.

Be constructed of those materials listed in Section 605.4 of the *International Plumbing Code* or materials tested, rated and approved for such use in accordance with ASME A112.4.1.

INSIGHTS (1)

1006.7 Boiler safety devices.

Boilers shall be equipped with controls and limit devices as required by the manufacturer's installation instructions and the conditions of the listing.

INSIGHTS (1)

1006.8 Electrical requirements.

The power supply to the electrical control system shall be from a two-wire branch circuit that has a grounded conductor, or from an isolation transformer with a two-wire secondary. Where an isolation transformer is provided, one conductor of the secondary winding shall be grounded. Control voltage shall not exceed 150 volts nominal, line to line. Control and limit devices shall interrupt the ungrounded side of the circuit. A means of manually disconnecting the control circuit shall be provided and controls shall be arranged so that when deenergized, the burner shall be inoperative. Such disconnecting means shall be capable of being locked in the off position and shall be provided with *ready access*.

Section 1007 Boiler Low-Water Cutoff

1007.1 General.

Steam and hot water boilers shall be protected with a low-water cutoff control.

> **Exception:** A low-water cutoff is not required for coil-type and water-tube-type boilers that require forced circulation of water through the boiler and that are protected with a flow sensing control.

INSIGHTS (2)

1007.2 Operation.

Low-water cutoff controls and flow sensing controls required by Section 1007.1 shall automatically stop the *combustion* operation of the *appliance* when the water level drops below the lowest safe water level as established by the manufacturer or when water circulation stops, respectively.

INSIGHTS (1)

Section 1008 Bottom Blowoff Valve

1008.1 General.

Steam boilers shall be equipped with bottom blowoff valve(s). The valve(s) shall be installed in the opening provided on the boiler. The minimum size of the valve(s) and associated piping shall be the size specified by the boiler manufacturer or the size of the boiler blowoff-valve opening. Where the maximum allowable working pressure of the boiler exceeds 100 psig (689 kPa), two bottom blowoff valves shall be provided consisting of either two slow-opening valves in series or one quick-opening valve and one slow-opening valve in series, with the quick-opening valve installed closest to the boiler.

1008.2 Discharge.

Blowoff valves shall discharge to a safe place of disposal. Where discharging to the drainage system, the installation shall conform to the *International Plumbing Code*.

Section 1009 Hot Water Boiler Expansion Tank

1009.1 Where required.

An expansion tank shall be installed in every hot water system. For multiple boiler installations, not less than one expansion tank is required. Expansion tanks shall be of the closed or open type. Tanks shall be rated for the pressure of the hot water system.

> **Exception:** Expansion tanks shall not be required in the collector loop of drain-back systems.

1009.2 Closed-type expansion tanks.

Closed-type expansion tanks shall be installed in accordance with the manufacturer's instructions. Expansion tanks for systems designed to have an operating pressure in excess of 30 psi (207 kPa) shall be constructed and certified in accordance with the ASME *Boiler and Pressure Vessel Code*. The size of the tank shall be based on the capacity of the hot-water-heating system. The minimum size of the tank shall be determined in accordance with the following equation where all necessary information is known:

(Equation 10-1) $Vt=(0.00041T-0.0466)Vs(PaPf)-(PaPo)$

For SI:

$Vt=(0.000738T-0.03348)Vs(PaPf)-(PaPo)$

where:

V_t =Minimum volume of tanks (gallons) (L).
V_s =Volume of system, not including expansion tanks (gallons) (L).
T =Average operating temperature (°F) (°C).
P_a =Atmospheric pressure (psi) (kPa).
P_f =Fill pressure (psi) (kPa).
P_o =Maximum operating pressure (psi) (kPa).

Where all necessary information is not known, the minimum size of the tank shall be determined from Table 1009.2.

TABLE 1009.2 CLOSED-TYPE EXPANSION TANK SIZING

SYSTEM VOLUME IN GALLONS	TANK CAPACITIES IN GALLONS	
	Pressurized Diaphragm Type	Nonpressurized Type
100	9	15
200	17	30
300	25	45
400	33	60
500	42	75
1,000	83	150
2,000	165	300

For SI: 1 gallon = 3.795 L.

1009.3 Open-type expansion tanks.

Open-type expansion tanks shall be located not less than 4 feet (1219 mm) above the highest heating element. The tank shall be adequately sized for the hot water system. An overflow with a minimum diameter of 1 inch (25 mm) shall be installed at the top of the tank. The overflow shall discharge to the drainage system in accordance with the *International Plumbing Code*.

Section 1010 Gauges

1010.1 Hot water boiler gauges.

Every hot water boiler shall have a pressure gauge and a temperature gauge, or a combination pressure and temperature gauge. The gauges shall indicate the temperature and pressure within the normal range of the system’s operation.

1010.2 Steam boiler gauges.

Every steam boiler shall have a water-gauge glass and a pressure gauge. The pressure gauge shall indicate the pressure within the normal range of the system’s operation.

INSIGHTS (1)

1010.2.1 Water-gauge glass.

The gauge glass shall be installed so that the midpoint is at the normal boiler water level.

Section 1011 Tests

1011.1 Tests.

Upon completion of the assembly and installation of boilers and pressure vessels, acceptance tests shall be conducted in accordance with the requirements of the ASME *Boiler and Pressure Vessel Code* or the manufacturer's requirements, and such tests shall be *approved*. A copy of all test documents along with all manufacturer's data reports required by the ASME *Boiler and Pressure Vessel Code* shall be submitted to the code official.

1011.2 Test gauges.

An indicating test gauge shall be connected directly to the boiler or pressure vessel where it is visible to the operator throughout the duration of the test. The pressure gauge scale shall be graduated over a range of not less than one and one-half times and not greater than four times the maximum test pressure. Gauges utilized for testing shall be calibrated and certified by the test operator.

Chapter 11 Refrigeration

User note:

About this chapter: *Chapter 11 provides for the protection of life and property from the potential fire and health hazards associated with refrigerant chemicals and the machinery that* *contains such chemicals. Some refrigerants are toxic, some are flammable and some are both.*

This chapter refers to the International Fire Code®, ASHRAE 15 and IIAR standards 2 through 5.

Section 1101 General

INSIGHTS (1)

1101.1 Scope.

This chapter shall govern the design, installation, construction and repair of refrigeration systems that vaporize and liquefy a fluid during the refrigerating cycle. Permanently installed refrigerant storage systems and other components shall be considered as part of the refrigeration system to which they are attached.

INSIGHTS (2)

1101.1.1 Refrigerants Other than Ammonia.

Refrigerant piping design and installation for systems containing a refrigerant other than ammonia, including pressure vessels and pressure relief devices, shall comply with this chapter and ASHRAE 15.

INSIGHTS (2)

1101.1.2 Ammonia refrigerant.

Refrigeration systems using ammonia as the refrigerant shall comply with IIAR 2, IIAR 3, IIAR 4 and IIAR 5 and shall not be required to comply with this chapter.

INSIGHTS (2)

1101.2 Factory-built equipment and appliances.

Listed and *labeled* self-contained, factory-built *equipment* and *appliances* shall be tested in accordance with the applicable standards specified in Table 1101.2. Such *equipment* and *appliances* are deemed to meet the design, manufacture and factory test requirements of this code if installed in accordance with their listing and the manufacturer's instructions.

INSIGHTS (3)

TABLE 1101.2 FACTORY–BUILT EQUIPMENT AND APPLIANCES

EQUIPMENT	STANDARDS
Refrigeration fittings, including press-connect, flared and threaded	UL 109 and UL 207
Air-conditioning equipment	UL 1995 or UL/CSA 60335-2-40
Packaged terminal air conditioners and heat pumps	UL 484 or UL/CSA 60335-2-40
Split-system air conditioners and heat pumps	UL 1995 or UL/CSA 60335-2-40
Dehumidifiers	UL 474 or UL/CSA 60335-2-40
Unit coolers	UL 412 or UL/CSA 60335-2-89
Commercial refrigerators, freezers, beverage coolers and walk-in coolers	UL 471 or UL/CSA 60335-2-89
Refrigerating units and walk-in coolers	UL 427 or UL 60335-2-89
Refrigerant-containing components and accessories	UL 207

1101.3 Protection.

Any portion of a refrigeration system that is subject to physical damage shall be protected in an *approved* manner.

1101.4 Water connection.

Water supply and discharge connections associated with *refrigeration systems* shall be made in accordance with this code and the *International Plumbing Code*.

1101.5 Fuel gas connection.

Fuel gas devices, *equipment* and *appliances* used with *refrigeration systems* shall be installed in accordance with the *International Fuel Gas Code*.

➡

1101.6 Maintenance.

Mechanical refrigeration systems shall be maintained in proper operating condition, free from accumulations of oil, dirt, waste, excessive corrosion, other debris and leaks.

INSIGHTS (2)

1101.7 Change in refrigerant type.

The type of refrigerant in refrigeration systems having a refrigerant circuit containing more than 220 pounds (99.8 kg) of Group A1 or 30 pounds (13.6 kg) of any other group refrigerant shall not be changed without prior notification to the code official and compliance with the applicable code provisions for the new refrigerant type.

[F] 1101.8 Refrigerant discharge.

Notification of refrigerant discharge shall be provided in accordance with the *International Fire Code*.

1101.9 Locking access port caps.

Refrigerant circuit access ports located outdoors shall be fitted with locking-type tamper-resistant caps or shall be otherwise secured to prevent unauthorized access.

> **Exception:** This section shall not apply to refrigerant circuit access ports on *equipment* installed in controlled areas such as on roofs with locked access hatches or doors.

INSIGHTS (1)

Section 1102 System Requirements

INSIGHTS (1)

1102.1 General.

The system classification, allowable refrigerants, maximum quantity, enclosure requirements, location limitations, and field pressure test requirements shall be determined as follows:

1.

Determine the *refrigeration system's* classification, in accordance with Section 1103.3.

2.

Determine the refrigerant classification in accordance with Section 1103.1.

3.

Determine the maximum allowable quantity of refrigerant in accordance with Section 1104, based on type of refrigerant, system classification and *occupancy*.

4.

Determine the *system* enclosure requirements in accordance with Section 1104.

5.

Refrigeration *equipment* and *appliance* location and installation shall be subject to the limitations of Chapter 3.

6.

Nonfactory-tested, field-erected *equipment* and *appliances* shall be pressure tested in accordance with Section 1108.

1102.2 Refrigerants.

The refrigerant shall be that which the *equipment* or *appliance* was designed to utilize or converted to utilize. Refrigerants not identified in Table 1103.1 shall be *approved* before use.

INSIGHTS (1)

1102.2.1 Mixing.

Refrigerants, including refrigerant blends, with different designations in ASHRAE 34 shall not be mixed in a system.

Exception: Addition of a second refrigerant is allowed where permitted by the *equipment* or *appliance* manufacturer to improve oil return at low temperatures. The refrigerant and amount added shall be in accordance with the manufacturer's instructions.

1102.2.2 Purity.

Refrigerants used in refrigeration systems shall be new, recovered or *reclaimed refrigerants* in accordance with Section 1102.2.2.1, 1102.2.2.2 or 1102.2.2.3. Where required by the *equipment* or *appliance* owner or the code official, the installer shall furnish a signed declaration that the refrigerant used meets the requirements of Section 1102.2.2.1, 1102.2.2.2 or 1102.2.2.3.

Exception: The refrigerant used shall meet the purity specifications set by the manufacturer of the *equipment* or *appliance* in which such refrigerant is used where such specifications are different from that specified in Sections 1102.2.2.1, 1102.2.2.2 and 1102.2.2.3.

1102.2.2.1 New refrigerants.

Refrigerants shall be of a purity level specified by the *equipment* or *appliance* manufacturer.

1102.2.2.2 Recovered refrigerants.

Refrigerants that are recovered from refrigeration and air-conditioning systems shall not be reused in other than the system from which they were recovered and in other systems of the same owner. *Recovered refrigerants* shall be filtered and dried before reuse. *Recovered refrigerants* that show clear signs of contamination shall not be reused unless reclaimed in accordance with Section 1102.2.2.3.

INSIGHTS (1)

1102.2.2.3 Reclaimed refrigerants.

Used refrigerants shall not be reused in a different owner's *equipment* or *appliances* unless tested and found to meet the purity requirements of AHRI 700. Contaminated refrigerants shall not be used unless reclaimed and found to meet the purity requirements of AHRI 700.

1102.3 Access port protection.

Refrigerant access ports shall be protected in accordance with Section 1101.9 whenever refrigerant is added to or recovered from refrigeration or air-conditioning systems.

Section 1103 Refrigeration System Classification

INSIGHTS (1)

1103.1 Refrigerant classification.

Refrigerants shall be classified in accordance with ASHRAE 34 as listed in Table 1103.1.

INSIGHTS (4)

TABLE 1103.1 REFRIGERANT CLASSIFICATION, AMOUNT AND OEL

CHEMICAL REFRIGERANT	FORMULA	CHEMICAL NAME OF BLEND	REFRIGERANT CLASSIFICATION	AMOUNT OF REFRIGERANT PER OCCUPIED SPACE			OEL[e]	[F] DEGREES OF HAZARD[a]
				Pounds per 1,000 cubic feet	ppm	g/m³		
R-11[d]	CCl_3F	trichlorofluoromethane	A1	0.39	1,100	6.2	C1,000	2-0-0[b]

R-12[d]	CCl_2F_2	dichlorodifluoromethane	A1	5.6	18,000	90	1,000	2-0-0[b]
R-13[d]	$CClF_3$	chlorotrifluoromethane	A1	—	—	—	1,000	2-0-0[b]
R-13B1[d]	$CBrF_3$	bromotrifluoromethane	A1	—	—	—	1,000	2-0-0[b]
R-14	CF_4	tetrafluoromethane (carbon tetrafluoride)	A1	25	110,000	400	1,000	2-0-0[b]
R-22	$CHClF_2$	chlorodifluoromethane	A1	13	59,000	210	1,000	2-0-0[b]
R-23	CHF_3	trifluoromethane (fluoroform)	A1	7.3	41,000	120	1,000	2-0-0[b]
R-30	CH_2Cl_2	dichloromethane (methylene chloride)	B1	—	—	—	—	—
R-32	CH_2F_2	difluoromethane (methylene fluoride)	A2[c]	4.8	36,000	77	1,000	1-4-0
R-40	CH_3Cl	chloromethane (methyl chloride)	B2	—	—	—	—	—
R-50	CH_4	methane	A3	—	—	—	1,000	—
R-113[d]	CCl_2FCClF_2	1,1,2-trichloro-1,2,2-trifluoroethane	A1	1.2	2,600	20	1,000	2-0-0[b]
R-114[d]	$CClF_2CClF_2$	1,2-dichloro-1,1,2,2-tetrafluoroethane	A1	8.7	20,000	140	1,000	2-0-0[b]
R-115	$CClF_2CF_3$	chloropentafluoroethane	A1	47	120,000	760	1,000	—
R-116	CF_3CF_3	hexafluoroethane	A1	34	97,000	550	1,000	1-0-0
R-123	$CHCl_2CF_3$	2,2-dichloro-1,1,1-trifluoroethane	B1	3.5	9,100	57	50	2-0-0[b]
R-124	$CHClFCF_3$	2-chloro-1,1,1,2-tetrafluoroethane	A1	3.5	10,000	56	1,000	2-0-0[b]

R-125	CHF_2CF_3	pentafluoroethane	A1	23	75,000	370	1,000	2-0-0[b]
R-134a	CH_2FCF_3	1,1,1,2-tetrafluoroethane	A1	13	50,000	210	1,000	2-0-0[b]
R-141b	CH_3CCl_2F	1,1-dichloro-1-fluoroethane	—	0.78	2,600	12	500	2-1-0
R-142b	CH_3CClF_2	1-chloro-1, 1-difluoroethane	A2	5.1	20,000	83	1,000	2-4-0
R-143a	CH_3CF_3	1,1,1-trifluoroethane	A2[c]	4.5	21,000	70	1,000	2-0-0[b]
R-152a	CH_3CHF_2	1,1-difluoroethane	A2	2.0	12,000	32	1,000	1-4-0
R-170	CH_3CH_3	ethane	A3	0.54	7,000	8.7	1,000	2-4-0
R-E170	CH_3OCH_3	Methoxymethane (dimethyl ether)	A3	1.0	8,500	16	1,000	—
R-218	$CF_3CF_2CF_3$	octafluoropropane	A1	43	90,000	690	1,000	2-0-0[b]
R-227ea	CF_3CHFCF_3	1,1,1,2,3,3,3-heptafluoropropane	A1	36	84,000	580	1,000	—
R-236fa	$CF_3CH_2CF_3$	1,1,1,3,3,3-hexafluoropropane	A1	21	55,000	340	1,000	2-0-0[b]
R-245fa	$CHF_2CH_2CF_3$	1,1,1,3,3-pentafluoropropane	B1	12	34,000	190	300	2-0-0[b]
R-290	$CH_3CH_2CH_3$	propane	A3	0.56	5,300	9.5	1,000	2-4-0
R-C318	$-(CF_2)_4-$	octafluorocyclobutane	A1	41	80,000	660	1,000	—

R-400[d]	zeotrope	R-12/114 (50.0/50.0)	A1	10	28,000	160	1,000	2-0-0[b]
R-400[d]	zeotrope	R-12/114 (60.0/40.0)	A1	11	30,000	170	1,000	—
R-401A	zeotrope	R-22/152a/124 (53.0/13.0/34.0)	A1	6.6	27,000	110	1,000	2-0-0[b]
R-401B	zeotrope	R-22/152a/124 (61.0/11.0/28.0)	A1	7.2	30,000	120	1,000	2-0-0[b]
R-401C	zeotrope	R-22/152a/124 (33.0/15.0/52.0)	A1	5.2	20,000	84	1,000	2-0-0[b]
R-402A	zeotrope	R-125/290/22 (60.0/2.0/38.0)	A1	17	66,000	270	1,000	2-0-0[b]
R-402B	zeotrope	R-125/290/22 (38.0/2.0/60.0)	A1	15	63,000	240	1,000	2-0-0[b]
R-403A	zeotrope	R-290/22/218 (5.0/75.0/20.0)	A2	7.6	33,000	120	1,000	2-0-0[b]
R-403B	zeotrope	R-290/22/218 (5.0/56.0/39.0)	A1	18	70,000	290	1,000	2-0-0[b]
R-404A	zeotrope	R-125/143a/134a (44.0/52.0/4.0)	A1	31	130,000	500	1,000	2-0-0[b]
R-405A	zeotrope	R-22/152a/142b/C318 (45.0/7.0/5.5/42.5)	—	16	57,000	260	1,000	—
R-406A	zeotrope	R-22/600a/142b (55.0/4.0/41.0)	A2	4.7	21,000	25	1,000	—
R-407A	zeotrope	R-32/125/134a (20.0/40.0/40.0)	A1	19	83,000	300	1,000	2-0-0[b]

R-407B	zeotrope	R-32/125/134a (10.0/70.0/20.0)	A1	21	79,000	330	1,000	2-0-0[b]
R-407C	zeotrope	R-32/125/134a (23.0/25.0/52.0)	A1	18	81,000	290	1,000	2-0-0[b]
R-407D	zeotrope	R-32/125/134a (15.0/15.0/70.0)	A1	16	68,000	250	1,000	2-0-0[b]
R-407E	zeotrope	R-32/125/134a (25.0/15.0/60.0)	A1	17	80,000	280	1,000	2-0-0[b]
R-407F	zeotrope	R-32/125/134a (30.0/30.0/40.0)	A1	20	95,000	320	1,000	—
R-407G	zeotrope	R-32/125/134a (2.5/2.5/95.0)	A1	13	52,000	210	1,000	—
R-407H	zeotrope	R-32/125/134a (32.5/15.0/52.5)	A1	19	92,000	300	1,000	—
R-408A	zeotrope	R-125/143a/22 (7.0/46.0/47.0)	A1	21	95,000	340	1,000	2-0-0[b]
R-409A	zeotrope	R-22/124/142b (60.0/25.0/15.0)	A1	7.1	29,000	110	1,000	2-0-0[b]
R-409B	zeotrope	R-22/124/142b (65.0/25.0/10.0)	A1	7.3	30,000	120	1,000	2-0-0[b]
R-410A	zeotrope	R-32/125 (50.0/50.0)	A1	26	140,000	420	1,000	2-0-0[b]
R-410B	zeotrope	R-32/125 (45.0/55.0)	A1	27	140,000	430	1,000	2-0-0[b]
R-411A	zeotrope	R-127/22/152a (1.5/87.5/11.0)	A2	2.9	14,000	46	990	—

R-411B	zeotrope	R-1270/22/152a (3.0/94.0/3.0)	A2	2.8	13,000	45	980	—
R-412A	zeotrope	R-22/218/142b (70.0/5.0/25.0)	A2	5.1	22,000	82	1,000	—
R-413A	zeotrope	R-218/134a/600a (9.0/88.0/3.0)	A2	5.8	22,000	94	1,000	—
R-414A	zeotrope	R-22/124/600a/142b (51.0/28.5/4.0/16.5)	A1	6.4	26,000	100	1,000	—
R-414B	zeotrope	R-22/124/600a/142b (50.0/39.0/1.5/9.5)	A1	6.0	23,000	95	1,000	—
R-415A	zeotrope	R-22/152a (82.0/18.0)	A2	2.9	14,000	47	1,000	—
R-415B	zeotrope	R-22/152a (25.0/75.0)	A2	2.1	12,000	34	1,000	—
R-416A	zeotrope	R-134a/124/600 (59.0/39.5/1.5)	A1	3.9	14,000	62	1,000	2-0-0[b]
R-417A	zeotrope	R-125/134a/600 (46.6/50.0/3.4)	A1	3.5	13,000	56	1,000	2-0-0[b]
R-417B	zeotrope	R-125/134a/600 (79.0/18.3/2.7)	A1	4.3	15,000	70	1,000	—
R-417C	zeotrope	R-125/134a/600 (19.5/78.8/1.7)	A1	5.4	21,000	87	1,000	—
R-418A	zeotrope	R-290/22/152a (1.5/96.0/2.5)	A2	4.8	22,000	77	1,000	—
R-419A	zeotrope	R-125/134a/E170 (77.0/19.0/4.0)	A2	4.2	15,000	67	1,000	—
R-419B	zeotrope	R-125/134a/E170 (48.5/48.0/3.5)	A2	4.6	17,000	74	1,000	—
R-420A	zeotrope	R-134a/142b (88.0/12.0)	A1	12	45,000	190	1,000	2-0-0[b]
R-421A	zeotrope	R-125/134a (58.0/42.0)	A1	17	61,000	280	1,000	2-0-0[b]
R-421B	zeotrope	R-125/134a (85.0/15.0)	A1	21	69,000	330	1,000	2-0-0[b]

R-422A	zeotrope	R-125/134a/600a (85.1/11.5/3.4)	A1	18	63,000	290	1,000	2-0-0[b]
R-422B	zeotrope	R-125/134a/600a (55.0/42.0/3.0)	A1	16	56,000	250	1,000	2-0-0[b]
R-422C	zeotrope	R-125/134a/600a (82.0/15.0/3.0)	A1	18	62,000	290	1,000	2-0-0[b]
R-422D	zeotrope	R-125/134a/600a (65.1/31.5/3.4)	A1	16	58,000	260	1,000	2-0-0[b]
R-422E	zeotrope	R-125/134a/600a (58.0/39.3/2.7)	A1	16	57,000	260	1,000	—
R-423A	zeotrope	R-134a/227ea (52.5/47.5)	A1	19	59,000	310	1,000	2-0-0[b]
R-424A	zeotrope	R-125/134a/600a/600/601a (50.5/47.0/0.9/1.0/0.6)	A1	6.2	23,000	100	970	2-0-0[b]
R-425A	zoetrope	R-32/134a/227ea (18.5/69.5/12.0)	A1	16	72,000	260	1,000	2-0-0[b]
R-426A	zeotrope	R-125/134a/600a/601a (5.1/93.0/1.3/0.6)	A1	5.2	20,000	83	990	—
R-427A	zeotrope	R-32/125/143a/134a (15.0/25.0/10.0/50.0)	A1	18	79,000	290	1,000	2-1-0
R-428A	zeotrope	R-125/143a/290/600a (77.5/20.0/0.6/1.9)	A1	23	83,000	370	1,000	—
R-429A	zeotrope	R-E170/152a/600a (60.0/10.0/30.0)	A3	0.81	6,300	13	1,000	—
R-430A	zeotrope	R-152a/600a (76.0/24.0)	A3	1.3	8,000	21	1,000	—
R-431A	zeotrope	R-290/152a (71.0/29.0)	A3	0.69	5,500	11	1,000	—

R-432A	zeotrope	R-1270/E170 (80.0/20.0)	A3	0.13	1,200	2.1	700	—
R-433A	zeotrope	R-1270/290 (30.0/70.0)	A3	0.34	3,100	5.5	880	—
R-433B	zeotrope	R-1270/290 (5.0-95.0)	A3	0.51	4,500	8.1	950	—
R-433C	zeotrope	R-1270/290 (25.0-75.0)	A3	0.41	3,600	6.6	790	—
R-434A	zeotrope	R-125/143a/600a (63.2/18.0/16.0/2.8)	A1	20	73,000	320	1,000	—
R-435A	zeotrope	R-E170/152a (80.0/20.0)	A3	1.1	8,500	17	1,000	—
R-436A	zeotrope	R-290/600a (56.0/44.0)	A3	0.50	4,000	8.1	1,000	—
R-436B	zeotrope	R-290/600a (52.0/48.0)	A3	0.51	4,000	8.1	1,000	—
R-437A	zeotrope	R-125/134a/600/601 (19.5/78.5/1.4/0.6)	A1	5.0	19,000	82	990	—
R-438A	zeotrope	R-32/125/134a/600/601a (8.5/45.0/44.2/1.7/0.6)	A1	4.9	20,000	79	990	—
R-439A	zeotrope	R-32/125/600a (50.0/47.0/3.0)	A2	4.7	26,000	76	990	—
R-440A	zeotrope	R-290/134a/152a (0.6/1.6/97.8)	A2	1.9	12,000	31	1,000	—
R-441A	zeotrope	R-170/290/600a/600 (3.1/54.8/6.0/36.1)	A3	0.39	3,200	6.3	1,000	—
R-442A	zeotrope	R-32/125/134a/152a/227ea (31.0/31.0/30.0/3.0/5.0)	A1	21	100,000	330	1,000	—

R-443A	zeotrope	R-1270/290/600a (55.0/40.0/5.0)	A3	0.19	1,700	3.1	580	—
R-444A	zeotrope	R-32/152a/1234ze(E) (12.0/5.0/83.0)	A2[c]	5.1	21,000	81	850	—
R-444B	zeotrope	R-32/152a/1234ze(E) (41.5/10.0/48.5)	A2[c]	4.3	23,000	69	890	—
R-445A	zeotrope	R-744/134a/1234ze(E) (6.0/9.0/85.0)	A2[c]	4.2	16,000	67	930	—
R-446A	zeotrope	R-32/1234ze(E)/600 (68.0/29.0/3.0)	A2[c]	2.5	16,000	39	960	—
R-447A	zeotrope	R-32/125/1234ze(E) (68.0/3.5/28.5)	A2[c]	2.6	16,000	42	900	—
R-447B	zeotrope	R-32/125/1234ze(E) (68.0/8.0/24.0)	A2[c]	23	30,000	360	970	—
R-448A	zeotrope	R-32/125/1234yf/134a/1234ze(E) (26.0/26.0/20.0/21.0/7.0)	A1	24	110,000	390	890	—
R-449A	zeotrope	R-32/125/1234yf/134a (24.3/24.7/25.3/25.7)	A1	23	100,000	370	830	—
R-449B	zeotrope	R-32/125/1234yf/134a (25.2/24.3/23.2/27.3)	A1	23	100,000	370	850	—
R-449C	zeotrope	R-32/125/1234yf/134a (20.0/20.0/31.0/29.0)	A1	23	98,000	360	800	—
R-450A	zeotrope	R-134a/1234ze(E) (42.0/58.0)	A1	20	72,000	320	880	—
R-451A	zeotrope	R-1234yf/134a (89.8/10.2)	A2[c]	5.3	18,000	81	520	—
R-451B	zeotrope	R-1234yf/134a (88.8/11.2)	A2[c]	5.3	18,000	81	530	—
R-452A	zeotrope	R-32/125/1234yf (11.0/59.0/30.0)	A1	27	10,000	440	780	—

R-452B	zeotrope	R-32/125/1234yf (67.0/7.0/26.0)	A2[c]	23	30,000	360	870	—
R-452C	zeotrope	R-32/125/1234yf (12.5/61.0/26.5)	A1	27	100,000	430	800	—
R-453A	zeotrope	R-32/125/134a/227ea/600/601a (20.0/20.0/53.8/5.0/0.6/0.6)	A1	7.8	34,000	120	1,000	—
R-454A	zeotrope	R-32/1234yf (35.0/65.0)	A2[c]	28	16,000	450	690	—
R-454B	zeotrope	R-32/1234yf (68.9/31.1)	A2[c]	22	19,000	360	850	—
R-454C	zeotrope	R-32/1234yf (21.5/78.5)	A2[c]	29	19,000	460	620	—
R-455A	zeotrope	R-744/32/1234yf (3.0/21.5/75.5)	A2[c]	23	30,000	380	650	—
R-456A	zeotrope	R-32/134a/1234ze(E) (6.0/45.0/49.0)	A1	20	77,000	320	900	—
R-457A	zeotrope	R-32/1234yf/152a (18.0/70.0/12.0)	A2[c]	25	15,000	400	650	—
R-458A	zeotrope	R-32/125/134a/227ea/236fa (20.5/4.0/61.4/13.5/0.6)	A1	18	76,000	280	1,000	—
R-459A	zeotrope	R-32/1234yf/1234ze(E) (68.0/26.0/6.0)	A2[c]	23	27,000	360	870	—
R-459B	zeotrope	R-32/1234yf/1234ze(E) (21.0/69.0/10.0)	A2[c]	30	16,000	470	640	—

R-460A	zeotrope	R-32/125/134a/1234ze(E) (12.0/52.0/14.0/22.0)	A1	24	92,000	380	650	—
R-460B	zeotrope	R-32/125/134a/1234ze(E) (28.0/25.0/20.0/27.0)	A1	25	120,000	400	950	—
R-461A	zeotrope	R-125/143a/134a/227ea/600a (55.0/5.0/32.0/5.0/3.0)	A1	17	61,000	270	1,000	—
R-462A	zeotrope	R-32/125/143a/134a/600 (9.0/42.0/2.0/44.0/3.0)	A2	3.9	16,000	62	1,000	—
R-463A	zeotrope	R-744/32/125/1234yf/134a (6.0/36.0/30.0/14.0/14.0)	A1	19	98,000	300	990	—
R-500[e]	azeotrope	R-12/152a (73.8/26.2)	A1	7.6	30,000	120	1,000	2-0-0[b]
R-501[d]	azeotrope	R-22/12 (75.0/25.0)	A1	13	54,000	210	1,000	—
R-502[e]	azeotrope	R-22/115 (48.8/51.2)	A1	21	73,000	330	1,000	2-0-0[b]
R-503[e]	azeotrope	R-23/13 (40.1/59.9)	—	—	—	—	1,000	2-0-0[b]
R-504[d]	azeotrope	R-32/115 (48.2/51.8)	—	28	140,000	450	1,000	—
R-507A	azeotrope	R-125/143a (50.0/50.0)	A1	32	130,000	520	1,000	2-0-0[b]
R-508A	azeotrope	R-23/116 (39.0/61.0)	A1	14	55,000	220	1,000	2-0-0[b]
R-508B	azeotrope	R-23/116 (46.0/54.0)	A1	13	52,000	200	1,000	2-0-0[b]

R-509A	azeotrope	R-22/218 (44.0/56.0)	A1	24	75,000	390	1,000	2-0-0[b]
R-510A	azeotrope	R-E170/600a (88.0/12.0)	A3	0.87	7,300	14	1,000	—
R-511A	azeotrope	R-290/E170 (95.0/5.0)	A3	0.59	5,300	9.5	1,000	—
R-512A	azeotrope	R-134a/152a (5.0/95.0)	A2	1.9	11,000	31	1,000	—
R-513A	azeotrope	R-1234yf/134a (56.0/44.0)	A1	20	72,000	320	650	—
R-513B	azeotrope	R-1234yf/134a (58.5/41.5)	A1	21	74,000	330	640	—
R-514A	azeotrope	R-1336mzz(S)/1130(E) (74.7/25.3)	B1	0.86	2,400	14	320	—
R-515A	azeotrope	R-1234ze(E)/227ea (88.0/12.0)	A1	19	62,000	300	810	—
R-516A	azeotrope	R-1234yf/134a/152a (77.5/8.5/14.0)	A2	7.0	27,000	110	590	—
R-600	$CH_3CH_2CH_2CH_3$	butane	A3	0.15	1,000	2.4	1,000	1-4-0
R-600a	$CH(CH_3)_2CH_3$	2-methylpropane (isobutane)	A3	0.59	4,000	9.6	1,000	2-4-0
R-601	$CH_3CH_2CH_2$ CH_2CH_3	pentane	A3	0.18	1,000	2.9	600	—
R-601a	$(CH_3)_2CHCH_2CH_3$	2-methylbutane (isopentane)	A3	0.18	1,000	2.9	600	—
R-610	$CH_3CH_2OCH_2CH_3$	ethoxyethane (ethyl ether)	—	—	—	—	400	—
R-611	$HCOOCH_3$	methyl formate	B2	—	—	—	100	—

R-718	H_2O	water	A1	—	—	—	—	0-0-0
R-744	CO_2	carbon dioxide	A1	4.5	40,000	72	5,000	2-0-0[b]
R-1130(E)	$CHCl=CHCl$	trans-1,2-dichloroethene	B1	0.25	1,000	4	200	—
R-1132a	$CF_2=CH_2$	1,1-difluoroethylene	A2	2.0	13,000	33	500	—
R-1150	$CH_2=CH_2$	ethene (ethylene)	A3	—	—	—	200	1-4-2
R-1224yd(Z)	$CF_3CF=CHCl$	(Z)-1-chloro-2,3,3,3-tetrafluoroethylene	A1	23	60,000	360	1,000	—
R-1233zd(E)	$CF_3CH=CHCl$	trans-1-chloro-3,3,3-trifluoro-1-propene	A1	5.3	16,000	85	800	—
R-1234yf	$CF_3CF=CH_2$	2,3,3,3-tetrafluoro-1-propene	A2[c]	4.7	16,000	75	500	—
R-1234ze(E)	$CF_3CH=CHF$	trans-1,3,3,3-tetrafluoro-1 -propene	A2[c]	4.7	16,000	75	800	—
R-1270	$CH_3CH=CH_2$	Propene (propylene)	A3	0.1	1,000	1.7	500	1-4-1
R-1336mzz(Z)	$CF_3CHCHCF_3$	cis-1,1,1,4,4,4-hexaflouro-2-butene	A1	5.4	13,000	87	500	—

For SI: 1 pound = 0.454 kg, 1 cubic foot = 0.0283m³.

a.
Degrees of hazard are for health, fire, and reactivity, respectively, in accordance with NFPA 704.

b.
Reduction to 1-0-0 is allowed if analysis satisfactory to the code official shows that the maximum concentration for a rupture or full loss of refrigerant charge would not exceed the IDLH, considering both the refrigerant quantity and room volume.

c.
The ASHRAE Standard 34 flammability classification for this refrigerant is 2L, which is a subclass of Class 2.

d.
Class I ozone depleting substance; prohibited for new installations.

e.
Occupational Exposure Limit based on the OSHA PEL, ACGIH TLV-TWA, the TERA WEEL or consistent value on a time-weighed average (TWA) basis (unless noted C for ceiling) for an 8 hr/d and 40 hr/wk.

1103.2 Occupancy classification.

Locations of refrigerating systems are described by *occupancy* classifications that consider the ability of people to respond to potential exposure to refrigerants. Where *equipment* or *appliances*, other than piping, are located outside a *building* and within 20 feet (6096 mm) of any *building* opening, such *equipment* or *appliances* shall be governed by the *occupancy* classification of the *building*. *Occupancy* classifications shall be defined as follows:

1.

Institutional *occupancy* is that portion of premises from which occupants cannot readily leave without the assistance of others because they are disabled, debilitated or confined. Institutional *occupancies* include, among others, hospitals, nursing homes, asylums and spaces containing locked cells.

2.

Public assembly *occupancy* is that portion of premises where large numbers of people congregate and from which occupants cannot quickly vacate the space. Public assembly *occupancies* include, among others, auditoriums, ballrooms, classrooms, passenger depots, restaurants and theaters.

3.

Residential *occupancy* is that portion of premises that provides the occupants with complete independent living facilities, including permanent provisions for living, sleeping, eating, cooking and sanitation. Residential *occupancies* include, among others, dormitories, hotels, multiunit apartments and private residences.

4.

Commercial *occupancy* is that portion of premises where people transact business, receive personal service or purchase food and other goods. Commercial *occupancies* include, among others, office and professional *buildings*, markets (but not large mercantile *occupancies*) and work or storage areas that do not qualify as industrial *occupancies*.

5.

Large mercantile *occupancy* is that portion of premises where more than 100 persons congregate on levels above or below street level to purchase personal merchandise.

6.

Industrial *occupancy* is that portion of premises that is not open to the public, where access by authorized persons is controlled, and that is used to manufacture, process or store goods such as chemicals, food, ice, meat or petroleum.

7.

Mixed *occupancy* occurs where two or more *occupancies* are located within the same *building*. Where each *occupancy* is isolated from the rest of the *building* by tight walls, floors and ceilings and by self-closing doors, the requirements for each *occupancy* shall apply to its portion of the *building*. Where the various *occupancies* are not so isolated, the *occupancy* having the most stringent requirements shall be the governing *occupancy*.

INSIGHTS (2)

1103.3 System classification.

Refrigeration systems shall be classified according to the degree of probability that refrigerant leaked from a failed connection, seal or component could enter an occupied area. The distinction is based on the basic design or location of the components.

INSIGHTS (1)

1103.3.1 Low-probability systems.

Double-indirect open-spray systems, indirect closed systems and indirect-vented closed systems shall be classified as low-probability systems, provided that all refrigerant-containing piping and fittings are isolated where the quantities in Table 1103.1 are exceeded.

INSIGHTS (1)

1103.3.2 High-probability systems.

Direct systems and indirect open-spray systems shall be classified as high-probability systems.

> **Exception:** An indirect open-spray system shall not be required to be classified as a high-probability system if the pressure of the secondary coolant is at all times (operating and standby) greater than the pressure of the refrigerant.

INSIGHTS (1)

Section 1104 System Application Requirements

INSIGHTS (1)

1104.1 General.

The refrigerant, *occupancy* and system classification cited in this section shall be determined in accordance with Sections 1103.1, 1103.2 and 1103.3, respectively.

1104.2 Machinery room.

Except as provided in Sections 1104.2.1 and 1104.2.2, all components containing the refrigerant shall be located either outdoors or in a *machinery room* where the quantity of refrigerant in an independent circuit of a *system* exceeds the amounts shown in Table 1103.1. For refrigerant blends not listed in Table 1103.1, the same requirement shall apply where the amount for any blend component exceeds that indicated in Table 1103.1 for that component. This requirement shall also apply where the combined amount of the blend components exceeds a limit of 69,100 parts per million (ppm) by volume. *Machinery rooms* required by this section shall be constructed and maintained in accordance with Section 1105 for Group A1 and B1 refrigerants and in accordance with Sections 1105 and 1106 for Group A2, B2, A3 and B3 refrigerants.

Exceptions:

1.

Machinery rooms are not required for *listed equipment* and *appliances* containing not more than 6.6 pounds (3 kg) of refrigerant, regardless of the refrigerant's safety classification, where installed in accordance with the *equipment's* or *appliance's* listing and the *equipment* or *appliance* manufacturer's installation instructions.

2.

Piping in compliance with Section 1107 is allowed in other locations to connect components installed in a *machinery room* with those installed outdoors.

INSIGHTS (1)

1104.2.1 Institutional occupancies.

The amounts shown in Table 1103.1 shall be reduced by 50 percent for all areas of institutional *occupancies* except kitchens, laboratories and mortuaries. The total of all Group A2, B2, A3 and B3 refrigerants shall not exceed 550 pounds (250 kg) in occupied areas or *machinery rooms*.

1104.2.2 Industrial occupancies and refrigerated rooms.

This section applies only to rooms and spaces that: are within industrial *occupancies*; contain a refrigerant evaporator; are maintained at temperatures below 68°F (20°C); and are used for manufacturing, food and beverage preparation, meat cutting, other processes and storage.

Where a *machinery room* would otherwise be required by Section 1104.2, a *machinery room* shall not be required where all of the following conditions are met:

1.

The space containing the machinery is separated from other *occupancies* by tight construction with tight-fitting doors.

2.

Access is restricted to authorized personnel.

3.

Refrigerant detectors are installed as required for *machinery rooms* in accordance with Section 1105.3.

> **Exception:** Refrigerant detectors are not required in unoccupied areas that contain only continuous piping that does not include valves, valve assemblies, *equipment* or *equipment* connections.

➡

4.

Surfaces having temperatures exceeding 800°F (427°C) and open flames are not present where any Group A2, B2, A3 or B3 refrigerant is used (see Section 1104.3.4).

5.

All electrical *equipment* and *appliances* conform to Class I, Division 2, *hazardous location* classification requirements of NFPA 70 where the quantity of any Group A2, B2, A3 or B3 refrigerant in a single independent circuit would exceed 25 percent of the lower flammability limit (LFL) upon release to the space.

6.

All refrigerant-containing parts in systems with a total connected compressor power exceeding 100 horsepower (hp) (74.6 kW)—except evaporators used for refrigeration or dehumidification, condensers used for heating, control and pressure relief valves for either, low-probability pumps and connecting piping—are located either outdoors or in a *machinery room*.

INSIGHTS (2)

1104.3 Refrigerant restrictions.

Refrigerant applications, maximum quantities and use shall be restricted in accordance with Sections 1104.3.1 through 1104.3.4.

1104.3.1 Air conditioning for human comfort.

In other than industrial *occupancies* where the quantity in a single independent circuit does not exceed the amount in Table 1103.1, Group B1, B2 and B3 refrigerants shall not be used in high-probability systems for air conditioning for human comfort.

1104.3.2 Nonindustrial occupancies.

Group A2 and B2 refrigerants shall not be used in high-probability systems where the quantity of refrigerant in any independent refrigerant circuit exceeds the amount shown in Table 1104.3.2. Group A3 and B3 refrigerants shall not be used except where *approved*.

Exception: This section does not apply to laboratories where the floor area per occupant is not less than 100 square feet (9.3 m^2).

INSIGHTS (3)

TABLE 1104.3.2 MAXIMUM PERMISSIBLE QUANTITIES OF REFRIGERANTS

TYPE OF REFRIGERATION SYSTEM	MAXIMUM POUNDS FOR VARIOUS OCCUPANCIES			
	Institutional	Public assembly	Residential	All other occupancies
Sealed absorption system				
In exit access	0	0	3.3	3.3

In adjacent outdoor locations	0	0	22	22
In other than exit access	0	6.6	6.6	6.6
Unit systems				
In other than exit access	0	0	6.6	6.6

For SI: 1 pound = 0.454 kg.

1104.3.3 All occupancies.

The total of all Group A2, B2, A3 and B3 refrigerants shall not exceed 1,100 pounds (499 kg) except where *approved*.

INSIGHTS (2)

1104.3.4 Protection from refrigerant decomposition.

Where any device having an open flame or surface temperature greater than 800°F (427°C) is used in a room containing more than 6.6 pounds (3 kg) of refrigerant in a single independent circuit, a hood and exhaust system shall be provided in accordance with Section 510. Such exhaust system shall exhaust *combustion products* to the outdoors.

Exception: A hood and exhaust system shall not be required where any of the following apply:

1. The refrigerant is R-718 (water) or R-744 (carbon dioxide).

2. The *combustion air* is ducted from the outdoors in a manner that prevents leaked refrigerant from being combusted.

3. A refrigerant detector is used to stop the *combustion* in the event of a refrigerant leak (see Sections 1105.3 and 1105.5).

INSIGHTS (2)

1104.4 Volume calculations.

Volume calculations shall be in accordance with Sections 1104.4.1 through 1104.4.3.

1104.4.1 Noncommunicating spaces.

Where the refrigerant-containing parts of a system are located in one or more spaces that do not communicate through permanent openings or HVAC ducts, the volume of the smallest, enclosed occupied space shall be used to determine the permissible quantity of refrigerant in the system.

1104.4.2 Communicating spaces.

Where an evaporator or condenser is located in an air duct system, the volume of the smallest, enclosed occupied space served by the duct system shall be used to determine the maximum allowable quantity of refrigerant in the system.

> **Exception:** If airflow to any enclosed space cannot be reduced below one-quarter of its maximum, the entire space served by the air duct system shall be used to determine the maximum allowable quantity of refrigerant in the system.

INSIGHTS (1)

1104.4.3 Plenums.

Where the space above a suspended ceiling is continuous and part of the supply or return air *plenum* system, this space shall be included in calculating the volume of the enclosed space.

Section 1105 Machinery Room, General Requirements

INSIGHTS (1)

[BF] 1105.1 Design and construction.

Machinery rooms shall be designed and constructed in accordance with the *International Building Code* and this section.

1105.2 Openings.

Ducts and air handlers in the *machinery room* that operate at a lower pressure than the room shall be sealed to prevent any refrigerant leakage from entering the airstream.

[F] 1105.3 Refrigerant detector.

Refrigerant detectors in *machinery rooms* shall be provided as required by Sections 608.9 and 608.18 of the *International Fire Code*.

1105.4 Tests.

Periodic tests of the mechanical ventilating system shall be performed in accordance with manufacturer's specifications and as required by the code official.

1105.5 Fuel-burning appliances.

Fuel-burning *appliances* and *equipment* having open flames and that use *combustion air* from the *machinery room* shall not be installed in a *machinery room*.

Exceptions:

1.

Where the refrigerant is water (R-718) or carbon dioxide (R-744).

2.

Fuel-burning *appliances* shall not be prohibited in the same *machinery room* with refrigerant-containing *equipment* or *appliances* where *combustion air* is ducted from outside the *machinery room* and sealed in such a manner as to prevent any refrigerant leakage from entering the *combustion* chamber, or where a refrigerant vapor detector is employed to automatically shut off the *combustion* process in the event of refrigerant leakage.

1105.6 Ventilation.

Machinery rooms shall be mechanically ventilated to the outdoors.

Exception: Where a refrigerating system is located outdoors more than 20 feet (6096 mm) from any *building* opening and is enclosed by a penthouse, lean-to or other open structure, natural or mechanical ventilation shall be provided. Location of the openings shall be based on the relative density of the refrigerant to air. The free-aperture cross section for the ventilation of the *machinery room* shall be not less than:

Equation 11-1 $F=G$

$$\text{For SI:} F=0.138G$$

where:

F =The free opening area in square feet (m^2).

G =The mass of refrigerant in pounds (kg) in the largest system, any part of which is located in the *machinery room*.

INSIGHTS (1)

1105.6.1 Discharge location.

The discharge of the air shall be to the outdoors in accordance with Chapter 5. Exhaust from mechanical ventilation systems shall be discharged not less than 20 feet (6096 mm) from a property line or openings into buildings.

1105.6.1.1 Indoor exhaust opening location.

Indoor mechanical exhaust intake openings shall be located where refrigerant leakage is likely to concentrate based on the refrigerant's relative density to air, and the locations of the air current paths and refrigerating machinery.

1105.6.2 Makeup air.

Provisions shall be made for *makeup air* to replace that being exhausted. Openings for *makeup air* shall be located to avoid intake of *exhaust air*. Supply and exhaust ducts to the *machinery room* shall not serve any other area, shall be constructed in accordance with Chapter 5 and shall be covered with corrosion-resistant screen of not less than 1/4-inch (6.4 mm) mesh.

INSIGHTS (1)

1105.6.3 Ventilation rate.

Mechanical ventilation systems shall be capable of exhausting the minimum quantity of air both at normal operating and emergency conditions, as required by Sections 1105.6.3.1 and 1105.6.3.2. Multiple fans or multispeed fans shall be allowed to produce the emergency ventilation rate and to obtain a reduced airflow for normal ventilation.

INSIGHTS (3)

1105.6.3.1 Quantity—normal ventilation.

During occupied conditions, the mechanical ventilation system shall exhaust the larger of the following:

1.

Not less than 0.5 cfm per square foot (0.0025 $m^3/s \cdot m^2$) of *machinery room* area or 20 cfm (0.009 m^3/s) per person.

2.

A volume required to limit the room temperature rise to 18°F (10°C) taking into account the ambient heating effect of all machinery in the room.

1105.6.3.2 Quantity—emergency conditions.

Upon actuation of the refrigerant detector required in Section 1105.3, the mechanical ventilation system shall *exhaust air* from the *machinery room* in the following quantity:

Equation 11-2 $Q=100\times G$

For SI:

$Q=0.07\times G$

where:

Q =The airflow in cubic feet per minute (m^3/s).
G =The design mass of refrigerant in pounds (kg) in the largest system, any part of which is located in the *machinery room*.

1105.7 Termination of relief devices.

Pressure relief devices, fusible plugs and purge systems located within the *machinery room* shall terminate outside of the structure at a location not less than 15 feet (4572 mm) above the adjoining grade level and not less than 20 feet (6096 mm) from any window, ventilation opening or exit.

➡

INSIGHTS (1)

[F] 1105.8 Emergency pressure control system.

Emergency pressure control systems shall be provided in accordance with Section 608.11 of the *International Fire Code*.

INSIGHTS (2)

[BE] 1105.9 Means of egress.

Machinery rooms larger than 1,000 square feet (93 m^2) shall have not less than two exits or exit access doorways. Where two exit access doorways are required, one such doorway is permitted to be served by a fixed ladder or an alternating tread device. Exit access doorways shall be separated by a horizontal distance equal to one-half the maximum horizontal dimension of the room. All portions of *machinery rooms* shall be within 150 feet (45 720 mm) of an exit or exit access doorway. An increase in exit access travel distance is permitted in accordance with Section 1017.1 of the *International Building Code*. Exit and exit access doorways shall swing in the direction of egress travel and shall be equipped with panic hardware, regardless of the occupant load served. Exit and exit access doorways shall be tight fitting and self-closing.

INSIGHTS (4)

Section 1106 Machinery Room, Special Requirements

INSIGHTS (1)

1106.1 General.

Where required by Section 1104.2, the *machinery room* shall meet the requirements of this section in addition to the requirements of Section 1105.

1106.2 Elevated temperature.

There shall not be an open flame-producing device or continuously operating hot surface over 800°F (427°C) permanently installed in the room.

➡

1106.3 Flammable refrigerants.

Where refrigerants of Groups A2, A3, B2 and B3 are used, the *machinery room* shall conform to the Class I, Division 2, *hazardous location* classification requirements of NFPA 70.

Exception: *Machinery rooms* for systems containing Group A2L *refrigerants* that are provided with ventilation in accordance with Section 1106.4.

➡

INSIGHTS (2)

1106.4 Special requirements for Group A2L refrigerant machinery rooms.

Machinery rooms with systems containing Group A2L *refrigerants* that do not conform to the Class I, Division 2, hazardous location electrical requirements of NFPA 70, as permitted by the exception to Section 1106.3, shall comply with Sections 1106.4.1 through 1106.4.3.

Exception: *Machinery rooms* conforming to the Class I, Division 2, hazardous location classification requirements of NFPA 70 are not required to comply with Sections 1106.4.1 and 1106.4.2.

INSIGHTS (2)

[F] 1106.4.1 Ventilation system activation.

Ventilation shall be activated by the refrigerant detection system in the machinery room. Refrigerant detection systems shall be in accordance with Section 608.9 of the *International Fire Code* and all of the following:

1.

The detectors shall activate at or below a refrigerant concentration of 25 percent of the LFL.

2.

Upon activation, the detection system shall activate the emergency ventilation system required by Section 1106.4.2.

3.

The detection, signaling and control circuits shall be supervised.

1106.4.2 Emergency ventilation system.

An emergency ventilation system shall be provided at the minimum exhaust rate specified in ASHRAE 15 or Table 1106.4.2. Shutdown of the emergency ventilation system shall be by manual means.

TABLE 1106.4.2 MINIMUM EXHAUST RATES

REFRIGERANT	Q(m/sec)	Q(cfm)
R32	15.4	32,600
R143	13.6	28,700
R444A	6.46	13,700
R444B	10.6	22,400
R445A	7.83	16,600
R446A	23.9	50,700
R447A	23.8	50,400
R451A	7.04	15,000
R451B	7.05	15,000
R1234yf	7.80	16,600
R1234ze(E)	5.92	12,600

1106.4.3 Emergency ventilation system discharge.

The emergency ventilation system point of discharge to the atmosphere shall be located outside of the structure at not less than 15 feet (4572 mm) above the adjoining grade level and not less than 20 feet (6096 mm) from any window, *ventilation* opening or *exit*.

[F] 1106.5 Remote controls.

Remote control of the mechanical *equipment* and *appliances* located in the *machinery room* shall comply with Sections 1106.5.1 and 1106.5.2.

INSIGHTS (2)

[F] 1106.5.1 Refrigeration system emergency shutoff.

A clearly identified switch of the break-glass type or with an *approved* tamper-resistant cover shall provide off-only control of refrigerant compressors, refrigerant pumps, and normally closed, automatic refrigerant valves located in the *machinery room*. Additionally, this *equipment* shall be automatically shut off whenever the refrigerant vapor concentration in the *machinery room* exceeds the vapor detector's upper detection limit or 25 percent of the LEL, whichever is lower.

INSIGHTS (2)

[F] 1106.5.2 Ventilation system.

A clearly identified switch of the break-glass type or with an *approved* tamper-resistant cover shall provide on-only control of the *machinery room* ventilation fans.

[F] 1106.6 Emergency signs and labels.

Refrigeration units and systems shall be provided with *approved* emergency signs, charts, and labels in accordance with the *International Fire Code*.

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Section 1107 Piping Material

➡

INSIGHTS (3)

1107.1 Piping.

Refrigerant piping material for other than R-717 (ammonia) systems shall conform to the requirements in this section. Piping material and installations for R-717 (ammonia) refrigeration systems shall comply with IIAR 2.

INSIGHTS (2)

1107.2 Used materials.

Used pipe, fittings, valves and other materials that are to be reused shall be clean and free from foreign materials and shall be *approved* for reuse.

INSIGHTS (2)

1107.3 Materials rating.

Materials, joints and connections shall be rated for the operating temperature and pressure of the refrigerant system. Materials shall be suitable for the type of refrigerant and type of lubricant in the refrigerant system. Magnesium alloys shall not be used in contact with any halogenated refrigerants. Aluminum, zinc, magnesium and their alloys shall not be used in contact with R-40 (methyl chloride).

INSIGHTS (2)

1107.4 Piping materials standards.

Refrigerant pipe shall conform to one or more of the standards listed in Table 1107.4. The exterior of the pipe shall be protected from corrosion and degradation.

INSIGHTS (2)

TABLE 1107.4 REFRIGERANT PIPE

PIPING MATERIAL	STANDARD
Aluminum tube	ASTM B210 ASTM B491/B491M
Brass (copper alloy) pipe	ASTM B43
Copper linesets	ASTM B280, ASTM B1003
Copper pipe	ASTM B42, ASTM B302
Copper tube[a]	ASTM B68, ASTM B75, ASTM B88, ASTM B280, ASTM B819
Steel pipe[b]	ASTM A53, ASTM A106
Steel tube	ASTM A254, ASTM A334

a.

Soft annealed copper tubing larger than 1 3/8 inch (35 mm) O.D. shall not be used for field-assembled refrigerant piping unless it is protected from mechanical damage.

b.

ASTM A53, Type F steel pipe shall not be used for refrigerant lines having an operating temperature less than -20°F (-29°C).

1107.4.1 Steel pipe Groups A2, A3, B2 and B3.

The minimum weight of steel pipe for Group A2, A3, B2 and B3 refrigerants shall be Schedule 80 for sizes 1 1/2 inches or less in diameter.

INSIGHTS (2)

1107.5 Pipe fittings.

Refrigerant pipe fittings shall be *approved* for installation with the piping materials to be installed, and shall conform to one of more of the standards *listed* in Table 1107.5 or shall be *listed* and *labeled* as complying with UL 207.

INSIGHTS (2)

TABLE 1107.5 REFRIGERANT PIPE FITTINGS

FITTING MATERIAL	STANDARD
Aluminum	ASTM B361
Brass (copper alloy)	ASME B16.15, ASME B16.24,
Copper	ASME B16.15, ASME B16.18, ASME B16.22, ASME B16.24, ASME B16.26, ASME B16.50
Steel	ASTM A105, ASTM A181, ASTM A193, ASTM A234, ASTM A420, ASTM A707

1107.5.1 Copper brazed field swaged.

The minimum and maximum cup depth of field-fabricated copper brazed swaged fitting connections shall comply with Table 1107.5.1.

INSIGHTS (2)

TABLE 1107.5.1 COPPER BRAZED SWAGED CUP DEPTHS

FITTING SIZE (inch)	MINIMUM DEPTH (inch)	MAXIMUM DEPTH (inch)
1/8	0.15	0.23
3/16	0.16	0.24

1/4	0.17	0.26
3/8	0.20	0.30
1/2	0.22	0.33
5/8	0.24	0.36
3/4	0.25	0.38
1	0.28	0.42
1 1/4	0.31	0.47
1 1/2	0.34	0.51
2	0.40	0.60
2 1/2	0.47	0.71
3	0.53	0.80
3 1/2	0.59	0.89
4	0.64	0.96

For SI: 1 inch = 25.4 mm.

1107.6 Valves.

Valves shall be of materials that are compatible with the type of piping material, refrigerants and oils in the system. Valves shall be *listed* and *labeled* and rated for the temperatures and pressures of the refrigerant systems in which the valves are installed.

INSIGHTS (2)

1107.7 Flexible connectors, expansion and vibration compensators.

Flexible connectors and expansion and vibration control devices shall be *listed* and *labeled* for use in refrigerant systems.

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INSIGHTS (2)

Section 1108 Joints and Connections

INSIGHTS (3)

1108.1 Approval.

Joints and connections shall be of an *approved* type. Joints and connections shall be tight for the pressure of the refrigerant system when tested in accordance with Section 1110.

INSIGHTS (2)

1108.1.1 Joints between different piping materials.

Joints between different piping materials shall be made with *approved* adapter fittings. Joints between dissimilar metallic piping materials shall be made with a dielectric fitting or a dielectric union conforming to dielectric tests of ASSE 1079. Adapter fittings with threaded ends between different materials shall be joined with thread lubricant in accordance with Section 1108.3.4.

INSIGHTS (2)

1108.2 Preparation of pipe ends.

Pipe shall be cut square, reamed and chamfered, and shall be free from burrs and obstructions. Pipe ends shall have full-bore openings and shall not be undercut.

INSIGHTS (2)

1108.3 Joint preparation and installation.

Where required by Sections 1108.4 through 1108.9, the preparation and installation of brazed, flared, mechanical, press-connect, soldered, threaded and welded joints shall comply with Sections 1108.3.1 through 1108.3.5.

INSIGHTS (2)

1108.3.1 Brazed joints.

Joint surfaces shall be cleaned. An *approved* flux shall be applied where required by the braze filler metal manufacturer. The piping being brazed shall be purged of air to remove the oxygen and filled with one of the following inert gases: oxygen-free nitrogen, helium or argon. The piping system shall be prepurged with an inert gas for a minimum time corresponding to five volume changes through the piping system prior to brazing. The pre-purge rate shall be at a minimum velocity of 100 feet per minute (0.508 m/s). The inert gas shall be directly connected to the tube system being brazed to prevent the entrainment of ambient air. After the pre-purge, the inert gas supply shall be maintained through the piping during the brazing operation at a minimum pressure of 1.0 psi (6.89 kPa) and a maximum pressure of 3.0 psi (20.67 kPa). The joint shall be brazed with a filler metal conforming to AWS A5.8.

INSIGHTS (2)

1108.3.2 Mechanical joints.

Mechanical joints shall be installed in accordance with the manufacturer's instructions.

INSIGHTS (2)

1108.3.2.1 Flared joints.

Flared fittings shall be installed in accordance with the manufacturer's instructions. The flared fitting shall be used with the tube material specified by the fitting manufacturer. The flared tube end shall be made by a tool designed for that operation.

INSIGHTS (2)

1108.3.2.2 Press-connect joints.

Press-connect joints shall be installed in accordance with the manufacturer's instructions.

INSIGHTS (2)

1108.3.3 Soldered joints.

Joint surfaces to be soldered shall be cleaned and a flux conforming to ASTM B813 shall be applied. The joint shall be soldered with a solder conforming to ASTM B32. Solder joints shall be limited to refrigerant systems using Group A1 refrigerant and having a pressure of less than or equal to 200 psi (1378 kPa).

INSIGHTS (2)

1108.3.4 Threaded joints.

Threads shall conform to ASME B1.1, ASME B1.13M, ASME B1.20.1 or ASME B1.20.3. Thread lubricant, pipe-joint compound or thread tape shall be applied on the external threads only and shall be *approved* for application on the piping material.

INSIGHTS (2)

1108.3.5 Welded joints.

Joint surfaces to be welded shall be cleaned by an *approved* procedure. Joints shall be welded with an *approved* filler metal.

INSIGHTS (2)

1108.4 Aluminum tube.

Joints between aluminum tubing or fittings shall be brazed, mechanical, press-connect or welded joints conforming to Section 1108.3.

INSIGHTS (2)

1108.5 Brass (copper alloy) pipe.

Joints between brass pipe or fittings shall be brazed, mechanical, press-connect, threaded or welded joints conforming to Section 1108.3.

INSIGHTS (2)

1108.6 Copper pipe.

Joints between copper or copper-alloy pipe or fittings shall be brazed, mechanical, press-connect, soldered, threaded or welded joints conforming to Section 1108.3.

INSIGHTS (2)

1108.7 Copper tube.

Joints between copper or copper-alloy tubing or fittings shall be brazed, flared, mechanical, press-connect or soldered joints.

INSIGHTS (2)

1108.8 Steel pipe.

Joints between steel pipe or fittings shall be mechanical joints, threaded, press-connect or welded joints conforming to Section 1108.3.

INSIGHTS (2)

1108.9 Steel tube.

Joints between steel tubing or fittings shall be flared, mechanical, press-connect or welded joints conforming to Section 1108.3.

INSIGHTS (2)

Section 1109 Refrigerant Pipe Installation

INSIGHTS (3)

1109.1 General.

Refrigerant piping installations, other than R-717 (ammonia) refrigeration systems, shall comply with the requirements of this section. The design of refrigerant piping shall be in accordance with ASME B31.5.

INSIGHTS (2)

1109.2 Piping location.

Refrigerant piping shall comply with the installation location requirements of Sections 1109.2.1 through 1109.2.7. Refrigerant piping for Groups A2L and B2L shall also comply with the requirements of Section 1109.3. Refrigerant piping for Groups A2, A3, B2 and B3 shall also comply with the requirements of Section 1109.4.

INSIGHTS (2)

1109.2.1 Minimum height.

Exposed refrigerant piping installed in open spaces that afford passage shall be not less than 7 feet 3 inches (2210 mm) above the finished floor.

INSIGHTS (2)

1109.2.2 Refrigerant pipe enclosure.

Refrigerant piping shall be protected by locating it within the building elements or within protective enclosures.

> **Exception:** Piping protection within the building elements or protective enclosure shall not be required in any of the following locations:
>
> 1. Where installed without ready access or located more than 7 feet 3 inches (2210 mm) above the finished floor.
> 2. Where located within 6 feet (1829 mm) of the refrigerant unit or *appliance*.
> 3. Where located in a *machinery room* complying with Section 1105.

INSIGHTS (2)

1109.2.3 Prohibited locations.

Refrigerant piping shall not be installed in any of the following locations:

1.

Exposed within a fire-resistance-rated exit access corridor.

2.

Within an interior exit stairway.

3.

Within an interior exit ramp.

4.

Within an exit passageway.

5.

Within an elevator, dumbwaiter or other shaft containing a moving object.

INSIGHTS (2)

1109.2.4 Piping in concrete floors.

Refrigerant piping installed in concrete floors shall be encased in pipe, conduit or ducts. The piping shall be protected to prevent damage from vibration, stress and corrosion.

INSIGHTS (2)

1109.2.5 Refrigerant pipe shafts.

Refrigerant piping that penetrates two or more floor/ceiling assemblies shall be enclosed in a fire-resistance-rated shaft enclosure. The fire-resistance-rated shaft enclosure shall comply with Section 713 of the *International Building Code*.

Exceptions:

1.

Systems using R-718 refrigerant (water).

2.

Piping in a direct system using Group A1 refrigerant where the refrigerant quantity does not exceed the limits of Table 1103.1 for the smallest occupied space through which the piping passes.

3.

Piping located on the exterior of the *building* where vented to the outdoors.

INSIGHTS (3)

1109.2.6 Exposed piping surface temperature.

Exposed piping with ready access having surface temperatures greater than 120°F (49°C) or less than 5°F (-15°C) shall be protected from contact or shall have thermal insulation that limits the exposed insulation surface temperature to a range of 5°F (-15°C) to 120°F (49°C).

INSIGHTS (2)

1109.2.7 Pipe identification.

Refrigerant pipe located in areas other than the room or space where the refrigerating *equipment* is located shall be identified. The pipe identification shall be located at intervals not exceeding 20 feet (6096 mm) on the refrigerant piping or pipe insulation. The minimum height of lettering of the identification label shall be 1/2 inch (12.7 mm). The identification shall indicate the *refrigerant designation* and safety group classification of refrigerant used in the piping system. For Group A2, A3, B2 and B3 refrigerants, the identification shall also include the following statement: “DANGER—Risk of Fire or Explosion. Flammable Refrigerant.” For any Group B refrigerant, the identification shall also include the following statement: “DANGER—Toxic Refrigerant.”

1109.3 Installation requirements for Group A2L or B2L refrigerant.

Piping systems using Group A2L or B2L refrigerant shall comply with the requirements of Sections 1109.3.1 and 1109.3.2.

INSIGHTS (2)

1109.3.1 Pipe protection.

In addition to the requirements of Section 305.5, aluminum, copper and steel tube used for Group A2L and B2L refrigerants and located in concealed locations where tubing is installed in studs, joists, rafters or similar member spaces, and located less than 1 1/2 inches (38 mm) from the nearest edge of the member, shall be continuously protected by shield plates. Protective steel shield plates having a minimum thickness of 0.0575 inch (1.46 mm) (No. 16 gage) shall cover the area of the tube plus the area extending not less than 2 inches (51 mm) beyond both sides of the tube.

INSIGHTS (2)

1109.3.2 Shaft ventilation.

Refrigerant pipe shafts with systems using Group A2L or B2L refrigerant shall be naturally or mechanically ventilated. The shaft ventilation exhaust outlet shall comply with Section 501.3.1. Naturally ventilated shafts shall have a pipe, duct or conduit not less than 4 inches (102 mm) in diameter that connects to the lowest point of the shaft and extends to the outdoors. The pipe, duct or conduit shall be level or pitched downward to the outdoors. Mechanically ventilated shafts shall have a minimum airflow velocity in accordance with Table 1109.3.2. The mechanical ventilation shall be continuously operated or activated by a refrigerant detector. Systems utilizing a refrigerant detector shall activate the mechanical ventilation at a maximum refrigerant concentration of 25 percent of the lower flammable limit of the refrigerant. The detector, or a sampling tube that draws air to the detector, shall be located in an area where refrigerant from a leak will concentrate. The shaft shall not be required to be ventilated for double-wall refrigerant pipe where the interstitial space of the double-wall pipe is vented to the outdoors.

INSIGHTS (2)

TABLE 1109.3.2 SHAFT VENTILATION VELOCITY

CROSS-SECTIONAL AREA OF SHAFT (square inches)	MINIMUM VENTILATION VELOCITY (feet per minute)
≤ 20	100
> 20 ≤ 250	200
> 250 ≤ 1,250	300
> 1,250	400

For SI: 1 square inch = 645 mm^2, 1 foot per minute = 0.0058 m/s.

1109.4 Installation requirements for Group A2, A3, B2 or B3 refrigerant.

Piping systems using Group A2, A3, B2 or B3 refrigerant shall comply with the requirements of Sections 1109.4.1 and 1109.4.2.

INSIGHTS (2)

1109.4.1 Piping material.

Piping material for Group A2, A3, B2 or B3 refrigerant located inside the building, except for *machinery rooms*, shall be copper pipe, brass pipe or steel pipe. Pipe joints located in areas other than the *machinery room* shall be welded. Self-contained *listed* and *labeled equipment* or *appliances* shall have piping material based on the listing requirements.

INSIGHTS (2)

1109.4.2 Shaft ventilation.

Refrigerant pipe shafts with systems using Group A2, A3, B2 or B3 refrigerant shall be continuously mechanically ventilated. The shaft ventilation exhaust outlet shall comply with Section 501.3.1. Mechanically ventilated shafts shall have a minimum airflow velocity as specified in Table 1109.3.2. The shaft shall not be required to be ventilated for double-wall refrigerant pipe where the interstitial space of the doublewall pipe is vented to the outdoors.

1109.5 Refrigerant pipe penetrations.

The annular space between the outside of a refrigerant pipe and the inside of a pipe sleeve or opening in a *building* envelope wall, floor or ceiling assembly penetrated by a refrigerant pipe shall be sealed in an *approved* manner with caulking material or foam sealant or closed with a gasketing system. The caulking material, foam sealant or gasketing system shall be designed for the conditions at the penetration location and shall be compatible with the pipe, sleeve and *building* materials in contact with the sealing materials. Refrigerant pipes penetrating fire-resistance-rated assemblies or membranes of fire-resistance-rated assemblies shall be sealed or closed in accordance with Section 714 of the *International Building Code*.

INSIGHTS (2)

1109.6 Stress and strain.

Refrigerant piping shall be installed so as to prevent strains and stresses that exceed the structural strength of the pipe. Where necessary, provisions shall be made to protect piping from damage resulting from vibration, expansion, contraction and structural settlement.

INSIGHTS (2)

1109.7 Condensate control.

Refrigerating piping and fittings that, during normal operation, will reach a surface temperature below the dew point of the surrounding air, and are located in spaces or areas where condensation has the potential to cause a safety hazard to the building occupants, structure, electrical *equipment* or any other *equipment* or *appliances*, shall be insulated or protected in an *approved* manner to prevent damage from condensation.

INSIGHTS (2)

1109.8 Stop valves.

Stop valves shall be installed in specified locations in accordance with Sections 1109.8.1 and 1109.8.2. Stop valves shall be supported in accordance with Section 1109.8.3 and identified in accordance with Section 1109.8.4.

Exceptions:

1.

Systems that have a refrigerant pumpout function capable of storing the entire refrigerant charge in a receiver or heat exchanger.

2.

Systems that are equipped with provisions for pumping out the refrigerant using either portable or permanently installed refrigerant recovery *equipment*.

3.

Self-contained *listed* and *labeled* systems.

INSIGHTS (2)

1109.8.1 Refrigerating systems containing more than 6.6 pounds (3.0 kg) of refrigerant.

Stop valves shall be installed in the following locations on refrigerating systems containing more than 6.6 pounds (3.0 kg) of refrigerant:

1.

The suction inlet of each compressor, compressor unit or condensing unit.

2.

The discharge outlet of each compressor, compressor unit or condensing unit.

3.

The outlet of each liquid receiver.

INSIGHTS (2)

1109.8.2 Refrigerating systems containing more than 100 pounds (45 kg) of refrigerant.

In addition to stop valves required by Section 1109.8.1, systems containing more than 100 pounds (45 kg) of refrigerant shall have stop valves installed in the following locations:

1.

Each inlet of each liquid receiver.

2.

Each inlet and each outlet of each condenser where more than one condenser is used in parallel.

Exceptions:

1.

Stop valves shall not be required at the inlet of a receiver in a condensing unit nor at the inlet of a receiver that is an integral part of the condenser.

2.

Systems utilizing nonpositive displacement compressors.

INSIGHTS (2)

1109.8.3 Stop valve support.

Stop valves shall be supported to prevent detrimental stress and strain on the refrigerant piping system. The piping system shall not be utilized to support stop valves on copper tubing or aluminum tubing 1 inch (25.4 mm) outside diameter or larger.

INSIGHTS (2)

1109.8.4 Identification.

Stop valves shall be identified where their intended purpose is not obvious. Where valves are identified by a numbering or lettering system, legend(s) or key(s) for the valve identification shall be located in the room containing the indoor refrigeration *equipment*. The minimum height of lettering of the identification label shall be 1/2 inch (12.7 mm).

INSIGHTS (2)

Section 1110 Refrigeration Piping System Test

INSIGHTS (3)

1110.1 General.

Refrigerant piping systems, other than R- 717 (ammonia) refrigeration systems, that are erected in the field shall be pressure tested for strength and leak tested for tightness, in accordance with the requirements of this section, after installation and before being placed in operation. Tests shall include both the high- and low-pressure sides of each system.

> **Exception:** *Listed* and *labeled equipment*, including compressors, condensers, vessels, evaporators, gas bulk storage tanks, safety devices, pressure gauges and control mechanisms, shall not be required to be tested.

INSIGHTS (2)

1110.2 Exposure of refrigerant piping system.

Refrigerant pipe and joints installed in the field shall be exposed for visual inspection and testing prior to being covered or enclosed.

INSIGHTS (2)

1110.3 Test gases.

The medium used for pressure testing the refrigerant system shall be one of the following inert gases: oxygen-free nitrogen, helium or argon. For R-744 refrigerant systems, carbon dioxide shall be allowed as the test medium. For R-718 refrigerant systems, water shall be allowed as the test medium. Oxygen, air, combustible gases and mixtures containing such gases shall not be used as a test medium. Systems erected on the premises with tubing not exceeding 5/8 inch (15.9 mm) outside diameter shall be allowed to use the refrigerant identified on the nameplate label or marking as the test medium.

INSIGHTS (2)

1110.4 Test apparatus.

The means used to pressurize the refrigerant piping system shall have on its outlet side a test pressure measuring device and either a pressure-limiting device or a pressure-reducing device. The test pressure measuring device shall have an accuracy of ±3 percent or less of the test pressure and shall have a resolution of 5 percent or less of the test pressure.

INSIGHTS (2)

1110.5 Piping system pressure test and leak test.

The refrigerant piping system shall be tested as a whole or separate tests shall be conducted for the low-pressure side and high-pressure side of the piping system. The refrigerant piping system shall be tested in accordance with both of the following methods:

1.

The system shall be pressurized for a period of not less than 60 minutes to not less than the lower of the design pressures or the setting of the pressure relief device(s). The design pressures for testing shall be the pressure *listed* on the label nameplate of the condensing unit, compressor, compressor unit, pressure vessel or other system component with a nameplate. Additional test gas shall not be added to the system after the start of the pressure test. The system shall not show loss of pressure on the test pressure measuring device during the pressure test. Where using refrigerant as a test medium in accordance with Section 1110.3, the test pressure shall be not less than the saturation dew point pressure at 77°F (25°C).

2.

A vacuum of 500 microns shall be achieved. After achieving a vacuum, the system shall be isolated from the vacuum pump. The system pressure shall not rise above 1,500 microns for a period of not less than 10 minutes.

INSIGHTS (2)

1110.5.1 Joints and refrigerant-containing parts in air ducts.

Joints and all refrigerant-containing parts of a refrigerating system located in an air duct of an air-conditioning system that conveys conditioned air to and from human-occupied spaces shall be tested at a pressure of 150 percent of the higher of the design pressure or pressure relief device setting.

INSIGHTS (2)

1110.5.2 Limited charge systems.

Limited charge systems with a pressure relief device, erected on the premises, shall be tested at a pressure not less than one and one-half times the pressure setting of the relief device. *Listed* and *labeled* limited charge systems shall be tested at the *equipment* or *appliance* design pressure.

INSIGHTS (2)

1110.6 Booster compressor.

Where a compressor protected by a pressure relief device is used as a booster to obtain an intermediate pressure, and such compressor discharges into the suction side of another compressor, the booster compressor shall be considered to be a part of the low-pressure side of the system.

INSIGHTS (2)

1110.7 Centrifugal/nonpositive displacement compressors.

Where testing systems using centrifugal or other nonpositive displacement compressors, the entire system shall be considered to be the low-pressure side for test purposes.

INSIGHTS (2)

1110.8 Contractor or engineer declaration.

The installing contractor or *registered design professional* of record shall issue a certificate of test to the code official for all *systems* containing 55 pounds (25 kg) or more of refrigerant. The certificate shall give the test date, name of the refrigerant, test medium and the field test pressure applied to the high-pressure side and the low-pressure side of the *system*. The certification of test shall be signed by the installing contractor or *registered design professional* and shall be made part of the public record.

INSIGHTS (2)

[F] Section 1111 Periodic Testing

[F] 1111.1 Testing required.

The following emergency devices and systems shall be periodically tested in accordance with the manufacturer's instructions and as required by the code official:

1.

Treatment and flaring systems.

2.

Valves and appurtenances necessary to the operation of emergency refrigeration control boxes.

3.

Fans and associated *equipment* intended to operate emergency ventilation systems.

4.

Detection and alarm systems.