# CHAPTER 5

# EXHAUST SYSTEMS

## SECTION 501
## GENERAL

**501.1 Scope.** This chapter shall govern the design, construction and installation of mechanical exhaust systems, including dust, stock and refuse conveyor systems, exhaust systems serving commercial cooking appliances and energy recovery ventilation systems.

**501.2 Outdoor discharge.** The air removed by every mechanical exhaust system shall be discharged outdoors at a point where it will not cause a nuisance and from which it cannot again be readily drawn in by a ventilating system. Air shall not be exhausted into an attic or crawl space.

**Exceptions:**

1. Whole-house ventilation-type attic fans that discharge into the attic space of dwelling units having private attics.
2. Commercial cooking recirculating systems.

**501.3 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, 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 system for a room, adequate means shall be provided for the natural exit 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 means shall be provided for the natural supply of the deficiency in the air supplied.

**501.4 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 which emit heat, odors, fumes, spray, gas or smoke, in such quantities so as to be irritating or injurious to health or safety.

**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.** Ventilation shall be provided in an approved manner in battery-charging areas to prevent a dangerous accumulation of flammable gases.

**[F] 502.4 Stationary lead-acid battery systems.** Ventilation shall be provided for stationary lead-acid battery systems in accordance with this chapter and Section 502.4.1 or 502.4.2.

**[F] 502.4.1 Hydrogen limit.** The ventilation system shall be designed to limit the maximum concentration of hydrogen to 1.0 percent of the total volume of the room.

**[F] 502.4.2 Ventilation rate.** Continuous ventilation shall be provided at a rate of not less than 1 cubic foot per minute per square foot (cfm/ft$^2$) [0.00508 m$^3$/(s • m$^2$)] of floor area of the room.

**[F] 502.5 Valve-regulated lead-acid batteries.** Valve-regulated lead-acid battery systems as regulated by Section 609 of the *International Fire Code*, shall be provided with ventilation in accordance with Section 502.5.1 or 502.5.2 for rooms and in accordance with Section 502.5.3 or 502.5.4 for cabinets.

**[F] 502.5.1 Hydrogen limit in rooms.** The ventilation system shall be designed to limit the maximum concentration of hydrogen to 1.0 percent of the total volume of the room during the worst-case event of simultaneous boost charging of all batteries in the room.

**[F] 502.5.2 Ventilation rate in rooms.** Continuous ventilation shall be provided at a rate of not less than 1 cubic foot per minute per square foot (cfm/ft.$^2$) [0.00508 m$^3$/(s•m$^2$)] of floor area of the room.

**[F] 502.5.3 Hydrogen limit in cabinets.** The ventilation system shall be designed to limit the maximum concentration of hydrogen to 1.0 percent of the total volume of the cabinet during the worst-case event of simultaneous boost charging of all batteries in the cabinet.

**[F] 502.5.4 Ventilation rate in cabinets.** Continuous ventilation shall be provided at a rate of not less than 1 cubic foot per minute per square foot (cfm/ft.$^2$) [0.00508 m$^3$/(s•m$^2$)] of the floor area covered by the cabinet. The room in which the cabinet is installed shall also be ventilated as required by Section 502.5.1 or 502.5.2.

**[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 a minimum of 100 feet per minute (0.5 m/s) air velocity 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 which operates at an airflow rate as follows:

$$Q = 100 \times A_{LD} \qquad \textbf{(Equation 5-1)}$$

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 which provides a minimum of 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 Spraying areas.** Mechanical ventilation of spraying areas shall be provided in accordance with Sections 502.7.3.1 through 502.7.3.7.

**[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 spraying 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. 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. The spray booths, spray spaces or spray rooms involved in any recirculation process shall be provided with mechanical ventilation that shall automatically exhaust 100 percent of the required air volume in the event of shutdown by approved equipment used to monitor vapor concentrations.
2. Air exhausted from spraying operations shall be permitted to be recirculated as makeup air to manned spraying operations if 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 present life safety hazards to personnel inside the spray booth, spray space or spray room.

**[F] 502.7.3.3 Air velocity.** Ventilation systems shall be designed, installed and maintained such that the average air velocity over the open face of the booth, or booth cross section in the direction of airflow during spraying operations, is not less than 100 feet per minute (0.51 m/s).

**[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 Termination point.** The termination point for exhaust ducts discharging to the atmosphere shall be located with the following minimum distances.

1. For ducts conveying explosive or flammable vapors, fumes or dusts: 30 feet (9144 mm) from the property line; 10 feet (3048 mm) from openings into the building; 6 feet (1829 mm) from exterior walls and roofs; 30 feet (9144 mm) from combustible walls and openings into the building which 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 line; 3 feet (914 mm) from exterior walls and roofs; 10 feet (3048 mm) from openings into the building; 10 feet (3048 mm) above adjoining grade.
3. For environmental air duct exhaust: 3 feet (914 mm) from the property line; 3 feet (914 mm) from openings into the building.

**[F] 502.7.3.7 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.** 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 spraying 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 cyclone or receptacle.

**[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 exterior of the building.

**[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.

**Exception:** Storage areas for flammable solids complying with 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/ft$^2$ [0.00508 m$^3$/(s · 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 of the break-glass type and shall be labeled: VENTILATION SYSTEM EMERGENCY SHUTOFF.
5. The exhaust ventilation system 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 (304 mm) of the floor.
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 ventilation shall not be recirculated within the room or building if the materials stored are capable of emitting hazardous vapors.

**[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 also 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 502.7.1.

**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 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 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 maximum allowable exempt quantity per control area, and which 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 maximum allowable quantity per control area 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.

**[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.

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

**[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 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 which 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 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 one-half 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 re-sale shall be provided with an approved means of ventilation.

**Exception:** Department of Transportation (DOT) specification cylinders with a maximum water capacity of 2.5 pounds (1 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 this section.

1. Exhausted enclosures and gas cabinets shall be in accordance with Section 502.8.2.
2. The velocity of ventilation across unwelded fittings and connections on the piping system shall not be less than 200 feet per minute (1.02 m/s).
3. The average velocity at the face of the access ports or windows in the gas cabinet shall not be 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] 502.10 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 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 502.7.2. 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 cabinets containing highly toxic or toxic gases shall also comply with Sections 502.9.7 and 502.9.8.

**[F] 502.10.2 Penetrations.** Exhaust ducts penetrating fire barrier assemblies shall be contained in a shaft of equivalent fire-resistive construction. Exhaust ducts shall not penetrate building separation 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 a minimum of 200 cubic feet per minute (cfm) (0.09 $m^3/s$) per lamp. The exhaust rate for xenon projectors shall be a minimum of 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 · 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.

**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.

**[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 natural gas- and hydrogen-fueled vehicles.** Repair garages used for the repair of natural gas- or hydrogen-fueled vehicles shall be provided with an approved mechanical ventilation system. The mechanical ventilation system shall be in accordance with Sections 502.16.1 and 502.16.2.

**Exception:** Where approved by the code official, natural ventilation shall be permitted in lieu of mechanical ventilation.

**[F] 502.16.1 Design.** Indoor locations shall be ventilated utilizing air supply inlets and exhaust outlets arranged to provide uniform air movement to the extent practical. Inlets shall be uniformly arranged on exterior walls near floor level. Outlets shall be located at the high point of the room in exterior walls or the roof.

1. Ventilation shall be by a continuous mechanical ventilation system or by a mechanical ventilation system activated by a continuously monitoring natural gas detection system activating at a gas concentration of 25 percent of the LFL. In all cases, the system shall shut down the fueling system in the event of failure of the ventilation system.
2. The ventilation rate shall be at least 1 cubic foot per minute per 12 cubic feet [0.00138 m$^3$/(s · m$^3$)] of room volume.

**[F] 502.16.2 Operation.** The mechanical ventilation system shall operate continuously.

**Exceptions:**

1. Mechanical ventilation systems that are interlocked with a gas detection system designed in accordance with the *International Fire Code*.
2. Mechanical ventilation systems in garages that are used only for the repair of vehicles fueled by liquid fuels or odorized gases, such as CNG, where the 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.

## 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. When 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. When 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 appliances 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 be independent of all other systems and 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.

**504.2 Exhaust penetrations.** Ducts that exhaust clothes dryers shall not penetrate or be located within any fireblocking, draftstopping 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.

**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.

**504.5 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 (645 $mm^2$) for makeup air shall be provided in the closet enclosure, or makeup air shall be provided by other approved means.

**504.6 Domestic clothes dryer ducts.** Residential dryer exhaust ducts which are not designed for a specific dryer shall be constructed of minimum 0.0157-inch (0.4mm) galvanized steel or other noncombustible material of equivalent strength and corrosion resistance. The ducts shall have a smooth interior finish with joints running in the direction of the airflow. The minimum size of the exhaust duct shall be 4 inches (102 mm) id. The maximum length of rigid metal duct shall not exceed 45 feet (13716 mm) from dryer location to wall or roof cap. There shall be a deduction of 5 feet (1524 mm) for each 45- degree (0.785 rad) bend and 10 feet (3048 mm) for 90-degree (1.57 rad) bend. The maximum length for noncombustible flexible duct shall not exceed 25 feet (7620 mm) from dryer location to the wall or roof cap. There shall be a deduction of 2½ feet (762 mm) for each 45-degree (0.785 rad) bend and 5 feet (1524 mm) for each 90-degree (1.57 rad) bend. All wall or roof caps shall be nonscreened with backdraft damper and minimum size of 4 inches (102 mm). The entire exhaust system shall be properly secured in place and shall terminate not less than 12 inches (305 mm) above finished grade. The maximum length of the exhaust does not include the transition duct.

Clothes dryer transition ducts used to connect the appliance to the exhaust duct system shall be metal and limited to a single length not to exceed 8 feet (2438 mm) and shall be listed and labeled for the application. Transition ducts shall not be concealed within construction.

**Exception:** Where the make and model of the clothes dryer to be installed is known and the manufacturer's installation instructions for such dryer are provided to the code official, the maximum length of the exhaust duct, including any transition duct, shall be permitted to be in accordance with the dryer manufacturer's installation instructions.

**504.6.1 Maximum length.** Deleted.

**504.6.2 Rough-in required.** Where a compartment or space for a domestic clothes dryer is provided, an exhaust duct system shall be installed in accordance with Sections 504.6 and 504.6.1.

**504.7 Commercial clothes dryers.** The installation of dryer exhaust ducts serving Type 2 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.

## SECTION 505
## DOMESTIC KITCHEN EXHAUST EQUIPMENT

**505.1 Domestic systems.** Where domestic range hoods and domestic appliances equipped with downdraft exhaust are located within dwelling units, such hoods and appliances shall discharge to the outdoors through ducts constructed of galvanized steel, stainless steel, aluminum or copper. Such ducts shall have smooth inner walls and shall be air tight and equipped with a backdraft damper.

**Exceptions:**

1. Where installed in accordance with the manufacturer's installation 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 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 greater than 1 inch (25 mm) above the indoor concrete floor surface.
2.4. The PVC duct shall extend not greater than 1 inch (25 mm) above grade outside of the building.
2.5. The PVC ducts shall be solvent cemented.

## 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 506.3.12.3.

**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 not less than 0.055 inch (1.4 mm) (No. 16 Gage) in thickness or stainless steel not less than 0.044 inch (1.1 mm) (No. 18 Gage) in thickness.

**Exception:** Listed and labeled factory-built commercial kitchen grease ducts shall be installed in accordance with Section 304.1.

**506.3.1.2 Makeup air ducts.** Make up 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. Listed and labeled factory-built commercial kitchen grease ducts installed in accordance with Section 304.1.

**506.3.2.1 Duct joint types.** Duct joints shall be butt joints 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 0.25 inch (6 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 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 (815°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 0.25 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. All bolts and nuts are to 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.

**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.

**506.3.3 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.

**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.** 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).

**Exception:** Listed and labeled factory-built commercial kitchen grease ducts and exhaust equipment installed in accordance with Section 304.1.

**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 one-fourth unit vertical in 12 units horizontal (2-percent slope) toward the hood or toward an approved grease reservoir. Where horizontal ducts exceed 75 feet (22 860 mm) in length, the slope shall not be less than one unit vertical in 12 units horizontal (8.3-percent slope).

**506.3.8 Grease duct cleanouts and other openings.** Grease duct systems shall not have openings therein other than those required for proper operation and maintenance of the system. Any portion of such system having sections not provided with access from the duct entry or discharge shall be provided with cleanout openings. Cleanout openings shall be equipped with tight-fitting doors constructed of steel having a thickness not less than that required for the duct. Doors shall be equipped with a substantial method of latching, sufficient to hold the door tightly closed. Doors shall be designed so that they are operable without the use of a tool. Door assemblies, including any frames and gasketing, shall be approved for the purpose, and shall not have fasteners that penetrate the duct. Listed and labeled access door assemblies shall be installed in accordance with the terms of the listing.

**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 20 inches by 20 inches (508 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.

**506.3.9 Grease duct horizontal cleanouts.** Cleanouts located on horizontal sections of ducts shall be spaced not more than 20 feet (6096 mm) apart. The cleanouts shall be located on the side of the duct with the opening not less than 1.5 inches (38 mm) above the bottom of the duct, and not less than 1 inch (25 mm) below the top of the duct. The opening minimum dimensions shall be 12 inches (305 mm) on each side. Where the dimensions of the side of the duct prohibit the cleanout installation prescribed herein, the openings shall be on the top of the duct or the bottom of the duct. Where located on the top of the duct, the opening edges shall be a minimum of 1 inch (25 mm) from the edges of the duct. Where located in the bottom of the duct, cleanout openings shall be designed to provide internal damming around the opening, shall be provided with gasketing to preclude grease leakage, shall provide for drainage of grease down the duct around the dam, and shall be approved for the application. Where the dimensions of the sides, top or bottom of the duct preclude the installation of the prescribed minimum-size cleanout opening, the cleanout shall be located on the duct face that affords the largest opening dimension and shall be installed with the opening edges at the prescribed distances from the duct edges as previously set forth in this section.

**506.3.10 Grease duct enclosure.** A grease duct serving a Type I hood that penetrates a ceiling, wall or floor shall be enclosed from the point of penetration to the outlet terminal. A duct shall penetrate exterior walls only at locations where unprotected openings are permitted by the *International Building Code*. Ducts shall be enclosed in accordance with the *International Building Code* requirements for shaft construction. The duct enclosure 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. Clearance from the duct to the interior surface of enclosures of combustible construction shall be not less than 18 inches (457 mm). Clearance from the duct to the interior surface of enclosures of noncombustible construction or gypsum wallboard attached to noncombustible structures shall be not less than 6 inches (152 mm). The duct enclosure shall serve a single grease exhaust duct system and shall not contain any other ducts, piping, wiring or systems.

**Exceptions:**

1. The shaft enclosure provisions of this section shall not be required where a duct penetration is pro-

tected with a through-penetration firestop system classified in accordance with ASTM E 814 and having an "F" and "T" rating equal to the fire-resistance rating of the assembly being penetrated and where the surface of the duct is continuously covered on all sides from the point at which the duct penetrates a ceiling, wall or floor to the outlet terminal with a classified and labeled material, system, method of construction or product specifically evaluated for such purpose, in accordance with a nationally recognized standard for such enclosure materials. Exposed duct wrap systems shall be protected where subject to physical damage.

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

**506.3.11 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."

**506.3.12 Exhaust outlets serving Type I hoods.** Exhaust outlets for grease ducts serving Type I hoods shall conform to the requirements of Sections 506.3.12.1 through 506.3.12.3.

**506.3.12.1 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.

**506.3.12.2 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. Other exterior openings shall not be located within 3 feet (914 mm) of such terminations.

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

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

**506.4 Ducts serving Type II hoods.** Single or combined Type II exhaust systems for food-processing operations shall be independent of all other exhaust systems. Commercial kitchen exhaust systems serving Type II hoods shall comply with Sections 506.4.1 and 506.4.2.

**506.4.1 Type II exhaust outlets.** Exhaust outlets for ducts serving Type II hoods shall comply with Sections 401.5 and 401.5.2. Such outlets shall be protected against local weather conditions and shall meet the provisions for exterior wall opening protectives in accordance with the *International Building Code.*

**506.4.2 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.

**506.5 Exhaust equipment.** Exhaust equipment, including fans and grease reservoirs, shall comply with Sections 506.5.1 through 506.5.5 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.

**506.5.2 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.

**506.5.3 Exhaust fan mounting.** An upblast fan shall be hinged and supplied with a flexible weatherproof electrical cable to permit inspection and cleaning. The ductwork shall extend a minimum of 18 inches (457 mm) above the roof surface.

**506.5.4 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.

**506.5.5 Termination location.** The outlet of exhaust equipment serving Type I hoods, shall be in accordance with Section 506.3.12.3

**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 Type II and shall be designed to capture and confine cooking vapors and residues.

**Exceptions:**

1. Factory-built commercial exhaust hoods which are tested in accordance with UL 710, listed, labeled and installed in accordance with Section 304.1 shall not be required to comply with Sections 507.4, 507.7, 507.11, 507.12, 507.13, 507.14 and 507.15.
2. Factory-built commercial cooking recirculating systems which are tested in accordance with UL 197, listed, labeled and installed in accordance with Section 304.1 shall not be required to comply with Sections 507.4, 507.5, 507.7, 507.12, 507.13, 507.14 and 507.15.
3. Net exhaust volumes for hoods shall be permitted to be reduced during no-load cooking conditions, where engineered or listed multi-speed or variable-speed controls automatically operate the exhaust system to maintain capture and removal of cooking effluents as required by this section.

**507.2 Where required.** A Type I or Type II hood shall be installed at or above all commercial cooking appliances in accordance with Sections 507.2.1 and 507.2.2. 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.

**507.2.1 Type I hoods.** Type I hoods shall be installed where cooking appliances produce grease or smoke, such as occurs with griddles, fryers, broilers, ovens, ranges and wok ranges.

**507.2.2 Type II hoods.** Type II hoods shall be installed where cooking or dishwashing appliances produce heat, steam, or products of combustion and do not produce grease or smoke, such as steamers, kettles, pasta cookers and dishwashing machines.

**Exceptions:**

1. Under-counter-type commercial dishwashing machines.
2. A Type II hood is not required for dishwashers and potwashers that are provided with heat and water vapor exhaust systems that are supplied by the appliance manufacturer and are installed in accordance with the manufacturer's instructions.
3. A single light-duty electric convection, bread, retherm or microwave oven. The additional heat and moisture loads generated by such appliances shall be accounted for in the design of the HVAC system.
4. A Type II hood is not required for the following electrically heated appliances: toasters, steam tables, popcorn poppers, hot dog cookers, coffee makers, rice cookers, egg cookers, holding/warming ovens. The additional heat and moisture loads generated by such appliances shall be accounted for in the design of the HVAC system.

**507.2.3 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, 507.2.1 and 507.2.2.

**Exception:** A maximum of two residential ranges (four burner) installed in dwelling units, churches, schools, day care centers, break areas and similar installations.

**507.2.4 Solid fuel.** Type I hoods for use over solid fuel-burning cooking appliances shall discharge to an exhaust system that is independent of other exhaust systems.

**507.3 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.

**507.4 Type I materials.** Type I hoods shall be constructed of steel not less than 0.043 inch (1.09 mm) (No. 18 MSG) in thickness, or stainless steel not less than 0.037 inch (0.94 mm) (No. 20 MSG) in thickness.

**507.5 Type II hood materials.** Type II hoods shall be constructed of steel not less than 0.030 inch (0.76 mm) (No. 22 Gage) in thickness, stainless steel not less than 0.024 inch (0.61 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.

**507.6 Supports.** Type I hoods shall be secured in place by noncombustible supports. All Type I and 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.

**507.7 Hood joints, seams and penetrations.** Hood joints, seams and penetrations shall comply with Sections 507.7.1 and 507.7.2.

**507.7.1 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.

**507.7.2 Type II hoods.** 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 water tight.

**507.8 Cleaning and grease gutters.** A hood shall be designed to provide for thorough cleaning of the entire hood. Grease gutters shall drain to an approved collection receptacle that is fabricated, designed and installed to allow access for cleaning. The container shall have a minimum capacity of 1 gallon (3.8 L) unless otherwise approved by the mechanical official.

**507.9 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).

**Exception:** Clearance shall not be required from gypsum wallboard attached to noncombustible structures provided that a smooth, cleanable, nonabsorbent and noncombustible material is installed between the hood and the gypsum wallboard over an area extending not less than 18 inches (457 mm) in all directions from the hood.

**507.10 Hoods penetrating a ceiling.** Type I hoods or portions thereof penetrating a ceiling, wall or furred space shall comply with all the requirements of Section 506.3.10.

**507.11 Grease filters.** Type I hoods shall be equipped with listed grease filters designed for the specific purpose. Grease-collecting equipment shall be provided with access for cleaning. The lowest edge of a grease filter located above the cooking surface shall be not less than the height specified in Table 507.11.

**TABLE 507.11**
**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.

**507.11.1 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. 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.

**507.11.2 Mounting position.** 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.

**507.12 Canopy size and location.** The inside lower edge of canopy-type commercial cooking hoods shall overhang or extend a horizontal distance of not less than 6 inches (152 mm) beyond the edge of the cooking surface, on all open sides. The vertical distance between the front lower lip of the hood and the cooking 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.

**507.13 Capacity of hoods.** Commercial food service hoods shall exhaust a minimum net quantity of air determined in accordance with this section and Sections 507.13.1 through 507.13.4. 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 extra-heavy-duty, heavy-duty, medium-duty, and light-duty cooking appliances are utilized under a single hood, the highest exhaust rate required by this section shall be used for the entire hood.

**507.13.1 Extra-heavy-duty cooking appliances**. The minimum net airflow for Type I hoods used for extra-heavy-duty cooking appliances shall be determined as follows:

| Type of Hood | CFM per linear foot of hood |
|---|---|
| Wall-mounted canopy | 550 |
| Single island canopy | 700 |
| Double island canopy (per side) | 550 |
| Backshelf/pass-over | Not allowed |
| Eyebrow | Not allowed |

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

**507.13.2 Heavy-duty cooking appliances**. The minimum net airflow for Type I hoods used for heavy-duty cooking appliances shall be determined as follows:

| Type of Hood | CFM per linear foot of hood |
|---|---|
| Wall-mounted canopy | 400 |
| Single island canopy | 600 |
| Double island canopy (per side) | 400 |
| Backshelf/pass-over | 400 |
| Eyebrow | Not allowed |

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

**507.13.3 Medium-duty cooking appliances.** The minimum net airflow for Type I hoods used for medium-duty cooking appliances shall be determined as follows:

| Type of Hood | CFM per linear foot of hood |
|---|---|
| Wall-mounted canopy | 300 |
| Single island canopy | 500 |
| Double island canopy (per side) | 300 |
| Backshelf/pass-over | 300 |
| Eyebrow | 250 |

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

**507.13.4 Light-duty cooking appliances**. The minimum net airflow for Type I hoods used for light duty cooking appliances and food service preparation and cooking operations approved for use under a Type II hood shall be determined as follows:

| Type of Hood | CFM per linear foot of hood |
|---|---|
| Wall-mounted canopy | 200 |
| Single island canopy | 400 |
| Double island canopy (per side) | 250 |
| Backshelf/pass-over | 250 |
| Eyebrow | 250 |

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

**507.14 Noncanopy size and location.** Noncanopy-type hoods shall be located a maximum of 3 feet (914 mm) above the cooking surface. The edge of the hood shall be set back a maximum of 1 foot (305 mm) from the edge of the cooking surface.

**507.15 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.

**507.16 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 507.13, 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.

**507.16.1 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. Capture and containment shall be verified visually by observing smoke or steam produced by actual or simulated cooking, such as with smoke candles, smoke puffers, etc.

**507.16.2 Certification.** These tests shall be witnessed by the code official, or at the code official's option, by a professional engineer who shall provide certification of performance to the code official.

## 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 shall be approximately equal to the amount of exhaust air. The makeup air shall not reduce the effectiveness of the exhaust system. Makeup air shall be provided by gravity or mechanical means or both. For mechanical makeup air systems, the exhaust and makeup air systems shall be electrically interlocked to insure that makeup air is provided whenever the exhaust system is in operation. Makeup air intake opening locations shall comply with Sections 401.5 and 401.5.1.

**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).

**Exceptions:**

1. Makeup air that is part of the air-conditioning system.
2. Makeup air that does not decrease the comfort conditions of the occupied space.

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

## SECTION 509
## FIRE SUPPRESSION SYSTEMS

**509.1 Where required.** Commercial cooking appliances required by Section 507.2.1 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*.

## 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.

**Laboratories:** 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.

**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, unless 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 which generates or emits combustible dust shall be provided with an approved dust-collection and exhaust system installed in conformance 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.

**[F] 510.2.2 Combustible fibers.** Equipment or machinery within a building which 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 Independent system.** Hazardous exhaust systems shall be independent of other types of exhaust systems. 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 provision 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 is 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. Each control branch has a flow regulating device.
4. Perchloric acid hoods and connected exhaust are excluded from manifolding.
5. Radioisotope hoods are equipped with filtration or carbon beds where required by the registered design professional.
6. Biological safety cabinets are filtered.
7. Provision is made for continuous maintenance of negative static pressure in the ductwork.

Contaminated air shall not be recirculated to occupied areas unless the contaminants have been removed. Air contaminated with explosive or flammable vapors, fumes, or dusts; flammable or toxic gases; or radioactive material shall not be recirculated.

**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 air-flow shall be provided with securely fixed minimum-position blocking devices to prevent restricting 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.

**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 shall be provided at a rate approximately equal to the rate that air is exhausted by the hazardous exhaust system. Makeup-air intakes shall be located so as to avoid recirculation of contaminated air.

**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 510.6.3.

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

**510.6.1 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*.

**510.6.2 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.

**510.6.3 Fire walls.** Ducts shall not penetrate a fire wall.

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

**510.8 Duct construction.** Ducts utilized to convey hazardous exhaust shall be constructed of approved G90 galvanized sheet steel, with a minimum nominal thickness as specified in Table 510.8.

Nonmetallic ducts utilized in systems exhausting nonflammable corrosive fumes or vapors shall be listed and labeled. Nonmetallic duct shall have a flame spread index of 25 or less and a smoke-developed index of 50 or less, when tested in accordance with ASTM E 84. Ducts shall be approved for installation in such an exhaust system.

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).

**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

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

**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 closer 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 within a distance of 30 feet (9144 mm).

**Exception:** 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 the installation is in accordance with the *International Fire Code* and the ICC *Electrical Code.*

**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 system exhaust discharge.** An exhaust system shall discharge to the outside of the building either directly by flue, or indirectly through the separator, bin or vault into which the system discharges.

**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 relief vents.** A safety or explosion relief vent shall be provided on all systems that convey combustible refuse or stock of an explosive nature, in accordance with the requirements of the *International Building Code*.

**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.

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

| CHIMNEYS SERVING | MINIMUM THICKNESS | | TERMINATION | | | | CLEARANCE | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Above any part of building within (feet) | | | Combustible construction (inches) | | Noncombustible construction | |
| | Walls (inch) | Lining | Above roof opening (feet) | 10 | 25 | 50 | Interior inst. | Exterior inst. | Interior inst. | Exterior inst. |
| 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 | | |
| 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 | | | |

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).

**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.

The termination point for exhaust ducts discharging to the atmosphere shall not be less than the following:

1. Ducts conveying explosive or flammable vapors, fumes or dusts: 30 feet (9144 mm) from property line; 10 feet (3048 mm) from openings into the building; 6 feet (1829 mm) from exterior walls or roofs; 30 feet (9144 mm) from combustible walls or openings into the building which are in the direction of the exhaust discharge; and 10 feet (3048 mm) above adjoining grade.
2. Other product-conveying outlets: 10 feet (3048 mm) from property line; 3 feet (914 mm) from exterior wall or roof; 10 feet (3048 mm) from openings into the building; and 10 feet (3048 mm) above adjoining grade.
3. Environmental air duct exhaust: 3 feet (914 mm) from property line; and 3 feet (914 mm) from openings into the building.

## SECTION 512
## SUBSLAB SOIL EXHAUST SYSTEMS

**512.1 General.** When 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; brass or copper pipe; copper tube of a weight not less than that of copper drainage tube, Type DWV; and plastic piping.

**512.3 Grade.** Exhaust system ducts shall not be trapped and shall have a minimum slope of one-eighth unit vertical in 12 units horizontal (1-percent slope).

**512.4 Termination.** Subslab soil exhaust system ducts shall extend through the roof and terminate at least 6 inches (152 mm) above the roof and at least 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

**[B] 513.1 Scope and purpose.** This section applies to mechanical and passive smoke control systems that are required by the *International Building 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-venting provisions found in Section 910 of the *International Building Code*.

**[B] 513.2 General design requirements.** Buildings, structures, or parts thereof required by this 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-estab-

lished 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

**[B] 513.3 Special inspection and test requirements.** In addition to the ordinary inspection and test requirements which 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*.

**[B] 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 513.4.6.

**[B] 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.

**[B] 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.

**[B] 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*.

**[B] 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.

**[B] 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.

**[B] 513.4.6 Duration of operation.** All portions of active or passive smoke control systems shall be capable of continued operation after detection of the fire event for not less than 20 minutes.

**[B] 513.5 Smoke barrier construction.** Smoke barriers shall comply with the *International Building Code*. Smoke barriers shall be constructed and sealed to limit leakage areas exclusive of protected openings. 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. Exit enclosures: $A/A_w = 0.00035$
3. 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 due to doors, operable windows or similar gaps. These shall be included in calculating the total leakage area.

**[B] 513.5.1 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 and operable windows. Compliance 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. Passive smoke control systems tested using other approved means such as door fan testing shall be as approved by the code official.

**[B] 513.5.2 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 which are protected utilizing the airflow method.
3. In Group I-2 where such doors are installed across corridors, a pair of opposite-swinging doors without a center mullion shall be installed having vision panels with approved fire-rated glazing materials in approved fire-rated frames, the area of which shall not exceed that tested. The doors shall be close-fitting within operational tolerances, and shall not have undercuts, louvers or grilles. The doors shall have head and jamb stops, astragals or rabbets at meeting edges and automatic-closing devices. Positive latching devices are not required.
4. Group I-3.
5. 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.

**[B] 513.5.2.1 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*.

**[B] 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.

**[B] 513.6.1 Minimum pressure difference.** The minimum pressure difference across a smoke barrier shall be 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 at least two times the maximum calculated pressure difference produced by the design fire.

**[B] 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:

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

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).

$\Delta P$ = Design pressure difference, inches (Pa) water gage.

**[B] 513.7 Airflow design method.** When 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.

**[B] 513.7.1 Velocity.** The minimum average velocity through a fixed opening shall not be less than:

$$v = 217.2\,[h\,(T_f - T_o)/(T_f + 460)]^{1/2} \qquad \textbf{(Equation 5-3)}$$

For SI: $v = 119.9\,[h\,(T_f - T_o)/T_f]^{1/2}$

where:

$H$ = Height of opening, feet (m).

$T_f$ = Temperature of smoke, °F (K).

$T_o$ = Temperature of ambient air, °F (K).

$v$ = Air velocity, feet per minute (m/minute).

**[B] 513.7.2 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. In no case shall airflow toward the fire exceed 200 feet per minute (1.02 m/s). Where the formula in Section 513.7.1 requires airflow to exceed this limit, the airflow method shall not be used.

**[B] 513.8 Exhaust method.** When approved by the code official, mechanical smoke control for large enclosed volumes, such as in atria or malls, shall be permitted to utilize the exhaust method. The design exhaust volumes shall be in accordance with this section.

**[B] 513.8.1 Exhaust rate.** The height of the lowest horizontal surface of the accumulating smoke layer shall be maintained at least 10 feet (3048 mm) above any walking surface which forms a portion of a required egress system within the smoke zone. The required exhaust rate for the zone shall be the largest of the calculated plume mass flow rates for the possible plume configurations. Provisions shall be made for natural or mechanical supply of outside air from outside or adjacent smoke zones to make up for the air exhausted. Makeup airflow rates, when measured at the potential fire location, shall not exceed 200 feet per minute (1.02 m/s) toward the fire. The temperature of the makeup air shall be such that it does not expose temperature-sensitive fire protection systems beyond their limits.

**[B] 513.8.2 Axisymmetric plumes.** The plume mass flow rate ($m_p$), in pounds per second (kg/s), shall be determined by placing the design fire center on the axis of the space being analyzed. The limiting flame height shall be determined by:

$$z_l = 0.533 Q_c^{2/5} \qquad \textbf{(Equation 5-4)}$$

For SI: $z_l = 0.166 Q_c^{2/5}$

where:

$m_p$ = Plume mass flow rate, pounds per second (kg/s).

$Q$ = Total heat output.

$Q_c$ = Convective heat output, British thermal units per second (kW).

(The value of $Q_c$ shall not be taken as less than $0.70Q$).

$z$ = Height from top of fuel surface to bottom of smoke layer, feet (m).

$z_l$ = Limiting flame height, feet (m). The $z_l$ value must be greater than the fuel equivalent diameter (see Section 513.9).

for $z > z_l$

$$m_p = 0.022 Q_c^{1/3} z^{5/3} + 0.0042 Q_c$$

For SI: $m_p = 0.071 Q_c^{1/3} z^{5/3} + 0.0018 Q_c$

for $z = z_l$

$m_p = 0.011\ Q_c$

For SI: $m_p = 0.035 Q_c$

for $z < z_l$

$m_p = 0.0208 Q_c^{3/5} z$

For SI: $m_p = 0.032 Q_c^{3/5} z$

To convert $m_p$ from pounds per second of mass flow to a volumetric rate, the following formula shall be used:

$$V = 60 m_p / \rho \qquad \textbf{(Equation 5-5)}$$

where:

$V$ = Volumetric flow rate, cubic feet per minute ($m^3/s$).

$\rho$ = Density of air at the temperature of the smoke layer, pounds per cubic feet ($T$: in °F)[kg/$m^3$ ($T$: in °C)].

**[B] 513.8.3 Balcony spill plumes.** The plume mass flow rate ($m_p$) for spill plumes shall be determined using the geometrically probable width based on architectural elements and projections in the following formula:

$$m_p = 0.124 (Q W^2)^{1/3} (z_b + 0.25 H) \qquad \textbf{(Equation 5-6)}$$

For SI: $m_p = 0.36 (Q W^2)^{1/3} (z_b + 0.25 H)$

where:

$H$ = Height above fire to underside of balcony, feet (m)

$m_p$ = Plume mass flow rate, pounds per second (kg/s).

$Q$ = Total heat output.

$W$ = Plume width at point of spill, feet (m).

$z_b$ = Height from balcony, feet (m).

**[B] 513.8.4 Window plumes.** The plume mass flow rate ($m_p$) shall be determined from:

$$m_p = 0.077 (A_w H_w^{1/2})^{1/3} (z_w + a)^{5/3} + 0.18 A_w H_w^{1/2} \qquad \textbf{(Equation 5-7)}$$

For SI: $m_p = 0.68 (A_w H_w^{1/2})^{1/3} (z_w + a)^{5/3} + 1.5 A_w H_w^{1/2}$

where:

$A_w$ = Area of the opening, square feet ($m^2$).

$H_w$ = Height of the opening, feet (m).

$m_p$ = Plume mass flow rate, pounds per second (kg/s).

$z_w$ = Height from the top of the window or opening to the bottom of the smoke layer, feet (m).

$a$ = $2.4 A_w^{2/5} H_w^{1/5} - 2.1 H_w$

**[B] 513.8.5 Plume contact with walls.** When a plume contacts one or more of the surrounding walls, the mass flow rate shall be adjusted for the reduced entrainment resulting from the contact provided that the contact remains constant. Use of this provision requires calculation of the plume diameter, that shall be calculated by:

$$d = 0.48 [(T_c + 460)/(T_a + 460)]^{1/2} z \qquad \textbf{(Equation 5-8)}$$

For SI: $d = 0.48 (T_c/T_a)^{1/2} z$

where:

$d$ = Plume diameter, feet (m).

$T_a$ = Ambient air temperature, °F (K).

$T_c$ = Plume centerline temperature, °F (K).

= $0.6 (T_a + 460)\ Q_c^{2/3}\ z^{-5/3} + T_a$

$z$ = Height at which $T_c$ is determined, feet (m).

For SI: $T_c = 0.08\ T_a\ Q_c^{2/3}\ z^{-5/3} + T_a$

**[B] 513.9 Design fire.** The design fire shall be based on a $Q$ of not less than 5,000 Btu per second (5275kW) unless a rational analysis is 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.

**[B] 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.

**[B] 513.9.2 Separation distance.** Determination of the design fire shall include consideration of the type of fuel, fuel spacing and configuration. The ratio of the separation distance to the fuel equivalent radius shall not be less than 4. The fuel equivalent radius shall be the radius of a circle of equal area to floor area of the fuel package. The design fire shall be increased if other combustibles are within the separation distance as determined by:

$$R = [Q / (12 \pi q'')]^{1/2} \qquad \textbf{(Equation 5-9)}$$

where:

$q''$ = Incident radiant heat flux required for nonpiloted ignition, Btu/$ft^2$ • s (W/$m^2$).

$Q$ = Heat release from fire, Btu/s (kW).

$R$ = Separation distance from target to center of fuel package, feet (m).

**[B] 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.

**[B] 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.

**[B] 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.

**[B] 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:

$$T_s = (Q_c/mc) + (T_a) \qquad \textbf{(Equation 5-10)}$$

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.

**[B] 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.

**[B] 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.

**[B] 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.

**[B] 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.

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

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

**[B] 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 Chapter 9 of the *International Building Code* and NFPA 72. Such systems shall be equipped with a control unit complying with UL 864 and listed as smoke control equipment.

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

**[B] 513.12.1 Wiring.** In addition to meeting the requirements of the ICC *Electrical Code*, all wiring, regardless of voltage, shall be fully enclosed within continuous raceways.

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

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

**[B] 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.

**[B] 513.13.1 Materials.** Control-air tubing shall be hard-drawn copper, Type L, ACR in accordance with ASTM B 42, ASTM B 43, ASTM B 68, ASTM B 88, ASTM B 251 and ASTM B 280. Fittings shall be wrought copper or brass, solder type in accordance with ASME B16.18 or ASME B16.22. Changes in direction shall be made with appropriate tool bends. Brass compression-type fittings shall be used at final connection to devices; other joints shall be brazed using a BCuP5 brazing alloy with solidus above 1,100°F (593°C) and liquids below 1,500°F (816°C). Brazing flux shall be used on copper-to-brass joints only.

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

1. Tubing shall be listed by an approved agency for flame and smoke characteristics.
2. Tubing and connected device shall be completely enclosed within a galvanized or paint-grade steel enclosure of not less than 0.030 inch (0.76 mm) (No. 22 galvanized sheet gage) thickness. Entry to the enclosure shall be by copper tubing with a protective grommet of neoprene or teflon or by suitable brass compression to male barbed adapter.
3. Tubing shall be identified by appropriately documented coding.
4. Tubing shall be neatly tied and supported within the enclosure. Tubing bridging cabinets and doors or moveable devices shall be of sufficient length to avoid tension and excessive stress. Tubing shall be protected against abrasion. Tubing serving devices on doors shall be fastened along hinges.

**[B] 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.

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

**[B] 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*.

**[B] 513.20 Underground building smoke exhaust system.** Where required by the *International Building Code* for underground buildings, a smoke exhaust system shall be provided in accordance with this section.

**[B] 513.20.1 Exhaust capability.** Where compartmentation is required, each compartment shall have an independent, automatically activated smoke exhaust system capable of manual operation. The system shall have an air supply and smoke exhaust capability that will provide a minimum of six air changes per hour.

**[F] 513.20.2 Operation.** The smoke exhaust system shall be operated in accordance with the *International Fire Code*.

**[F] 513.20.3 Alarm required.** Activation of the smoke exhaust system shall activate an audible alarm at a constantly attended location in accordance with the *International Fire Code*.

## SECTION 514
## ENERGY RECOVERY VENTILATION SYSTEMS

**514.1 General.** Energy recovery ventilation systems shall be installed in accordance with this section. Where required for purposes of energy conservation, energy recovery ventilation systems shall also comply with the *International Energy Conservation Code*.

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

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

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