NFPA 33

Standard for Spray Application Using Flammable or Combustible Materials

1995 Edition

National Fire Protection Association, 1 Batterymarch Park, PO Box 9101, Quincy, MA 02269-9101
An International Codes and Standards Organization

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Spray Application Using Flammable or Combustible Materials

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This edition of NFPA 33, *Standard for Spray Application Using Flammable or Combustible Materials* was prepared by the Technical Committee on Finishing Processes and acted on by the National Fire Protection Association, Inc., at its Annual Meeting held May 22-25, 1995, in Denver, CO. It was issued by the Standards Council on July 21, 1995, with an effective date of August 11, 1995, and supersedes all previous editions.

This edition of NFPA 33 was approved as an American National Standard on August 11, 1995.

Changes other than editorial are indicated by a vertical rule in the margin of the pages on which they appear. These lines are included as an aid to the user in identifying changes from the previous edition.

Origin and Development of NFPA 33

The original NFPA Standard on Paint Spraying and Spray Booths was initiated in 1921. The first edition was published in 1922 as part of a Standard on Dip Tanks (now NFPA 34). Revised editions were published in 1926, 1928, 1935, 1937, 1941, 1946, 1950, 1953, 1954, 1955, 1957, 1959, 1960, 1961, 1963, 1966, 1969, 1973, 1977, 1982, 1985, 1987, 1989, and 1995.

The following are the major changes adopted in this 1995 edition of NFPA 33:

A complete revision of Chapter 3 to more clearly set forth the requirements for construction of spray areas.

A complete revision of Chapter 4 to effect editorial improvement of existing requirements and to incorporate more specific requirements for lighting fixtures and for robotic spray apparatus.

More specific and more detailed requirements for maximum allowable quantities of flammable and combustible liquids in spray areas and mix rooms.

A requirement that all automated electrostatic spray equipment installed after July 1, 1996 be listed.

A new Chapter 15 to address manufacturing processes using styrene cross-linked composites (glass fiber reinforced plastics).

Editorial improvement of all other text.

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This list represents the membership at the time the Committee was balloted on the text of this edition. Since that time, changes in membership may have occurred. A key to classifications is found at the back of this document.

NOTE: Membership on a committee shall not in and of itself constitute an endorsement of the Association or any document developed by the committee on which the member serves.

Committee Scope: This Committee shall have primary responsibility for documents on safeguarding against the fire and explosion hazards associated with spray application processes, dipping processes, coating processes, and other similar processes, including glass fiber/resin fabrication processes, except for certain dipping processes that are within the scope of the Committee on Ovens and Furnaces.

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NOTICE: An asterisk (*) following the number or letter designating a paragraph indicates that explanatory material on the paragraph can be found in Appendix A.

A parenthetical "x," i.e., "(x)," following a defined term or the number or letter designating a paragraph indicates text that has been extracted from another document. The source document is listed in parentheses at the end of the definition or paragraph.

Information on referenced publications can be found in Chapter 17 and Appendix C.

FOREWORD

The safety of life and property from fire or explosion in the spray application of flammable or combustible paints, coatings, and finishes depends upon the extent, arrangement, maintenance, and operation of the process.

An analysis of actual experience in industry demonstrates that the largest fire losses and fire frequency have occurred where good practice standards were not observed.

Chapter 1 Scope and Definitions

1-1* Scope.

1-1.1 This standard shall apply to the spray application of flammable or combustible materials, as herein defined, either continuously or intermittently, by any of the following methods:

(a) Compressed air atomization,

(b) Airless or hydraulic atomization,

(c) Electrostatic application methods,

(d) Other acceptable application means.

1-1.2 This standard shall also apply to the application of flammable or combustible materials, as herein defined, either continuously or intermittently, by any of the following methods:

(a) Fluidized bed application methods,

(b) Electrostatic fluidized bed application methods,

(c) Other acceptable application methods.

1-1.3* This standard shall not apply to spray application processes or operations that are conducted outdoors.

1-1.4* This standard shall not apply to the use of small portable spraying equipment or aerosol products that are not used repeatedly in the same location.

1-1.5 This standard shall not apply to the spray application of noncombustible materials.

Exception: Where certain waterborne, spray-applied materials that contain flammable or combustible liquids or that produce combustible residues or deposits are used, the applicable provisions of this standard shall apply.

1-1.6 This standard shall not apply to the hazards of toxicity or industrial health and hygiene. (*See 1-2.2.*)

1-2 Purpose.

1-2.1 The purpose of this standard shall be to provide requirements for reasonable fire safety for spray application of flammable or combustible materials. This standard anticipates conditions of average use. Where unusual industrial processes are involved, the authority having jurisdiction shall be permitted to require additional safeguards or modifications to the requirements of this standard, provided equivalent safety is achieved.

1-2.2 The purpose of this standard shall be to address only the fire and explosion hazards of spray application processes and operations. This standard shall not address toxicity and shall not address industrial health and hygiene. From the standpoint of personnel safety, it shall be recognized that the materials used in these processes could be present in concentrations that present a health hazard, even though these concentrations do not present a fire or explosion hazard. The requirements of this standard are intended to minimize the risk of fire and explosion; they are not intended and might not be adequate to protect personnel from the toxic or negative effects from exposure to the materials used.

1-3 Applicability. Chapters 2 through 8 and Chapter 16 shall apply to *all* spray application processes within the scope of this standard. Chapters 9 and 10 shall apply only to electrostatic spray application processes. Chapter 11 shall apply only to drying, curing, and fusion processes and operations. Chapter 12 shall apply only to automobile undercoating. Chapter 13 shall apply only to powder coating application processes and operations. Chapters 14 and 15 shall apply only to multicomponent coating systems and to processes that involve the use of catalysts, such as organic peroxide formulations.

1-4 Equivalency. Nothing in this standard shall be intended to prevent the use of systems, methods, or devices of equivalent or superior quality, strength, fire resistance, effectiveness, durability, or safety over those prescribed by this standard, provided that technical documentation is submitted to the authority having jurisdiction to demonstrate equivalency and the system, method, or device is approved for the intended purpose.

1-5 Retroactivity. The provisions of this standard shall be considered necessary to provide a reasonable level of protection from loss of life and property from fire and explosion. They reflect situations and the state-of-the-art prevalent at the time the standard was issued. Unless otherwise noted, it is not intended that the provisions of this standard be applied to facilities, equipment, structures, or installations that were existing or approved for construction or installation prior to the effective date of this standard, except in those cases where it is determined by the authority having jurisdiction that the existing situation involves a distinct hazard to life or adjacent property.

1-6 Definitions. For the purpose of this standard, the following terms shall be defined as follows.

Approved. Acceptable to the authority having jurisdiction.

NOTE: The National Fire Protection Association does not approve, inspect, or certify any installations, procedures, equipment, or materials; nor does it approve or evaluate testing laboratories. In determining the acceptability of installa-

tions, procedures, equipment, or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure, or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization concerned with product evaluations that is in a position to determine compliance with appropriate standards for the current production of listed items.

Authority Having Jurisdiction. The organization, office, or individual responsible for approving equipment, an installation, or a procedure.

NOTE: The phrase "authority having jurisdiction" is used in NFPA documents in a braod manner, since jurisdictions and approved agencies vary, as do their responsibilities. Where public safety is primary, the authority having jurisdiciton may be a federal, state, local or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction; at government installations, the commanding officer or department official may be the authority having jurisdiction.

Chopper Gun. A device that feeds glass fiber roving through a cutting unit and injects the cut glass fibers into a stream of catalized liquid resin that is then sprayed onto a surface.

Combustible Powder. Any finely-divided solid coating material that is capable of being ignited.

(Electrical) Utilization Equipment (x). Equipment that utilizes electric energy for electronic, electromechanical, chemical, heating, lighting, or similar purposes. (NFPA 70, *National Electrical Code®*, Article 100.)

Electrostatic Fluidized Bed. A chamber holding powder coating material that is aerated from below to form an air-supported, expanded cloud of the powder. The powder is electrically charged with a charge opposite to that of the object or material being coated.

Flammable or Combustible Material. Any material, including its residue, that is used in the spray application process and also meets one of the following definitions, as given elsewhere in this section:

(a) Flammable liquid,

(b) Combustible liquid,

(c) Combustible powder.

Fluidized Bed. A chamber holding powder coating material that is aerated from below to form an air-supported, expanded cloud of the powder. The object or material being coated is preheated, then immersed into the cloud.

Labeled. Equipment or materials to which has been attached a label, symbol, or other identifying mark of an organization that is acceptable to the authority having jurisdiction and concerned with product evaluation, that maintains periodic inspection of production of labeled equipment or materials, and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

Limited Combustible (x). As applied to a material of construction, any material that does not meet the definition of noncombustible, as stated elsewhere in this section, and that, in the form in which it is used, has a potential heat value not exceeding 3,500 BTU lb (8141 kJ/kg) when tested in accordance with NFPA 259, *Standard Test Method for Potential Heat of Building Materials*, and also meets one of the following subparagraphs (a) or (b).

(a) Materials having a structural base of noncombustible material, with a surfacing not exceeding a thickness of $\frac{1}{8}$ in. (3.2 mm) that has a flame spread rating not greater than 50, when tested in accordance with NFPA 255, *Standard Method of Test of Surface Burning Characteristics of Building Materials.*

(b) Materials, in the form and thickness used and not described by (a) above, having neither a flame spread rating greater than 25 nor evidence of continued progressive combustion and having such composition that surfaces that would be exposed by cutting through the material in any plane have neither a flame spread rating greater than 25 nor evidence of continued progressive combustion, when tested in accordance with NFPA 255, *Standard Method of Test of Surface Burning Characteristics of Building Materials.* (NFPA 220, *Standard on Types of Building Construction*, Chapter 2.)

Liquid (x). Any material that has a fluidity greater than that of 300 penetration asphalt when tested in accordance with ASTM D5, *Test for Penetration for Bituminous Materials.* When not otherwise identified, the term 'liquid' shall mean both flammable and combustible liquids. (See NFPA 30, *Flammable and Combustible Liquids Code,* Chapter 1.)

Combustible Liquid (x). A liquid having a flash point at or above 100°F (37.8°C).

Combustible liquids shall be subdivided as follows:

Class II liquid: Any liquid that has a flash point at or above 100°F (37.8°C) and below 140°F (60°C).

Class IIIA liquid: Any liquid that has a flash point at or above 140°F (60°C) and below 200°F (93°C).

Class IIIB liquid: Any liquid that has a flash point at or above 200°F (93°C).

(See NFPA 30, *Flammable and Combustible Liquids Code,* Chapter 1.)

Flammable Liquid (x). A liquid having a flash point below 100°F (37.8°C) and having a vapor pressure that does not exceed 40 psia (2068 mm Hg) at 100°F (37.8°C).

Flammable liquids shall be known collectively as Class I liquids and shall be subdivided as follows:

Class IA liquid: Any liquid that has a flash point below 73°F (22.8°C) and a boiling point below 100°F (37.8°C).

Class IB liquid: Any liquid that has a flash point below 73°F (22.8°C) and a boiling point at or above 100°F (37.8°C).

Class IC liquid: Any liquid that has a flash point at or above 73°F (22.8°C) and below 100°F (37.8°C).

(NFPA 30, *Flammable and Combustible Liquids Code,* Chapter 1.)

Listed. Equipment or materials included in a list published by an organization acceptable to the authority having jurisdiction and concerned with product evaluation, that maintains periodic inspection of production of listed equipment or materials, and whose listing states either that the equipment or material meets appropriate designated standards or has been tested and found suitable for use in a specified manner.

NOTE: The means for identifying listed equipment may vary for each organization concerned with product evaluation, some of which do not recognize equipment as listed unless it is also labeled. The authority having jurisdiction should utilize the system employed by the listing organization to identify a listed product.

Noncombustible Material (x). As applied to a material of construction, any material which, in the form in which it is used and under the conditions anticipated, will not ignite, burn, support combustion, or release flammable vapors when subjected to fire or heat. Materials reported as noncombustible when tested in accordance with ASTM E136, *Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C*, shall be considered noncombustible by this definition. (*See NFPA 220, Standard on Types of Building Construction,* Chapter 2.)

Nonincendive. Electrical equipment and associated wiring that are incapable, under normal operating conditions, of releasing sufficient electrical or thermal energy to cause ignition of specific hazardous materials in their most easily ignited concentrations in air.

Overspray. Any sprayed material that is not deposited on the intended object.

Resin Application Area. Any area in which polyester resins or gelcoats are spray applied.

Spray Area.* Any area in which dangerous quantities of flammable or combustible vapors, mists, residues, dusts, or deposits are present due to the operation of spray processes.

The spray area includes:

(a) The interior of any spray booth or spray room, except as specifically provided for in Section 11-4; and

(b) The interior of any exhaust plenum and any exhaust duct leading from the spray process; and

(c) Any area in the direct path of a spray application process.

Spray Booth. A power-ventilated structure that encloses a spray application operation or process, and confines and limits the escape of the material being sprayed, including vapors, mists, dusts, and residues that are produced by the spraying operation and conducts or directs these materials to an exhaust system. Spray booths are manufactured in a variety of forms, including automotive refinishing, downdraft, open-face, traveling, tunnel, and updraft booths. This definition is not intended to limit the term "spray booth" to any particular design. The entire spray booth is considered part of the spray area. A spray booth is not a spray room.

Spray Booth, Dry Type. A spray booth that is not equipped with a water-washing system to remove overspray from the exhaust airstream. A dry spray booth is equipped with one or more of the following:

(a) Distribution or baffle plates to promote an even flow of air through the booth or to reduce the overspray before it is pulled into the exhaust system;

(b) Dry media filters, either fixed or on rolls, to remove overspray from the exhaust airstream;

(c) Powder collection systems that capture powder overspray.

Spray Booth, Waterwash. A spray booth that is equipped with a water-washing system designed to minimize the concentrations of dusts or residues entering exhaust ducts and to permit the collection of the dusts or residues.

Spray Room. A power-ventilated fully-enclosed room used exclusively for open spraying of flammable or combustible materials. The entire spray room is considered part of the spray area. A spray booth is not a spray room.

Chapter 2* Location of Spray Application Operations

2-1 General. Spray application operations and processes shall be confined to spray booths, spray rooms, or spray areas, as defined in this standard.

2-2 Locations in Other Occupancies. Spray application operations and processes shall not be conducted in any building that is classified as an assembly, educational, institutional, or residential occupancy, unless they are located in a room that is separated both vertically and horizontally from all surrounding areas by construction having a fire resistance rating of not less than 2 hours and that is protected by an approved automatic sprinkler system designed and installed in accordance with NFPA 13, *Standard for the Installation of Sprinkler Systems.*

Chapter 3* Construction and Design of Spray Areas, Spray Rooms, and Spray Booths

3-1 Walls and Ceilings. Walls and ceilings that intersect or enclose a spray area shall be constructed of noncombustible or limited-combustible materials or assemblies and shall be securely and rigidly mounted or fastened. The interior surfaces of the spray area shall be smooth, designed and installed to prevent pockets that can trap residues, and designed to facilitate ventilation and cleaning.

Air intake filters that are a part of a wall or ceiling assembly shall be listed as Class 1 or Class 2, in accordance with UL 900, *Test Performance of Air Filter Units.*

The floor of the spray area shall be constructed of noncombustible material, limited-combustible material, or combustible material that is completely covered by noncombustible material.

Aluminum shall not be used.

3-1.1 If walls or ceiling assemblies are constructed of sheet metal, single-skin assemblies shall be no thinner than 0.0478 in. (1.2 mm) and each sheet of double-skin assemblies shall be no thinner than 0.0359 in. (0.9 mm).

3-1.2 Structural sections of spray booths shall be permitted to be sealed with latex-based or similar caulks and sealants to minimize air leakage.

3-1.3 Spray rooms shall be constructed of and separated from surrounding areas of the building by construction assemblies that have a fire resistance rating of 1 hour.

3-1.4 Enclosed spray booths and spray rooms shall be provided with means of egress that meet the requirements of NFPA *101®, Life Safety Code®*.

3-1.5 Spray booths that are used exclusively for powder coating shall meet the requirements of Chapter 13. They shall be permitted to be constructed of suitable fire retardant combustible materials where approved by the authority having jurisdiction.

Exception: Listed spray booth assemblies that are constructed of other materials shall be permitted.

3-2 Conveyor Openings. Conveyor openings that are necessary for transporting or moving work into and out of the spray area shall be as small as practical.

3-3* Separation from Other Occupancies. Spray booths shall be separated from other operations by a minimum distance of 3 ft (915 mm) or by a partition, wall, or floor/ceiling assembly having a minimum fire resistance rating of 1 hour. Multiple connected spray booths shall not be considered as "other operations."

Exception: As provided for in Section 11-3.

3-3.1 Spray booths shall be installed so that all parts of the booth are readily accessible for cleaning.

3-3.2 A clear space of not less than 3 ft (915 mm) shall be maintained on all sides of the spray booth. This clear space shall be kept free of any storage or combustible construction.

Exception No. 1: This requirement shall not prohibit locating a spray booth closer than 3 ft (915 mm) to or directly against an interior partition, wall, or floor/ceiling assembly that has a fire resistance rating of not less than 1 hour, provided the spray booth can be adequately maintained and cleaned.

Exception No. 2: This requirement shall not prohibit locating a spray booth closer than 3 ft (915 mm) to an exterior wall or a roof assembly provided the wall or roof is constructed of non-combustible material and provided the spray booth can be adequately maintained and cleaned.

3-4 Movement of Powered Vehicles. Powered vehicles shall not be moved into or out of a spray area or operated in a spray area unless the spray application operation or process is stopped and the ventilation system is maintained in operation.

Exception: This requirement shall not apply to vehicles that are listed for the specific hazards of the spray area.

3-5 Vision Panels. Panels for light fixtures or for observation shall be of heat-treated glass, wired glass, or hammered-wired glass and shall be sealed to confine vapors, mists, residues, dusts, and deposits to the spray area. Panels for light fixtures shall be separated from the fixture to prevent the surface temperature of the panel from exceeding 200°F (93°C).

3-6 Ventilation. Spray areas that are equipped with ventilation distribution or baffle plates or with dry overspray collection filters shall meet the requirements of 3-6.1 through 3-6.5.

3-6.1 Distribution plates or baffles shall be constructed of noncombustible materials and shall be readily removable or accessible for cleaning on both sides.

3-6.2 Filters shall not be used when applying materials known to be highly susceptible to spontaneous heating or spontaneous ignition.

3-6.3 Supports and holders for filters shall be constructed of noncombustible materials.

3-6.4 Overspray collection filters shall be readily removable or accessible for cleaning or replacement.

3-6.5 Filters shall not be alternately used for different types of coating materials if the combination of the materials might result in spontaneous heating or ignition. (*See also Section 8-8.*)

Chapter 4 Electrical and Other Sources of Ignition

4-1* General. Electrical wiring and utilization equipment shall meet all the applicable requirements of Articles 500, 501, 502, and 516 of NFPA 70, *National Electrical Code*, and this chapter.

Exception No. 1: Powered vehicles shall meet the requirements of Section 3-4.

Exception No. 2: Resin application operations shall meet the requirements of Chapter 15.

4-1.1 Electrostatic spray application apparatus also shall meet the requirements of Chapter 9 or Chapter 10, whichever is applicable.

4-1.2 Drying, curing, and fusing apparatus also shall meet the requirements of Chapter 11.

4-1.3 Automobile undercoating operations also shall meet the requirements of Chapter 12.

4-1.4 Powder coating apparatus also shall meet the requirements of Chapter 13.

4-1.5* Open flames, spark-producing equipment or processes, and equipment whose exposed surfaces exceed the autoignition temperature of the material being sprayed shall not be located in the spray area or in surrounding areas classified as Division 2.

Exception: This requirement shall not apply to drying, curing, or fusing apparatus as covered by Chapter 11.

4-1.6* Any utilization equipment or apparatus that is capable of producing sparks or particles of hot metal and is located above or adjacent to either the spray area or the surrounding Division 2 areas shall be of the totally enclosed type or shall be constructed to prevent the escape of sparks or particles of hot metal.

4-2 Electrical Devices in Spray Areas.

4-2.1 Electrical wiring and utilization equipment that is located in the spray area and is not subject to deposits of combustible residues shall be suitable for Class I, Division 1 or Class II, Division 1 locations, whichever is applicable. (See NFPA 70, *National Electrical Code.*)

4-2.2* Electrical wiring and utilization equipment that is located in the spray area and is subject to deposits of combustible residues shall be listed for such exposure and shall be suitable for Class I, Division 1 or Class II, Division 1 locations, whichever is applicable. (See NFPA 70, *National Electrical Code*.)

4-3 Electrical Devices Adjacent to Spray Areas. Electrical wiring and utilization equipment located adjacent to the spray area shall be classified in accordance with 4-3.1 through 4-3.5.

4-3.1 Electrical wiring and utilization equipment located outside, but within 20 ft (6100 mm) horizontally and 10 ft (3050 mm) vertically, of an unenclosed spray area and not separated from the spray area by partitions extending to the boundaries of the area designated as Division 2 in Figure 4-3.1 shall be suitable for Class I, Division 2 or Class II, Division 2 locations, whichever is applicable.

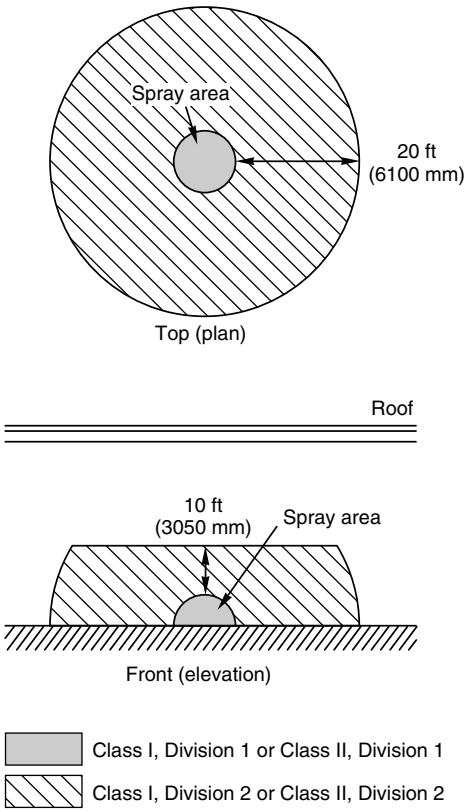


Figure 4-3.1 Electrical area classification for open spray areas.

4-3.2 If spray application operations are conducted within a closed-top, open-face or open-front booth or room, any electrical wiring or utilization equipment located outside of the booth or room but within the boundaries designated as Division 2 in Figures 4-3.2(a) and 4-3.2(b) shall be suitable for Class I, Division 2 or Class II, Division 2 locations, whichever is applicable.

The Class I, Division 2 or Class II, Division 2 locations shown in Figures 4-3.2(a) and 4-3.2(b) shall extend from the edges of the open face or open front of the booth or room in accordance with the following:

(a) If the exhaust ventilation system is interlocked with the spray application equipment, then the Division 2 location shall extend 5 ft (1525 mm) horizontally and 3 ft (915 mm) vertically from the open face or open front of the booth or room, as shown in Figure 4-3.2(a).

(b) If the exhaust ventilation system is *not* interlocked with the spray application equipment, then the Division 2 location shall extend 10 ft (3050 mm) horizontally and 3 ft (915 mm) vertically from the open face or open front of the booth or room, as shown in Figure 4-3.2(b).

For the purposes of this subsection, "interlocked" shall mean that the spray application equipment cannot be operated unless the exhaust ventilation system is operating and functioning properly and spray application is automatically stopped if the exhaust ventilation system fails.

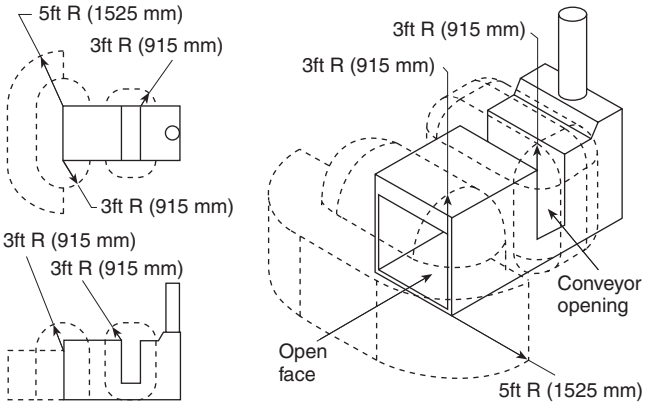


Figure 4-3.2(a) Class I (or Class II), Division 2 locations adjacent to an open-faced or open-front spray booth or spray room where exhaust ventilation is interlocked with spray application equipment.

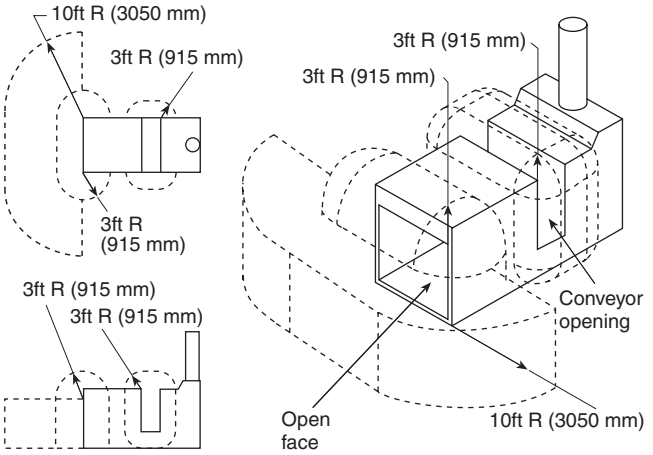


Figure 4-3.2(b) Class I (or Class II), Division 2 locations adjacent to an open-faced or open-front spray booth or spray room where exhaust ventilation is not interlocked with spray application equipment.

4-3.3 If spray application operations are conducted within an open-top booth, any electrical wiring or utilization equipment located within the space 3 ft (915 mm) vertically of the top of the booth shall be suitable for Class I, Division 2 or Class II, Division 2 locations, whichever is applicable. In addition, any electrical wiring or utilization equipment located within 3 ft (915 mm) in all directions of openings other than the open top also shall be suitable for Class I, Division 2 or Class II, Division 2 locations, whichever is applicable.

4-3.4 If spray application operations are confined to an enclosed spray booth or room, any electrical wiring or utilization equipment located within 3 ft (915 mm) of any opening shall be suitable for Class I, Division 2 or Class II, Division 2 locations, whichever is applicable. (*See Figure 4-3.4.*)

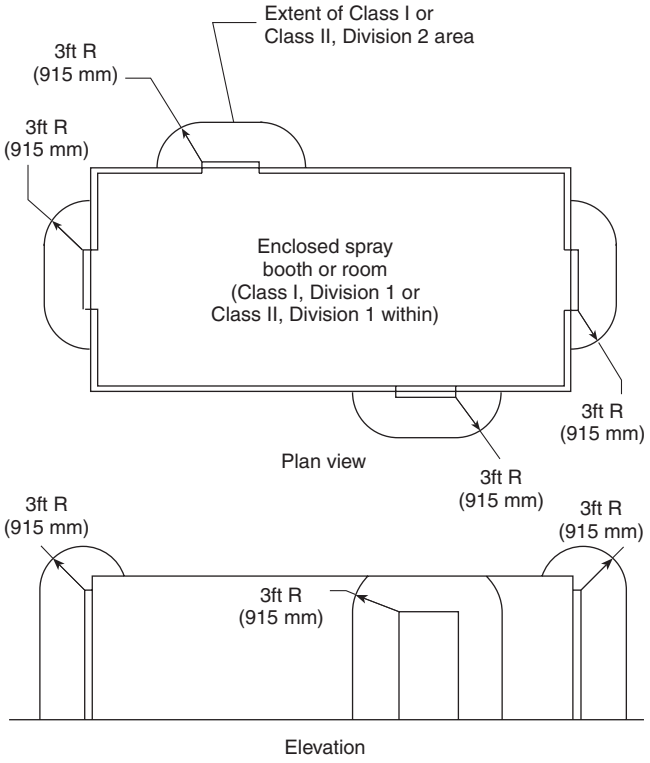


Figure 4-3.4 Class I (or Class II), Division 2 locations adjacent to an enclosed spray booth or spray room.

4-3.5 Where spray application equipment and supply containers are located in an adequately ventilated area that is adjacent to the spray area, but outside of the storage room or mixing room, the area within 3 ft (915 mm) in all directions from any open container or equipment and extending to the floor or grade level shall be classified as Class I, Division 1 or Class II, Division 1, whichever is applicable. The area extending 2 ft (610 mm) beyond the Division 1 location shall be classified as Class I, Division 2 or Class II, Division 2, whichever is applicable. In addition, the area within 10 ft (3050 mm) horizontally of the perimeter of such open container or equipment, up to a height of 18 in. (458 mm) above the floor or grade level shall be classified as Class I, Division 2 or Class II, Division 2, whichever is applicable. Electrical wiring and utilization equipment installed in these areas shall be suitable for the location. (*See Figure 4-3.5 for an example.*)

4-4 Light Fixtures.

4-4.1 Light fixtures that are attached to the walls or ceilings of a spray area, but are outside of any classified area and are separated from the spray area by glass panels that meet the requirements of Section 3-5 shall be suitable for use in ordinary hazard (general purpose) locations. (*See Figure 4-4.1.*) Such fixtures shall be serviced from outside the spray area.

4-4.2 Light fixtures that are attached to the walls or ceilings of a spray area; are located within the Class I, Division 2 or Class II, Division 2 location; and are separated from the spray area by glass panels that meet the requirements of Section 3-5 shall be suitable for use in that location. Such fixtures shall be serviced from outside the spray area. (*See Figure 4-4.1.*)

4-4.3 Light fixtures that are an integral part of the walls or ceiling of a spray area shall be permitted to be separated from the spray area by glass panels that are an integral part of the fixture. Such fixtures shall be listed for use in Class I, Division 2 or Class II, Division 2 locations, whichever is applicable, and also shall be suitable for accumulations of deposits of combustible residues. Such fixtures shall be permitted to be serviced from inside the spray area. (*See Figure 4-4.3.*)

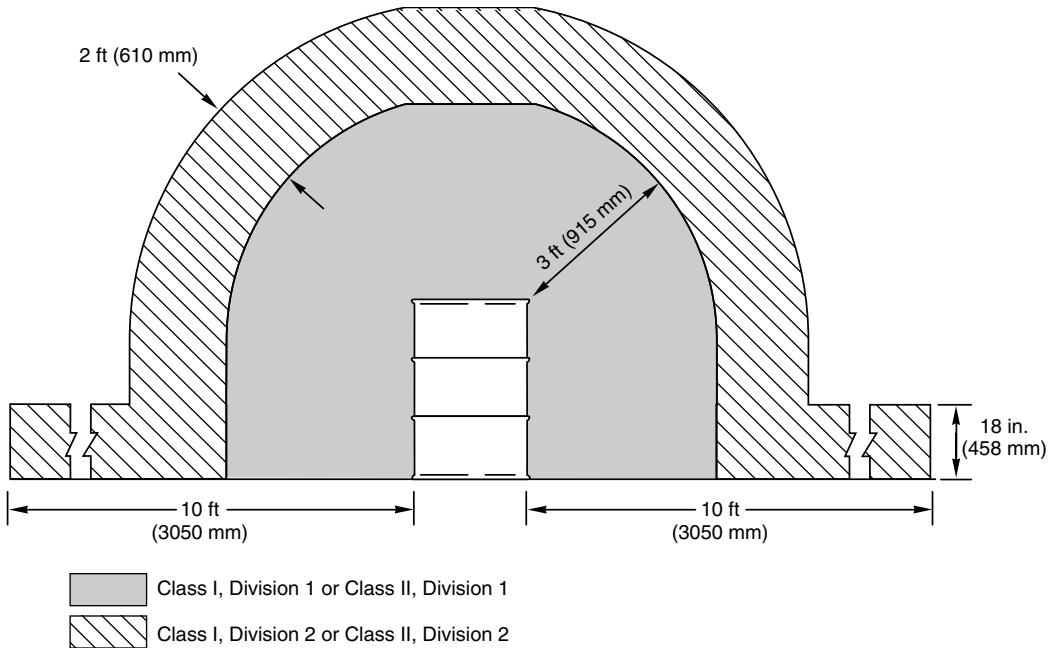


Figure 4-3.5 Electrical area classification around an open container.

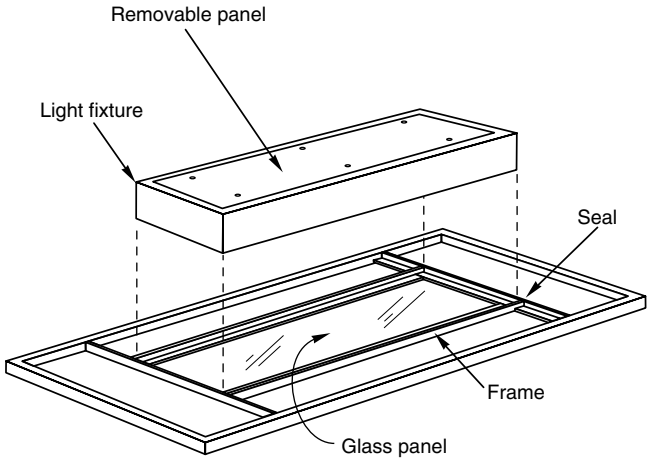


Figure 4-4.1 Example of a light fixture mounted outside of the spray area and serviced from outside the spray area.

4-4.4 Light fixtures that are located inside the spray area shall meet the requirements of Sections 4-2 and 4-5.

4-5* Static Electricity. In order to prevent sparks from the accumulation of static electricity, all persons, all electrically-conductive parts of the spray room or spray booth, the exhaust ducts, spray equipment, objects or containers that receive the spray stream, and piping systems that convey flammable or combustible liquids or aerated combustible solids shall be electrically bonded and grounded. (NFPA 77, *Recommended Practice on Static Electricity*, contains information about grounding for static electric charge.)

4-6 Flexible Power Cords. For automated equipment and robotic equipment, flexible power cords shall be permitted to be used in hazardous (classified) locations and shall be permitted to be connected to the fixed part of the electrical circuit, provided they meet all of the following conditions:

(a) They are approved for extra-hard usage;

(b) They are equipped with a grounding conductor that meets the requirements of Section 400-2 of NFPA 70, *National Electrical Code*;

(c) They are connected to terminals or conductors in an approved manner;

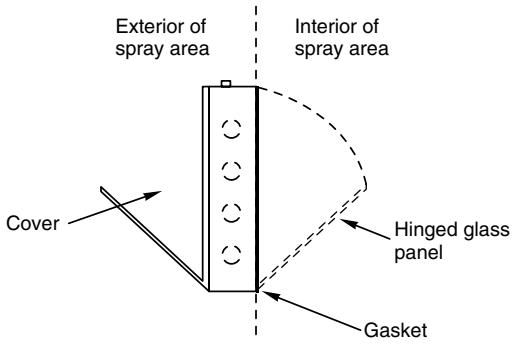
(d) They are supported by a positive mechanical clamp in such a manner that permits the cord to be readily replaced and prevents strain at the cord connections within the terminal enclosure;

(e) They are provided with explosionproof seals where the cord enters junction boxes, fittings, or enclosures;

(f) They are listed for deposits of combustible residues.

4-7 Portable Electric Lights. Portable electric light fixtures shall not be used in any spray area while spray application operations are being conducted.

Exception: Where portable electric light fixtures are required for use in spaces that are not readily illuminated by fixed light fixtures within the spray area, they shall meet the requirements of 4-2.2.



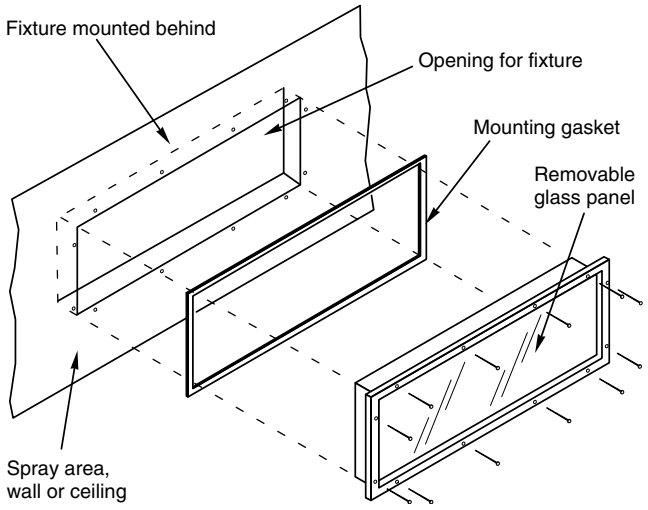


Figure 4-4.3 Examples of light fixtures that are an integral part of the spray area and are serviced from inside the spray area.

Chapter 5 Ventilation

5-1 General. Ventilating and exhaust systems shall be designed and installed in accordance with the applicable requirements of NFPA 91, *Standard for Exhaust Systems for Air Conveying of Materials*, except as amended by the requirements of this chapter.

5-2* Performance Requirements. Each spray area shall be provided with mechanical ventilation that is capable of confining and removing vapors and mists to a safe location and is capable of confining and controlling combustible residues, dusts, and deposits. The concentration of the vapors and mists in the exhaust stream of the ventilation system shall not exceed 25 percent of the lower flammable limit.

Exception: In confined spaces, where ventilation might not be capable of providing the necessary ventilation, a properly applied inerting procedure shall be permitted to be used. Such procedures shall meet the applicable requirements of NFPA 69, Standard on Explosion Prevention Systems, and shall be acceptable to the authority having jurisdiction.

5-2.1 Spray areas equipped with overspray collection filters shall have visible gauges, audible alarms, or an effective inspection program to ensure that the required air velocity is being maintained.

5-2.2 Power Coating Systems. Powder coating systems also shall meet the requirements of Section 13-6.

5-2.3 Mechanical ventilation shall be kept in operation at all times while spray operations are being conducted and for a sufficient time thereafter to allow the vapors from drying coated objects or material and residues to be exhausted. Where spray operations are conducted automatically without an attendant constantly on duty, the operating controls of the spray apparatus shall be arranged so that the spray apparatus cannot function unless the exhaust fans are operating.

5-3* Make-up Air. An adequate supply of clean make-up air shall be provided to compensate for the air exhausted from spray operations. The intake for this make-up air shall be located so that the air exhausted from spray operations is not recirculated.

5-4 Routing of Exhaust Ducts. Air exhausted from spray operations shall be conducted by ducts directly to the outside of the building. Exhaust ducts shall follow the most direct route to the point of discharge, but shall not penetrate a fire wall. The exhaust discharge shall be directed away from any fresh air intakes. The exhaust duct discharge point shall be at least 6 ft (1830 mm) from any exterior wall or roof. The exhaust duct shall not discharge in the direction of any combustible construction that is within 25 ft (7625 mm) of the exhaust duct discharge point nor shall it discharge in the direction of any unprotected opening in any noncombustible or limited-combustible construction that is within 25 ft (7625 mm) of the exhaust duct discharge point.

5-5 Recirculation of Exhaust.

5-5.1 Air exhausted from spray areas shall not be recirculated.

Exception: Air exhausted from a spray operation shall be permitted to be recirculated as make-up air for an unmanned spray operation or cascaded to subsequent unmanned spray operations, provided all of the following conditions have been met:

*(a) * Solid particulates shall have been removed from the recirculated air.*

(b) The concentration of vapors in the exhaust airstream shall not exceed 25 percent of the lower flammable limit.

(c) Listed equipment shall be used to monitor the concentration of vapors in all exhaust airstreams.

(d) An alarm shall be sounded and the spray operation shall be automatically shut down if the concentration of any vapor in the exhaust airstream exceeds 25 percent of the lower flammable limit.

(e) Equipment installed to process and remove contaminants from the air exhausted from spray operations shall be approved by the authority having jurisdiction.

5-5.2* These provisions shall not disallow the use of recirculated air to occupied spaces. However, other requirements addressing the toxicity and the permissible exposure limits shall also apply.

5-6 Manifolding of Exhaust Ducts. Individual spray booths shall be separately ducted to the building exterior.

Exception No. 1: Multiple cabinet spray booths whose combined frontal area does not exceed 18 ft^2 (1.7 m^2) shall be permitted to be manifolded, if the sprayed materials used are not likely to react and cause ignition of the residue in the ducts.

*Exception No. 2: *Where treatment of exhaust is necessary for air pollution control or for energy conservation, ducts shall be permitted to be manifolded if all of the following conditions are met:*

(a) The sprayed materials used shall be unlikely to react and cause ignition of the residue in the ducts.

(b) No nitrocellulose-based finishing material shall be used.

(c) An air-cleaning system shall be provided to reduce the amount of overspray carried into the duct manifold. (A booth filter system shall be considered adequate.)

(d) Automatic sprinkler protection shall be provided at the junction of each booth exhaust with the manifold, in addition to the protection required by Chapter 7.

(e) The installation shall be approved by the authority having jurisdiction.

5-7 Materials of Construction. Exhaust ducts and fasteners shall be constructed of steel.

Exception: Other materials of construction shall be permitted to be used in cases where the conveyed materials are not compatible with steel.

5-8* Support of Exhaust Ducts. Exhaust ducts shall be supported to prevent collapse under fire conditions.

5-8.1 Duct supports shall be designed to carry the weight of the duct system itself, plus the anticipated weight of any residues. If sprinkler protection is provided inside the duct system, then the duct supports also shall be designed to carry the anticipated weight of any accumulation of sprinkler discharge.

5-8.2 Hangers and supports shall be fastened securely to the building or to the structure to avoid vibration and stress on the duct system.

5-8.3 Hangers and supports shall be designed to allow for expansion and contraction.

5-8.4 Exhaust ducts shall not use building walls, floors, ceilings, or roofs as component parts.

5-9 Exhaust Duct Cross Section. Exhaust ducts shall be permitted to be round, rectangular, or any other suitable shape. They shall be provided with doors, panels, or other means to facilitate inspection, maintenance, cleaning, and access to fire protection devices.

5-10 Exhaust Fans and Drives.

5-10.1 The rotating element of the exhaust fan shall be nonferrous or the fan shall be constructed so that a shift of the impeller or shaft will not permit two ferrous parts of the fan to rub or strike. There shall be ample clearance between the rotating element and fan casing to avoid a fire by friction, necessary allowances being made for ordinary expansion and loading and to prevent contact between moving parts and the duct or fan housing. Fan blades shall be mounted on a shaft that is sufficiently heavy to maintain proper alignment even when the blades of the fan are heavily loaded. All bearings shall be of the self-lubricating type or shall be lubricated from a point outside the duct and preferably shall be located outside the duct and the booth.

5-10.2 Electric motors that drive exhaust fans shall not be placed inside any spray area unless they meet the provisions of 4-2.2.

5-10.3 Belts shall not enter any spray area unless the belt and pulley within the spray area is completely enclosed.

5-11* Drying Areas. Freshly sprayed workpieces shall be dried only in spaces that are ventilated to prevent the concentration of vapors from exceeding 25 percent of the lower flammable limit. *(See also Chapter 11.)*

Chapter 6 Storage, Handling, and Distribution of Flammable and Combustible Liquids

6-1* General. Storage, handling, and mixing of flammable and combustible liquids shall meet all the applicable requirements of NFPA 30, *Flammable and Combustible Liquids Code*. Storage, handling, and mixing of flammable and combustible liquids at process areas shall also meet the requirements of this chapter.

6-2 Storage in Process Areas.

6-2.1 There shall be not more than three approved flammable liquid storage cabinets in any single process area without the approval of the authority having jurisdiction. Storage cabinets shall be listed or shall be designed and constructed to meet the requirements of NFPA 30, *Flammable and Combustible Liquids Code*. Any single cabinet shall contain not more than 120 gal (454 L) of Class I, Class II, or Class IIIA liquids, of which not more than 60 gal (227 L) shall be Class I and Class II liquids.

6-2.2 The quantity of liquid located in the vicinity of spraying operations, but outside of a storage cabinet, an inside storage room, a cut-off room or attached building, or other specific process area that is cut off by at least a 2-hour fire-rated separation from the spraying operations, shall not exceed the quantity given in either (a) or (b), whichever is greater:

(a) A supply for one day, or

(b) 25 gal (95 L) of Class IA liquids in containers, plus

120 gal (454 L) of Class IB, IC, II, or III liquids in containers, plus

Two portable tanks each not exceeding 660 gal (2498 L) of Class IB, IC, Class II, or Class IIIA liquids, plus

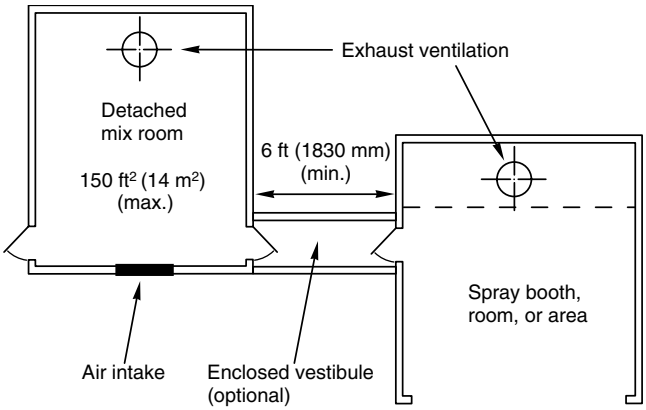
Twenty portable tanks each not exceeding 660 gal (2498 L) of Class IIIB liquids.

6-2.3 The quantity of flammable and combustible liquids located in a spray area or in a mixing room adjacent to a spray area shall meet the requirements of Section 6-3.

6-3 Mixing.

6-3.1 The withdrawal of flammable or combustible liquids from containers and the filling of containers, including portable mixing tanks, shall be done only in a mixing room or in a spray area. The amount of liquid that shall be permitted to be mixed or located in a spray area shall not exceed 60 gal (227 L). The ventilation system shall be in operation and precautions shall be taken to protect against spills of liquid and sources of ignition. (*See Maximum volume of liquid allowed in Figure 6-3.2.*)

6-3.2 Mixing rooms shall be permitted to be located adjacent to the spray area, provided quantities of liquid are less than 2 gal/ft^2 (81.5 L/m^2), the floor area is less than 150 ft^2 (14 m^2), and the installation meets the requirements of 6-3.2.1 through 6-3.2.6. (*See Figure 6-3.2 for an example of this arrangement.*)



Maximum volume of liquid allowed:

	Gallons	Liters
Spray area	60	227
Mix room	300	1135

Figure 6-3.2 Spray area (booth, room, or open area) with adjacent detached mixing room, including maximum volume of liquid allowed.

6-3.2.1 Where the combined quantities of liquids located in a spray area and in the mixing room do not exceed 60 gal (227 L), then the mixing room shall be permitted to be located less than 6 ft (1830 mm) from the spray area or shall be permitted to be an integral part of the spray booth or spray room. [*See Figures 6-3.2.1(a), 6-3.2.1(b), and 6-3.2.1(c) for examples.*]

6-3.2.2 Construction shall meet the requirements of Section 3-1, 3-1.1, and 3-1.2.

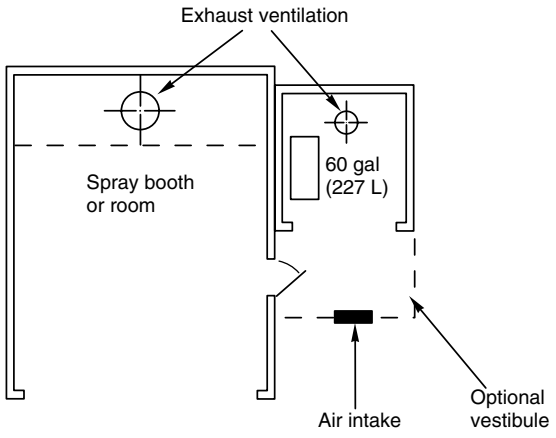
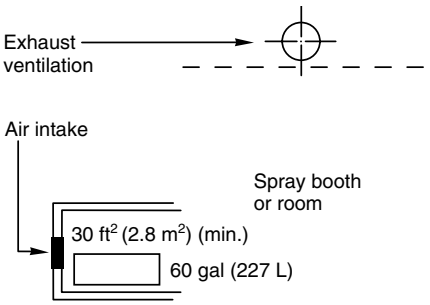


Figure 6-3.2.1(a) Spray booth or spray room with adjacent three-sided mixing room, with or without vestibule.

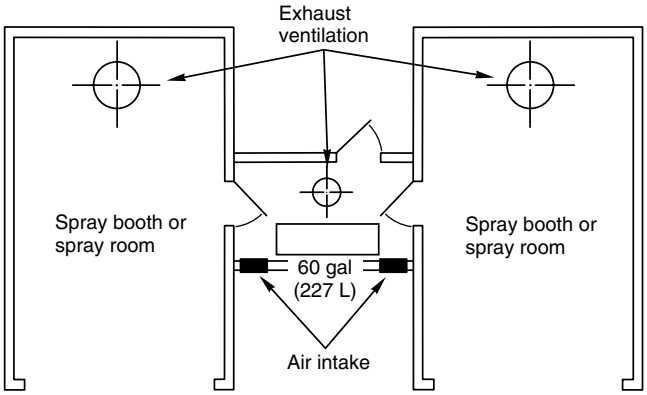


Maximum volume of liquid allowed:

	Gallons	Liters
Spray area and mixing room	60	227

Note: Additional ventilation might be required.

Figure 6-3.2.1(b) Spray booth or spray room with integral mixing room.



Maximum volume of liquid allowed: 60 gal (227 L)

Figure 6-3.2.1(c) Spray booth or spray room connected by enclosed mixing room.

6-3.2.3 The room shall be designed to contain a liquid spill.

6-3.2.4 The room shall be provided with continuous mechanical ventilation with a capacity of not less than 1 cfm/ft² (0.3 $m^3/min/m^2$) with a minimum rate of 150 cfm (4 m^3/min).

6-3.2.5 An approved automatic fire extinguishing system that meets the requirements of Chapter 7 shall be provided.

6-3.2.6 An adequate number of suitable fire extinguishers shall be provided and shall be located immediately adjacent to the mixing room. (*See NFPA 10, Standard for Portable Fire Extinguishers.*)

6-3.3 Where the quantities of liquids or the floor area exceed those specified in 6-3.1 and 6-3.2, the requirements of NFPA 30, *Flammable and Combustible Liquids Code*, shall apply.

6-3.4 Dispensing and mixing rooms shall be classified, for purposes of electrical area classification, the same as enclosed spray booths, in accordance with 4-3.4.

6-4 Distribution Systems — Piping.

6-4.1 Piping systems that convey flammable or combustible liquids between storage tanks, mixing rooms (paint kitchens), and spray areas shall be of steel or other material having comparable properties of resistance to heat and physical damage. The piping systems shall be installed so that a rupture of the system for any reason is unlikely. Piping systems shall be properly bonded and grounded. (NFPA 77, *Recommended Practice on Static Electricity*, provides information on bonding and grounding.)

6-4.2* Piping systems within the spray area shall be of steel or material having comparable heat and physical resistance where possible. Where tubing or hose is used, a shut-off valve shall be provided on the steel pipe at the connection.

6-4.3* Tubing or hose shall be periodically inspected and replaced as necessary. Replacement tubing or hose shall be that recommended by the equipment manufacturer.

6-4.4 Where a pump is used to supply the liquid used in the spray application process, piping, tubing, hose, and other accessories shall be designed to withstand the maximum working pressure of the pump, or means shall be provided to limit the discharge pressure of the pump.

6-4.5* Where a pump is used to supply the liquid used in the spray application process, an automatic means shall be provided to shut off the supply of liquid in event of a fire. When pressurized tanks larger than 5 gal (19 L) are used to supply the liquid used in the spray application process, an automatic means shall be provided to shut off liquid flow at the tank outlet in the event of fire.

6-4.6 All pressure tubing, hose, and couplings shall be inspected at regular intervals appropriate to the service. With the hose extended, the hose and couplings shall be tested using the "in-service maximum operating pressure." Any hose showing material deteriorations, signs of leakage, or weakness in its carcass or at the couplings shall be replaced.

6-5 Distribution Systems — General.

6-5.1 Closed containers, approved portable tanks, approved safety cans, or a properly arranged system of piping shall be used for transporting liquids. Open containers shall not be used for transportation or storage.

6-5.2 Wherever liquids are transferred from one container to another, both containers shall be effectively bonded and grounded to dissipate static electricity. (NFPA 77, *Recommended Practice on Static Electricity*, provides information on static protection.)

6-5.3 Containers that supply spray nozzles shall be of the closed type or shall be provided with metal covers that are kept closed. Containers that do not rest on the floor shall have properly designed supports or shall be suspended by wire cables. Containers that supply spray nozzles by gravity flow shall not exceed 10-gal (38-L) capacity.

6-5.4 Original shipping containers shall not be subjected to air pressure for supplying spray nozzles.

6-5.5 Containers that are pressurized to supply spray nozzles, air storage tanks, and coolers shall comply with all applicable requirements of the ASME, *Code for Unfired Pressure Vessels*, for construction, tests, and maintenance.

6-5.6 If a heater is used to heat the liquid being sprayed, it shall be low-pressure steam, low-pressure hot water, or electric. If electric, it shall be approved and listed for the specific location in which it is used. (*See Chapter 4.*) Heaters shall not be located in spray booths or other locations subject to the accumulation of deposits of combustible residue. Agitators, if used, shall be driven by compressed air, water, low-pressure steam, or electricity. If powered by an electric motor, the motor shall meet the requirements of Chapter 4.

Chapter 7* Protection

7-1 General. Spray areas and mixing rooms shall be protected with an approved automatic fire extinguishing system.

7-1.1 For continuous spray application operations, activation of the fire extinguishing system shall automatically accomplish all of the following:

(a) Activate a local alarm in the vicinity of the spraying operation and activate the facility's alarm system, if such a system is provided,

(b) Shut down the coating material delivery system,

(c) Terminate all spray application operations,

(d) Stop any conveyors into and out of the spray area.

(*See Sections 7-5 and 7-6 for additional requirements for fixed powder application systems and fixed liquid electrostatic application systems.*)

7-1.2 Also for continuous spray application operations, a manual fire alarm and emergency system shut-down station shall be installed to serve each spray area. When activated, this station shall accomplish all of the functions listed in 7-1.1 (a) through (d). At least one such station shall be within ready access of operating personnel. If access to this station is likely to involve exposure to danger, an additional station shall be located adjacent to an exit from the area.

7-1.3 Air make-up and spray area exhaust systems shall not be interlocked with the fire alarm system and shall remain functioning during any fire alarm condition.

Exception No. 1: Where the type of fire extinguishing system used requires that ventilation be discontinued, air make-up and exhaust systems shall be permitted to be shut down and dampers shall be permitted to close.

Exception No. 2: For powder coating systems, the requirements of Section 7-5 shall be met instead of 7-1.3.

7-2* Automatic Sprinkler Systems.

7-2.1 The automatic sprinkler system in spray areas and mixing rooms shall meet all applicable requirements of NFPA 13, *Standard for the Installation of Sprinkler Systems*, for Extra Hazard (Group 2) occupancies.

Exception: As provided for in Section 15-3.

7-2.2 The automatic sprinkler system shall be a wet pipe system where practical. Spray operations that require an open-head deluge system, a combination open- and closed-head automatic sprinkler system, a foam-water sprinkler system, or any other type of extinguishing system (dry chemical or gaseous agent) shall be so protected, subject to the approval of the authority having jurisdiction.

7-2.3 Water supply for sprinklers shall be sufficient to supply all sprinklers likely to open in any one fire incident without depleting the available water for use in hose streams. Where sprinklers are installed to protect spray areas and mixing rooms only, water shall be permitted to be furnished from the domestic supply, subject to the approval of the authority having jurisdiction and provided the domestic supply can meet the design criteria for Extra Hazard (Group 2) occupancies, as defined in NFPA 13, *Standard for Sprinkler Systems.*

7-2.4* The sprinklers for each spray area and mixing room shall be controlled by a separate, accessible, listed indicating valve. Sprinkler systems in stacks or ducts shall be automatic and of a type not subject to freezing.

7-2.5 Sprinklers protecting spray areas and mixing rooms shall be protected against overspray residue so that they will operate quickly in event of fire. If covered, cellophane bags having a thickness of 0.003 in. (0.076 mm) or less, or thin paper bags shall be used. Coverings shall be replaced frequently so that heavy deposits of residue do not accumulate. Sprinklers that have been painted or coated, except by the sprinkler manufacturer, shall be replaced with new listed sprinklers having the same characteristics.

7-3 Alternate Extinguishing Systems.

7-3.1* Where automatic sprinkler protection is not available or where another type of extinguishing means is better suited to provide the required protection for the spray application operation, spray areas and mixing rooms shall be permitted to be protected with a dry chemical extinguishing system installed in accordance with the requirements of NFPA 17, *Standard for Dry Chemical Extinguishing Systems*; a carbon dioxide system installed in accordance with the requirements of NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems*; or a gaseous agent extinguishing system installed in accordance with NFPA 2001, *Standard on Clean Agent Fire Extinguishing Systems.*

7-3.2* The extinguishing system shall be capable of discharging its contents into the entire protected area simultaneously, including the exhaust plenum and exhaust ductwork.

7-4 Portable Fire Extinguishers. An adequate supply of approved portable fire extinguishers shall be installed near all spray areas and mixing rooms. (See NFPA 10, *Standard for Portable Fire Extinguishers.*)

7-5* Protection for Automated Powder Application Equipment. Automated powder application equipment shall be protected further by the installation of an approved, supervised flame detection apparatus that shall, in event of ignition, react to the presence of flame within one-half (0.5) second and shall accomplish all of the following:

(a) Shut down all energy supplies (electrical and compressed air) to conveyor, ventilation, application, transfer, and powder collection equipment;

(b) Close segregation dampers in associated ductwork to interrupt airflows from application equipment to powder collectors;

(c) Activate an alarm.

7-6* Protection for Automated Liquid Electrostatic Spray Application Equipment. Automated liquid electrostatic spray application equipment shall be further protected by the installation of an approved, supervised flame detection apparatus that shall, in event of ignition, react to the presence of flame within one-half (0.5) second and shall accomplish all of the following:

(a) Meet all of the requirements of 7-1.1,

(b) Disconnect power to the high voltage elements in the spray area and de-energize the system.

Chapter 8* Operations and Maintenance

8-1* General. Maintenance procedures shall be established to ensure that all spray application apparatus and processes are operated and maintained in accordance with the manufacturers' specifications and the requirements of this standard. Proper maintenance shall be the responsibility of the users of the apparatus and processes.

8-1.1* Spray application operations shall not be conducted outside of predetermined spray areas, and all requirements of this standard that apply to spray areas shall be followed strictly.

8-2* Combustible Deposits. All spray areas shall be kept free of the accumulation of deposits of combustible residues. Combustible coverings (thin paper, plastic, etc.) and strippable coatings shall be permitted to be used to facilitate cleaning operations in spray areas. If residue accumulates to excess in booths, duct or duct discharge points, or other spray areas, then all spraying operations shall be discontinued until conditions are corrected.

8-3 High Pressure Hose Lines. High pressure hose lines that convey flammable or combustible coating material in "airless" spray application operations shall be frequently inspected and properly maintained. Hose lines and equipment shall be located so that, in the event of a leak or rupture, coating material will not be discharged into any space having a source of ignition.

8-4 Maintenance Procedures.

8-4.1 Maintenance procedures shall be established to ensure that overspray collector filters are replaced before excessive restriction to airflow occurs. Overspray collectors shall be inspected after each period of use, and clogged filters shall be discarded and replaced.

8-4.2 All discarded overspray collector filters, residue scrapings, and debris contaminated with residue shall be removed immediately to a safe, well-detached location or placed in a water-filled metal container and disposed of at the close of the day's operation unless maintained completely submerged in water.

8-5* Waste Containers. Approved metal waste cans shall be provided wherever rags or waste are impregnated with sprayed material and all such rags or waste deposited therein immediately after use. The contents of waste cans shall be disposed of properly at least once daily at the end of each shift.

8-6 Clothing. Employees' clothing contaminated with sprayed material shall not be left on the premises overnight unless kept in metal lockers.

8-7 Cleaning Solvents.

8-7.1 Solvents for cleaning operations shall have flash points above 100°F (37.8°C).

Exception: For cleaning spray nozzles and auxiliary equipment, solvents having flash points not less than those normally used in spray operations shall be permitted to be used.

8-7.2 Cleaning operations using flammable or combustible solvents shall be conducted inside spray areas with ventilating equipment operating or in other adequately ventilated locations that meet the requirements of Chapter 4.

8-8* Spontaneous Ignition Hazards. The same spray booth shall not be alternately used for different types of coating materials if the combination of the materials is conducive to spontaneous ignition, unless all deposits of the first-used coating material are removed from the booth and exhaust ducts prior to spraying with the second coating material.

8-9* Chlorinated Solvents. Coating materials containing chlorinated solvents shall not be used with spray application apparatus or fluid-handling equipment if the chlorinated solvent will come into contact with aluminum within a piping system, pump, enclosed container, or any enclosure that is capable of being pressurized by the potential reaction. This shall apply even if the container or system has been constructed with pressure relief devices.

8-10 Smoking. "NO SMOKING OR OPEN FLAMES" signs in large letters on contrasting color background shall be conspicuously posted at all spray areas and paint storage rooms.

8-11* Hot Work. Welding, cutting, and similar spark-producing operations shall not be permitted in or adjacent to spray areas until a written permit authorizing such work has been issued. The permit shall be issued by a person in authority following his or her inspection of the area to ensure that proper precautions have been taken and will be followed until the job is completed. (See NFPA 51B, *Standard for Fire Prevention in Use of Cutting and Welding Processes.*)

Chapter 9 Automated Electrostatic Spray Equipment

9-1 Scope. This chapter shall apply to any equipment using electrostatically charged elements for the atomization, charging, and (or) precipitation of flammable and combustible materials for coatings on articles or for other similar purposes in which the charging or atomizing device is attached to a mechanical support or manipulator. This shall include robotic devices. This chapter shall not apply to devices that are held or manipulated by hand.

9-2 General.

9-2.1 The installation and use of automated electrostatic spray application apparatus shall comply with the requirements of this chapter and also shall comply with the applicable requirements of all other chapters.

9-2.2 Where robot programming procedures involve manual manipulation of the robot arm while spraying with the high voltage components energized, the provisions of Section 10-5 also shall apply.

9-3 Automated Electrostatic Systems. All automated electrostatic equipment systems shall comply with the requirements of 9-3.1 through 9-3.9.

9-3.1 Transformers, high voltage supplies, control apparatus, and all other electrical portions of the equipment shall be located outside of the spray area, as defined in Chapter 1, or shall otherwise meet the requirements of Chapter 4 of this standard.

Exception: High voltage grids, electrodes, electrostatic atomizing heads, integral power supplies, and their connections shall not be required to meet this requirement.

9-3.2 Electrodes and electrostatic atomizing heads shall be adequately supported and shall be insulated from ground. Electrodes and electrostatic atomizing heads that are permanently attached to their bases, supports, reciprocators, or robots shall be deemed to comply with this section.

9-3.3 High voltage leads shall be properly insulated and protected from mechanical damage or exposure to destructive chemicals. Any exposed element at high voltage shall be effectively and permanently supported on suitable insulators and shall be effectively guarded against accidental contact or grounding.

9-3.4* All electrically conductive objects in the spray area, except those objects required by the process to be at high voltage, shall be electrically connected to ground with a resistance of not more than 1 megohm. This requirement shall apply to containers of coating material, wash cans, guards, hose connectors, brackets, and any other electrically conductive objects or devices in the area. This requirement shall also apply to any personnel that might be in the spray area.

9-3.4.1 Containers for any liquids in the spray area also shall be electrically conductive.

9-3.5 Objects or material being coated shall be electrically connected to ground with a resistance of not more than 1 megohm. Areas of contact shall be sharp points or knife edges, where possible, and those areas of contact shall be protected from overspray, where practical.

9-3.5.1 Objects or material transported by a conveyor shall be maintained in electrical contact with the conveyor or other grounding contacts. Hooks and hangers shall be cleaned regularly to ensure adequate grounding.

9-3.6 Electrostatic apparatus shall be equipped with automatic means that rapidly de-energizes the high voltage elements under any of the following conditions:

(a) Shutdown of ventilating fans or failure of ventilating equipment from any cause.

(b) Stopping of the conveyor carrying objects or material through the high voltage field unless stopping is required by the spray process.

(c) Occurrence of excessive current leakage at any point on the high voltage system.

(d) De-energizing the primary voltage input to the power supply.

9-3.7 Safeguards such as adequate booths, fencing, railings, interlocks, or other means shall be placed about the equipment or incorporated therein so that they, either by their location or character or both, ensure that a safe separation of the process is maintained.

9-3.8 Signs shall be conspicuously posted to:

(a) Designate the process zone as dangerous with regard to fire and accident.

(b) Identify the grounding requirements for all electrically conductive objects in the spray area, including persons.

(c) Restrict access to qualified personnel only.

9-3.9 All insulators shall be kept clean and dry.

9-4 Incendive Equipment. Spray equipment that is not considered to be nonincendive shall comply with 9-4.1 and 9-4.2.

9-4.1 Conveyors or hangers shall be arranged to maintain a distance of at least twice the sparking distance between the objects or material being spray coated and electrodes, electrostatic atomizing heads, or charged conductors. Warnings defining this safe distance shall be provided.

9-4.2 The high voltage elements shall be automatically de-energized rapidly enough to prevent an arc in the event the clearance between the objects or material being coated and the electrodes or electrostatic atomizing heads falls below that specified in 9-4.1.

9-5 Listing and Approved.

9-5.1 Spray equipment shall be listed or approved.

9-5.2 Spray equipment installed after July 1, 1996, shall be listed.

Exception: This requirement shall not apply to replacement components for systems installed on or before July 1, 1996.

Chapter 10 Hand-Held Electrostatic Spray Equipment

10-1 Scope. This chapter shall apply to any equipment using electrostatically charged elements for the atomization, charging, and (or) precipitation of flammable and combustible materials for coatings on articles or for other similar purposes in which the charging or atomizing device is hand-held and manipulated during the spraying operation.

10-2 General. The installation and use of hand-held electrostatic spray application apparatus shall comply with the requirements of this chapter and also shall comply with the applicable requirements of all other chapters.

10-3 Hand-Held Apparatus. Hand-held electrostatic spray apparatus and devices shall be listed. The high voltage circuits shall be designed so as not to produce a spark of sufficient intensity to ignite the most hazardous of those vapor-air mixtures or powder-air mixtures likely to be encountered, nor to result in appreciable shock hazard upon coming in contact with a grounded object under all normal operating conditions.

10-3.1 The electrostatically charged exposed elements of the hand gun shall be capable of being energized only by an actuator that also controls the coating material supply.

10-3.2 Where the liquid coating material is electrically energized, adequate precautions shall be taken to prevent electric shock.

10-4 Electrical Components. Transformers, high voltage supplies, control apparatus, and all other electrical portions of the equipment, with the exception of the hand gun itself and its connections to the power supply, shall be located outside of the spray area or shall otherwise meet the requirements of Chapter 4.

10-5 Grounding.

10-5.1* The handle of the spray gun shall be electrically connected to ground by a conductive material. It shall be constructed so that the operator, in normal operating position, is in electrical contact with the grounded handle by a resistance of not more than 1 megohm to prevent buildup of a static charge on the operator's body. Signs indicating the necessity for grounding persons entering the spray area shall be conspicuously posted.

10-5.2 All electrically conductive objects in the spray area, except those objects required by the process to be at high voltage, shall be electrically connected to ground with a resistance of not more than 1 megohm. This requirement shall apply to containers of coating material, wash cans, guards, hose connectors, brackets, and any other electrically conductive objects or devices in the area. This requirement also shall apply to any personnel that might be in the area.

10-5.3 Objects or material being coated shall be electrically connected to ground with a resistance of not more than 1 megohm. Areas of contact shall be sharp points or knife edges, where possible, and those areas of contact shall be protected from overspray, where practical.

10-5.4 Objects or material transported by a conveyor shall be maintained in electrical contact with the conveyor or other grounding contacts. Hooks and hangers shall be cleaned regularly to ensure adequate grounding.

Chapter 11 Drying, Curing, or Fusion Processes

11-1 General. Drying, curing, or fusing apparatus used in connection with spray application of flammable and combustible materials shall meet all applicable requirements of NFPA 86, *Standard for Ovens and Furnaces*.

11-1.1 Spray booths, spray rooms, or other enclosures used for spray application of flammable and combustible materials shall not be used for drying, curing, or fusing operations.

Exception: As provided for in Sections 11-2 and 11-3.

11-2 Spray Enclosures Used for Ambient Air Drying. If a spray booth, spray room, or other enclosure is also used for air-drying, curing, or fusing operations and the air temperature therein is not elevated above ambient conditions, the ventilation system shall maintain the concentration of any vapors in the exhaust stream below 25 percent of the lower flammable limit.

11-3 Spray Enclosures Used For Drying at Elevated Temperatures.

11-3.1 Spray booths, spray rooms, or other enclosures used for batch-type spray application operations, including automobile refinishing operations, shall be permitted to alternately be used for drying, curing, or fusing operations, provided they meet all applicable requirements of this standard and the requirements of 11-3.1.1 through 11-3.1.6.

11-3.1.1 The interior surfaces (especially the floor) of the spray area shall be cleaned regularly to minimize the accumulation of deposits of combustible residues.

11-3.1.2 A high temperature limit switch shall be provided to automatically shut off the drying apparatus if the air temperature in the spray area exceeds 200°F (93°C).

11-3.1.3 Radiant drying apparatus that is permanently attached to the walls, ceiling, or partitions of the spray area shall be listed for exposure to flammable or combustible vapors, mists, dusts, residues, or deposits.

11-3.1.4 Spraying apparatus, drying apparatus, and the ventilating system shall be equipped with suitable interlocks arranged so that:

(a) Spray apparatus cannot be operated when drying apparatus is in operation or while portable radiant drying apparatus is in the spray area, and

(b) Interlocks comply with NFPA 86, *Standard for Ovens and Furnaces*.

11-3.1.5 Any containers of flammable or combustible liquids shall be removed from the booth before the drying apparatus is energized.

11-3.1.6 Fuel tanks containing fuel other than gasoline or diesel fuel shall be removed from any vehicle brought into the spray area.

11-3.2 Spray booths, spray rooms, or other enclosures used for spray application operations shall be permitted to be adjacent to or connected to rooms or equipment used for drying, curing, or fusing. Interconnecting doors and related interlocks shall meet the requirements of NFPA 86, *Standard for Ovens and Furnaces*. In addition, an interlock shall be provided to prevent spray application operations when the interconnecting doors are open. A high temperature limit switch shall be provided to automatically shut off the drying apparatus if the air temperature in the spray area exceeds 200°F (93°C).

11-4 Warning Signs. Drying, curing, or fusing apparatus shall be affixed with a permanently attached, prominently located warning sign indicating that ventilation shall be maintained during the drying, curing, or fusing period and that spraying shall not be conducted in the vicinity in such manner as to deposit residue on the apparatus.

11-5* Ventilation. All fusing apparatus shall be adequately ventilated to remove any vapors generated.

Chapter 12 Automobile Undercoating in Garages

12-1 General. Spray undercoating of automobiles in garages, conducted in areas having adequate natural or mechanical ventilation, shall be exempt from the requirements of this standard pertaining to spray coating operations, where:

(a) Undercoating materials not more hazardous than kerosene (as classified by Underwriters Laboratories Inc. in respect to fire hazard rating 30-40) are used; or

(b) Undercoating materials using only solvents having a flash point in excess of 100°F (37.8°C) are used; and

(c) No open flames are within 20 ft (6100 mm) while such operations are conducted.

12-2 Non-complying Undercoating Operations. Spray undercoating operations that do not meet the requirements of Section 12-1 shall meet all applicable requirements of this standard pertaining to spray finishing operations.

Chapter 13 Powder Coating

13-1 Scope. This chapter shall apply to processes in which combustible dry powders are applied by spray application operations. The hazards associated with combustible dusts are present in such processes to a degree depending upon the chemical composition of the material and its particle size, shape, and distribution. Generally, coating powders are applied by means of:

(a) Fluidized bed,

(b) Electrostatic fluidized bed,

(c) Powder spray guns,

(d) Electrostatic powder spray guns.

13-2 General. The installation and use of powder coating application apparatus shall comply with the requirements of this chapter and also shall comply with the applicable requirements of all other chapters.

13-3 Applicability. Sections 13-4 through 13-9 are general and shall apply to all methods of powder coating application. Sections 13-10 through 13-12 shall apply to the specific method indicated therein.

13-4 Location. Powder coating operations shall be confined to properly designed enclosures provided with protection that meets the requirements of Chapter 7 and shall be located in accordance with Section 2-2.

13-5 Enclosures. Powder shall be effectively confined by conducting coating operations within:

(a) Completely enclosed, adequately ventilated rooms of noncombustible or limited-combustible construction with smooth surfaces designed to prevent accumulation of powder and to facilitate cleaning, or

(b) Adequately ventilated spray booths meeting the requirements of Sections 3-1 through 3-5, and by using effectively enclosed, adequately ventilated containers (tanks, bins, etc.).

13-6 Electrical and Other Sources of Ignition.

13-6.1 Electrical equipment and other sources of ignition shall meet both the requirements of Chapter 4 of this standard and Articles 500 and 502 of NFPA 70, *National Electrical Code.*

13-6.2 When the object or material being coated is preheated in an oven, the controls shall be set so that the surface temperature of the object or material does not come within 50°F (28°C) of the autoignition temperature of the powder used.

13-6.3 All electrically conductive objects in the spray area, except those objects required by the process to be at high voltage, shall be electrically connected to ground with a resistance of not more than 10^6 ohms (1 megohm), as measured with an instrument that applies at least 500 volts to the circuit being evaluated. This requirement also shall apply to any personnel that might be in the area.

13-7* Ventilation.

13-7.1 Where powder overspray is conveyed by means of ductwork to a remote recovery system, the following shall apply:

(a) Nondeposited, air-suspended powders shall be safely removed from the spray operation to the powder recovery system. For systems connected by ducts to enclosed collectors, sufficient airflow shall be provided to maintain the exhaust duct at a powder concentration that will not exceed one-half the "minimum explosive concentration" (MEC) of the powder in use. [*See 13-7.1(b) for exception.*] If the MEC of the powder has not been established, then the exhaust duct powder concentration shall be maintained below 0.015 oz/ft^3 (15 g/m^3). Exhaust equipment shall bear an identification plate stating the ventilation rate for which it was designed (ft^3/or m^3/hr).

(b) Where, by design, the coating operation is conducted at an exhaust duct concentration above 50 percent of the MEC, listed explosion suppression equipment shall be provided. (See NFPA 69, *Standard on Explosion Prevention Systems.*)

13-7.2 Where powder overspray is collected at the spray area by a recovery system that is a part of the spray system, the requirements of 13-7.1 shall not apply.

13-7.3 Air exhausted from the recovery system of a powder operation shall not be recirculated unless the particulate composition of the exhaust air has been returned to an acceptable safe level and suitable equipment continuously monitors the filtration system to signal the operator and to automatically shut down the operation in the event the filtration system fails to maintain the air in this condition.

13-7.4 Any enclosures of a powder coating operation (booth, recovery enclosure, etc.) that are effectively "tight" enclosures shall be provided with adequate deflagration venting to safely relieve internal pressure in case of mixture ignition. (See NFPA 68, *Guide for Venting of Deflagrations.*)

13-7.5 Ventilation for fluidized beds and electrostatic fluidized beds shall be designed to effectively prevent escape of nondeposited powder from the enclosure.

13-7.6 Ventilation for spray booths shall be adequate to confine air-suspended powder to the booth and recovery system at all times.

13-8 Drying, Curing, or Fusing Equipment.

13-8.1 The temperature of the object or material being coated shall be maintained at least 50°F (28°C) below the autoignition temperature of the powder.

13-8.2 Drying, curing, and fusing equipment shall meet all applicable requirements of NFPA 86, *Standard for Ovens and Furnaces.*

13-9 Operation and Maintenance.

13-9.1 The area surrounding the spray area, including horizontal surfaces such as ledges, beams, pipes, hoods, and booth floors, shall be maintained to prevent the accumulation of powder.

13-9.2 Surfaces shall be cleaned in such manner as to avoid scattering powder or creating powder clouds. Vacuum sweeping equipment, where used, shall be of a type approved for use in hazardous locations.

13-9.3 Means shall be provided to prevent tramp iron or spark-producing material from being introduced into the powders being applied.

13-9.4 "NO SMOKING OR OPEN FLAMES" signs in large letters on contrasting color background shall be conspicuously posted at all powder coating areas and powder storage rooms.

13-10 Automated Electrostatic Powder Spraying Equipment. The provisions of Chapter 9 and other sections of Chapter 13 shall apply to fixed electrostatic equipment, except that electrical equipment not covered therein shall conform to Section 13-6.

13-11 Hand-Held Electrostatic Powder Spraying Equipment. The provisions of Chapter 10 and other sections of Chapter 13 shall apply to electrostatic hand guns where used in powder coating, except that the high voltage circuits shall be designed so as not to produce a spark of sufficient intensity to ignite any powder-air mixtures likely to be encountered instead of the vapor-air mixtures referred to, and except that electrical equipment not covered therein shall conform to Section 13-6.

13-12 Electrostatic Fluidized Beds.

13-12.1 The high voltage circuits shall be designed so that any discharge produced when the charging electrodes of the bed are approached or contacted by a grounded object shall not be of sufficient intensity to ignite any powder-air mixture likely to be encountered, nor result in an appreciable shock hazard.

13-12.2 Transformers, power packs, control apparatus, and all other electrical portions of the equipment, with the exception of the charging electrodes and their connections to the power supply, shall be located outside of the area classified as hazardous or otherwise shall conform to the requirements of Section 13-6.

13-12.3 All electrically conductive objects within the powder coating area, except those objects required by the process to be at high voltage, shall be electrically connected to ground with a resistance of not more than 10^6 ohms (1 megohm). This requirement also shall apply to any personnel who might be in the area. The powder coating equipment shall carry a prominent, permanently installed warning regarding the necessity for grounding these objects.

13-12.4 Objects or material being coated shall be maintained in electrical contact [less than 10^6 ohms (1 megohm)] with the conveyor or other support in order to ensure proper grounding. Hangers shall be regularly cleaned to ensure effective contact. Areas of contact shall be sharp points or knife edges where possible.

13-12.5 The electrical equipment and compressed air supplies shall be interlocked with the ventilation system so that the equipment cannot be operated unless the ventilation fans are in operation.

Chapter 14* Organic Peroxides and Plural Component Coatings

14-1 Scope. This chapter shall apply to the spray application operations that involve the use of organic peroxide formulations and other plural component coatings.

Exception: As covered in Chapter 15.

14-2 General. Spray application operations that involve the use of organic peroxide formulations and other plural component coatings shall be conducted in spray areas that are protected by approved automatic sprinkler systems that meet the requirements of Chapter 7.

14-3 Prevention of Contamination. Care shall be exercised at all times to prevent the contamination of organic peroxide formulations with any foreign substance. Only spray guns and related handling equipment that are specifically manufactured for use with organic peroxide formulations shall be used. Separate fluid-handling equipment shall be used for the resin and for the catalyst and they shall not be interchanged.

14-3.1 The wetted portions of equipment and apparatus that handle organic peroxide formulations shall be constructed of stainless steel (300 series), polyethylene, Teflon®, or other materials that are specifically recommended for the application.

14-3.2 Care shall be exercised to prevent contamination of organic peroxide formulations with dusts or overspray residues resulting from the sanding or spray application of finishing materials. Such mixing can result in a spontaneous fire or explosion.

14-3.3 Spills of organic peroxide formulations shall be promptly removed so there are no residues. Spilled material shall be permitted to be absorbed by using a noncombustible absorbent and then disposed of promptly in accordance with the manufacturer's recommendations.

14-4 Storage of Organic Peroxides. Organic peroxide formulations shall be stored in accordance with the requirements of NFPA 43B, *Code for the Storage of Organic Peroxide Formulations*, and with the manufacturer's recommendations.

14-5 Handling of Organic Peroxides. Care shall be exercised in handling organic peroxide formulations to avoid shock and friction, which can cause decomposition and violent reaction.

14-6* Mixing of Organic Peroxides with Promoters. Organic peroxide formulations shall not be mixed directly with any cobalt compounds or other promoters or accelerators as violent decomposition or explosion can result. To minimize the possibility of such accidental mixing, these materials shall not be stored adjacent to each other.

14-7 Smoking. Smoking shall be prohibited, "NO SMOKING" signs shall be prominently displayed, and only nonsparking tools shall be used in any area where organic peroxide formulations are stored, mixed, or applied.

14-8 Trained Personnel. Only designated personnel trained to use and handle organic peroxide formulations shall be permitted to use these materials.

14-9 Material Safety Data Sheets. Where organic peroxide formulations are used, the Material Safety Data Sheet (MSDS), or its equivalent, shall be consulted.

Chapter 15* Styrene Cross-Linked Composites Manufacturing (Glass Fiber Reinforced Plastics)

15-1 Scope. This chapter shall apply to manufacturing processes involving spray application of styrene cross-linked thermoset resins (commonly known as glass fiber reinforced plastics) for hand lay-up or spray fabrication methods, i.e., resin application areas, and where the processes do not produce vapors that exceed 25 percent of the lower flammable limit.

15-2 Resin Application Equipment. The equipment and apparatus for spray application of the resin shall be installed and used in accordance with the requirements of Chapters 14 and 15.

15-3 Fire Protection. Resin application areas shall be protected by an automatic sprinkler system that is designed and installed in accordance with the requirements of NFPA 13, *Standard for the Installation of Sprinkler Systems*, for at least Ordinary Hazard, Group 2 occupancies.

15-4 Resin Storage. The quantity of flammable and combustible liquids located in the vicinity of resin application areas outside of an inside storage room or storage cabinet in any one process area shall not exceed the greater of:

(a) A supply for one day; or

(b) The sum of 25 gal (95 L) of Class IA liquids in containers and 120 gal (454 L) of Class IB, IC, II, or III liquids in containers; or

(c) One approved portable tank not exceeding 660 gal (2498 L) of Class IB, IC, II, or III liquids.

15-5 Electrical and Other Hazards.

15-5.1 Electrical wiring and utilization equipment located in resin application areas that is not subject to deposits of combustible residues shall be installed in accordance with the requirements of NFPA 70, *National Electrical Code*, for ordinary hazard locations.

15-5.2 Electrical wiring and utilization equipment located in resin application areas that is subject to deposits of combustible residues shall be listed for such exposure and shall be suitable for Class I, Division 1, or Class II, Division 1 locations, whichever is applicable. Such wiring and utilization equipment shall be installed in accordance with the requirements of NFPA 70, *National Electrical Code*, for the appropriate hazardous (classified) location.

15-5.3 All metal parts of resin application areas, exhaust ducts, ventilation fans, spray application equipment, workpieces or containers that receive the spray stream, and piping that conveys flammable or combustible liquids shall be electrically grounded. (NFPA 77, *Recommended Practice on Static Electricity*, contains information on static electricity.)

15-5.4 Space heating appliances or other hot surfaces in resin application areas shall not be located where deposits or residues can readily accumulate.

15-6 Ventilation.

15-6.1 Mechanical ventilation shall be designed and installed throughout the resin application area in accordance with the requirements of Chapter 5.

Exception: Buildings that are not enclosed for at least three-quarters of their perimeter shall not be required to meet this requirement.

15-6.2 Local ventilation shall be provided where personnel are under or inside of the workpiece being fabricated.

15-7 Use and Handling.

15-7.1 The storage and use of organic peroxide formulations shall meet the requirements of Chapter 14.

15-7.2 Excess catalyzed resin, while still in the liquid state, shall be drained into an open-top, noncombustible container. Enough water shall be added to the container to cover the contained resin by at least 2 in. (51 mm).

15-7.3 In areas where chopper guns are used, paper, polyethylene film, or similar material shall be provided to cover the exposed surfaces of the walls and floor to allow the build-up of overchop to be readily removed. When the accumulated overchop has reached an average thickness of 2 in. (51 mm), it shall be disposed of after a minimum curing time of 4 hours.

Exception: A single day's accumulation of more than an average of 2 in. (51 mm) shall be permitted, provided that it is properly cured and disposed of before operations are resumed.

15-7.3.1 Used paper, polyethylene film, or similar material shall be placed in a noncombustible container and properly disposed of when removed from the facility.

Chapter 16* Training

16-1 General. All personnel involved in the spray application processes covered by this standard shall be instructed in the potential safety and health hazards; the operational, maintenance, and emergency procedures required; and the importance of constant operator awareness.

16-1.1 Personnel required to handle or use flammable or combustible materials shall be instructed in the safe handling, storage, and use of the materials, as well as the emergency procedures that might be required.

16-1.2* All personnel required to enter or to work within confined or enclosed spaces shall be instructed as to the nature of the hazard involved, the necessary precautions to be taken, and in the use of protective and emergency equipment required.

16-1.3 All personnel shall be instructed in the proper use, maintenance, and storage of all emergency, safety, or personal protective equipment that they might be required to use in their normal work performance.

16-1.4 Some appropriate form of documentation shall be employed to record the type and date of training provided to each individual involved in these processes.

Chapter 17 Referenced Publications

17-1 The following documents or portions thereof are referenced within this standard and shall be considered part of the requirements of this document. The edition indicated for each reference is the current edition as of the date of the NFPA issuance of this document.

17-1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems*, 1993 edition.

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 1994 edition.

NFPA 17, *Standard for Dry Chemical Extinguishing Systems*, 1994 edition.

NFPA 30, *Flammable and Combustible Liquids Code*, 1993 edition.

NFPA 43B, *Code for the Storage of Organic Peroxide Formulations*, 1993 edition.

NFPA 70, *National Electrical Code*, 1996 edition.

NFPA 86, *Standard for Ovens and Furnaces*, 1995 edition.

NFPA 91, *Standard for Exhaust Systems for Air Conveying of Materials*, 1995 edition.

NFPA *101*, *Life Safety Code*, 1994 edition.

NFPA 220, *Standard on Types of Building Construction*, 1995 edition.

NFPA 255, *Standard Method of Test of Surface Burning Characteristics of Building Materials*, 1990 edition.

NFPA 259, *Standard Test Method for Potential Heat of Building Materials*, 1993 edition.

NFPA 2001, *Standard on Clean Agent Fire Extinguishing Systems*, 1994 edition.

17-1.2 Other Publications.

17-1.2.1 ASME Publication. American Society of Mechanical Engineers, United Engineering Center, 345 East 47th Street, New York, NY 10017.

ASME *Code for Unfired Pressure Vessels*, 1980.

17-1.2.2 ASTM Publications. American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

ASTM D 5, *Test for Penetration for Bituminous Materials*, 1994.

ASTM E 136, *Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750° C*, 1994.

17-1.2.3 UL Publications. Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, IL 60062.

UL 900, *Test Performance of Air Filter Units*, 1994.

Appendix A Explanatory Material

Appendix A is not a part of the requirements of this NFPA document but is included for informational purposes only. This appendix contains explanatory material, numbered to correspond with the applicable text paragraphs.

A-1-1 The risk to life and property because of the fire and explosion hazards of spray application of flammable and combustible materials will vary depending on the arrangement and operation of the particular process and on the nature of the material being sprayed. The principle hazards addressed in this standard are those of the materials being sprayed: flammable and combustible liquids and combustible powders, as well as their vapors, mists, and dusts, and the highly combustible deposits and residues that result from their use. Properly designed, constructed, and ventilated spray areas are able to confine and control combustible residues, dusts, or deposits and to remove vapors and mists from the spray area and discharge them to a safe location, thus reducing the likelihood of fire or explosion. Likewise, accumulations of overspray residues, some of which are not only highly combustible but also subject to spontaneous ignition, can be controlled.

The control of sources of ignition in spray areas and in areas where flammable and combustible liquids or powders are handled, together with constant supervision and maintenance, are essential to safe spray application operations. The human element requires careful consideration of the location of spray application operations and the installation of fire extinguishing systems so that the potential for spread of fire to other property and damage to property by extinguishing agent discharge is reduced.

A-1-1.3 This standard does not cover spray application operations that are conducted outdoors on buildings, bridges, tanks, or similar structures. These situations occur only occasionally for any given structure and overspray deposits are not likely to present a hazardous condition. Also, the space where there might be an ignitable vapor-air or dust-air mixture is very limited due to atmospheric dilution.

A-1-1.4 The occasional use of small portable spray equipment or aerosol spray containers, on an intermittent or regular basis and in the same location inside a building, is not likely to result in hazardous accumulations of overspray. Therefore, such operations are not within the scope of this standard. The following safeguards, however, should be observed:

(a) Adequate ventilation should be provided at all times, particularly when spray application is conducted in relatively small rooms or enclosures.

(b) Spray application should not be conducted in the vicinity of open flames or other sources of ignition. Either the spray operation should be relocated or the source of ignition should be removed or turned off.

(c) Containers of coating materials, thinners, or other hazardous materials should be kept tightly closed when not actually being used.

(d) Oily or coating-laden rags or waste should be disposed of promptly and in a safe manner at the end of each day's operations, due to the potential for spontaneous ignition.

(e) The same fundamental rules for area cleanliness and housekeeping that are required for industrial spray application operations should be observed.

A-1-6 Spray Area. For the purpose of this standard, the authority having jurisdiction can define the limits of the spray area in any specific case. The spray area in the vicinity of spray application operations will necessarily vary with the design and arrangement of the equipment and with the method of operation. When spray application operations are strictly confined to predetermined spaces that are provided with adequate and reliable ventilation (such as a properly designed and constructed spray booth), the spray area will ordinarily not extend beyond this space. When spray application operations are *not* confined to an adequately ventilated space, then the spray area might extend throughout the room or building area where the spraying is conducted.

A-2 Fires involving spray application operations and processes can be expected to develop rapidly and to generate copious quantities of heat and smoke. In sprinklered buildings, such fires can also result in the operation of a greater-than-normal number of sprinklers. The following guidance is offered:

Operations and equipment should be arranged and located so that there is adequate egress for personnel and adequate access for fire-fighting operations. Where spray application operations are extensive, they should be located in a separate building or in an area that is separated by fire-rated construction from all other operations or storage.

Spray application operations that incorporate assembly lines or conveyor systems will present special problems. If conveyor systems extend between separate buildings, a noncombustible or limited-combustible, sprinkler-protected enclosure or passageway might be of value. If conveyor systems pass through floors, the openings should be surrounded by deep [greater than 18 in. (458 mm)] draft curtains on the underside of the floor deck and might even be provided with automatic high-velocity spray nozzles arranged to create a counter draft. If conveyor systems pass through fire walls or fire partitions, it will be difficult to reliably protect the openings by means of automatic-closing fire doors. One option is to provide a noncombustible or limited-combustible, sprinkler-protected tunnel on both sides of the opening.

Rooms that house spray application operations should be separated from other occupancies or operations by construction that meets the requirements of Chapter 3 of this standard.

In sprinklered buildings, where spray application operations occupy one portion of an open area, the spray application operations should be surrounded by noncombustible or limited-combustible draft curtains extending downward at least 18 in. (458 mm) from the ceiling, but deeper if practical. These draft curtains will aid in minimizing the number of sprinkler heads that open beyond the area of primary concern. Additional consideration might be given to the use of heat and smoke vents to aid in fire control.

Sprinkler discharge should be drained to the outside of the building, to an internal drain system, or to some other suitable location. Properly designed and installed floor drains and scuppers of sufficient number and size to handle expected sprinkler discharge should be provided. Where spray application operations are located on an upper floor, they should not be located directly above goods or equipment that are subject to water damage. In addition, the floor should be made watertight and means should be provided to drain sprinkler discharge directly from the area.

Finally, spray application operations should not be located in a basement area.

A-3 Spray booths can be of a wide variety of shapes and sizes to accommodate the various industrial applications of spray application. Without the use of a spray booth, the spray area, as defined in Section 1-6, can constitute a considerable area, with all the requirements for a spray area then becoming applicable. It is important that only equipment suitable for specific purposes be utilized in connection with the handling and application of flammable or combustible liquids or powders.

A-3-3 The other operations referred to in this subsection are those that do not involve spray application processes.

A-4-1 Because of the requirements for special safeguards, electrostatic apparatus, drying, curing, and fusing apparatus, and automobile undercoating operations are covered in other chapters of this standard.

A-4-1.5 There should be no open flames, hot surfaces, or spark-producing equipment in the spray area or in any area where they might be exposed to combustible residues. Open flames or spark-producing equipment should not be located where they can be exposed to deposits of combustible residues. Some residues can be ignited at low temperatures, such as those produced by steam pipes, incandescent light fixtures, and power tools.

A-4-1.6 Areas that are above or adjacent to spray areas, where materials are located, stored, mixed, or processed, should be ventilated. Equipment that is known to produce flame, sparks, or particles of hot metal, including light fixtures, that are adjacent to areas that are safe under normal operating conditions, but which can become dangerous due to accident or careless operation, should not be installed in such areas unless the equipment is totally enclosed or is separated from the area by partitions that will prevent the sparks or particles from entering the area.

A-4-2.2 Equipment that is listed for both Class I, Division 1 and Class II, Division 1 locations and is also listed for accumulation of deposits of combustible residues can be installed in the spray area.

A-4-5 (x) During operation of any electrostatic equipment, however, electrically conductive isolated objects within the process area are influenced by the process and can become charged to voltages that result in spark discharges capable of igniting flammable or combustible substances. Objects commonly involved in such incidents include workpieces on conveyor racks that have fouled contact points; solvent containers or tools placed on nonconducting paint residues, cardboard, or wooden rests; spray-booth components such as loose floor grates; and human beings insulated from ground by rubber footwear, paint residue accumulations on floors, and gloves.

Even in spray painting environments where there is no electrostatic equipment in operation, but where sticky, electrically nonconductive paint residues have accumulated on the floor, a significant hazard is associated with static electrification of human bodies that results from walking across such a floor. As few as two or three steps can produce sufficient voltage on the body of a worker to create an incendive spark when he or she approaches a grounded object. If this spark occurs in a flammable vapor such as is found surrounding a solvent container or a freshly painted object, a fire results. (NFPA 77, *Recommended Practice on Static Electricity*, 7-7.3.3 and 7-7.4.)

A-5-2 Determination of Lower Flammable Limit. Some paints, varnishes, lacquers, and other coating materials contain volatile flammable solvents. In addition, such solvents are often added as "thinners." When exposed to the atmosphere, these solvents give off vapors that mix with the surrounding air and, if the concentration reaches as much as approximately 1 percent solvent in air, these vapors can be ignited and an explosion can occur Spray applications using only liquids that have relatively high flash points, although less likely to produce ignitable atmospheres than those using low flash point liquids, can, nevertheless, result in mists that are capable of

propagating a flame in a manner similar to combustible solids in dust explosions.

Theoretical considerations can assist in hazard evaluation in some instances. For example, 1 gal (3.8 L) of the average solvent will occupy approximately 23 ft^3 (0.65 m^3) when evaporated into vapor at average room temperature. Therefore, if 1 gal (3.8 L) of liquid solvent is completely evaporated and thoroughly mixed with the surrounding air of an enclosure, the enclosure must have a volume of more than 2,300 ft^3 (65 m^3) to avoid an ignitable mixture, assuming the lower limit of the flammable range of the solvent is 1 percent in air. This is a conservative number; almost all of the solvents used in spray finishing have a lower flammable limit greater than 1 percent. In using such theoretical considerations, caution should be exercised to prevent erroneous conclusions. When liquids are sprayed, the area in the direct path of the spray will exceed the lower flammable limit. Vapors from most solvents are heavier than air and small quantities of vapor can form an ignitable mixture in low, unventilated spaces in the vicinity of or even remote from the point of evaporation before they mix with the full volume of available air by natural diffusion and the mixture becomes too "lean" to burn. When liquid is sprayed, the rate of evaporation is greatly increased so that the lower flammable limit is quickly reached. For these reasons, a safety factor of 4 to 1 has been traditionally used and the ventilation requirement rounded off to 10,000 ft^3/gal (74.5 m^3/L) evaporated at the maximum flow rate of the spray apparatus.

Adequate mechanical ventilation throughout all areas where ignitable vapors or mists might be present is essential to prevent the formation of flammable mixtures. The volume of air movement necessary will obviously vary with the arrangement of spraying operations, the amount of spray material used in a given length of time, and the rate of evaporation of the particular solvent.

Spray Booths. It is imperative to maintain the concentration of vapor in the exhaust airstream below 25 percent of the lower flammable limit. It is also necessary to confine and remove vapors and mists to a safe location and to control combustible residues, dusts, and deposits. This requires a sufficient flow of air through the booth and the air moving at a sufficiently high velocity. Air velocity alone, however, is not an adequate measure of the performance of the ventilation system of the spray booth. While hand-held instruments can be used to measure velocity, fluctuations are often so extreme that averages can be misleading. Even if spray booths show wide fluctuations in air velocity, they can be considered as meeting the requirements of this standard if they are successful in confining and removing vapors and mists to a safe location or confining and controlling combustible residues, dusts, and deposits. In general, if vapors, mists, and residues move towards the filters and the exhaust duct, they will be confined and controlled. If overspray is coming out of the open face or the conveyor opening of the booth, then the ventilation system is not functioning properly.

Air velocities should be increased to compensate for high rates of spray application, for application equipment that produces large volumes of overspray, or for operations where the objects or material being coated are close to the open face or conveyor openings. Air velocities should also be increased for operations where large objects are moved into and out of the booth on conveyors at relatively high speeds and for operations where the objects have irregular shapes or cavities. Air velocities can be decreased for efficient application systems, such as those using heated materials, airless spray application apparatus, high volume/low pressure application equipment, and electrostatic application equipment.

Spray Rooms. Spray rooms should be designed to provide air movement that is as uniform as possible, so that all vapors and mists will move to the exhaust system. While 10,000 ft^3 of air per gallon of solvent evaporated (74.5 m^3/L) is considered adequate to maintain a uniform mixture of vapor and air at or below the lower flammable limit, additional ventilation might be necessary due to the requirement that vapors and mists be removed and that residues, dusts, and deposits be controlled.

Open Spraying. Where large workpieces, such as railway cars or large vehicles, are being sprayed, it is frequently necessary to provide multiple air inlets and exhaust in the proximity of all portions of the workpiece, simultaneously producing a rather high air velocity at all points where spray might be applied. In many cases this has been accomplished by strategically locating air makeup ducts overhead and exhausting air at the floor level below the application point.

A-5-3 Make-up Air. All spray areas require make-up air and since the air exhausted from spray application operations is normally contaminated and can only be recirculated under rigidly controlled conditions, the source of the make-up air should be given careful consideration. When the capacity of the ventilating fan is low and the area where the exhaust system is located is large, sufficient make-up air can often be provided by natural infiltration of air through building walls, windows, doors, etc. In general, if the volume of the room or building where the exhaust system is located is not at least equal to 20 times the volumetric capacity of the fans (three air changes per hour), then additional make-up air should be provided. Outside air should be tempered and might have to be dehumidified or chilled for proper operation of the spray application apparatus. Automatic controls, including a high temperature limit switch, fan interlocks, and safety shut-off valves, should be provided for safe operation.

The method of distributing the make-up air requires careful consideration. If the velocities and distribution of air through baffles, filters, and registers have not been carefully designed, the spray application operation can be inefficient. The velocity of the air through filters, etc., should not exceed 200 ft/min (60 m/min). Higher velocities can disrupt spray application operations due to turbulent airflow in the vicinity of the spray apparatus. This turbulence can also cause a properly designed exhaust system to fail to confine and remove vapors or to fail to confine and control residues, dusts, and deposits.

In some heating arrangements, forced make-up or replacement air directly compensating for the contaminated air exhausted from spray application operations is used in place of, or to augment, general area heating and ventilation.

With the many variables that can be encountered in heating and ventilating systems, it is generally advisable to engage the services of a qualified ventilating engineer to obtain a safe and efficient installation.

The features that should be considered include:

(a) Location of sources of heat to comply with Chapter 4.

(b) Location of air intakes to prevent recalculation of contaminated air. Equipping air intakes with appropriate screens or filters.

(c) Automatic temperature and proportioning controls, including an independent excess temperature limit control.

(d) A safety system interlocked with the heater to automatically provide for its safe ignition and to minimize the hazards that might result from failure of its proper operating cycle, proper pressure of fuel supply, ventilation, and electrical power.

(e) An interlock between the spray booth exhaust system and the make-up air system to ensure that both systems are operable to provide a proper balance of supply and replacement air.

(f) In the case of direct-fired units, operating controls that will ensure that concentrations of unburned fuel or products of combustion are kept to levels that will be safe for operating personnel if inhaled.

A-5-5.1(a) It is critical for effective monitoring that sensors be protected from obstruction and contamination. See NFPA 72, *National Fire Alarm Code*, for recommended maintenance and calibration procedures.

A-5-5.2 If recirculated air is used for make-up air for occupied spaces, including spray areas, spray booths, spray rooms, and other process areas, the requirements for decontamination and maximum allowable concentrations of solvents will be far more stringent than those required by this standard for fire and explosion prevention. Refer to appropriate occupational safety and health and industrial hygiene standards for permissible exposure limits.

A-5-6 Exception No. 2. Exhaust systems should be individually ducted to the outside of the building. Where treatment of the exhaust airstream is necessary to satisfy environmental regulations or where energy conservation measures are used, this might not be practical and manifolding of the exhaust ducts might be necessary. It should be understood that manifolding of exhaust ducts increases the fire hazard. A fire starting in one booth can spread through the exhaust system and involve other spray areas. Heat exchangers, which are sometimes used to preheat the exhaust air before it enters an incinerator, are subject to fires from the spontaneous ignition of residue that collects on heat exchanger surfaces.

A-5-8 The designer of the exhaust ducts and fasteners should refer to appropriate design guides, such as SMACNA 77, *Round Industrial Duct Construction Standards*, and SMACNA 80, *Rectangular Industrial Duct Construction Standards*, published by the Sheet Metal and Air Conditioning Contractor's National Association, Inc.

A-5-11 Additional Ventilation. If there are other operations that give off ignitable vapors in the vicinity of a spray application operation, these should be provided with independent mechanical ventilation.

A-6-1 For large spray operations, coatings, thinners, and solvents can be stored in the following locations: underground storage tanks, aboveground storage tanks, separate buildings, or separate dedicated rooms within the facility. In some cases, liquids are pumped to a mixing room or paint kitchen, where they are mixed and then pumped to the spray area. For smaller operations, separate storage and mixing areas might not be justified. However, it is desirable to minimize the fire loading in or near the spray area by one or a combination of the following methods:

(a) flammable liquid storage cabinets;

(b) a protected enclosed metal structure; or

(c) use of metal containers with limitations on the quantity of liquid located near the spray area.

A-6-4.2 Valves should be kept shut when spray application operations are not being conducted to minimize the release of coating material in the event of fire.

A-6-4.3 If plastic tubing leaks within shielded areas, such as within color changers, the resulting spray fire will destroy all tubing, releasing large quantities of coating material in an area that cannot be reached by the booth protection system. Automatic protection systems should be provided for these areas.

A major cause of fire in automatic electrostatic spray booths has been replacement of original equipment plastic tubing with other types of tubing. This tubing, particularly if conductive coatings are used, is susceptible to the development of pinhole leaks.

A-6-4.5 The severity and extent of the many fires in spray application operations has been substantially increased when rubber or plastic supply hoses were burned off, resulting in the addition of the entire contents of the supply system to the fire. By limiting the amount of fuel available, the magnitude of the fire can be held to more manageable limits. The shutoff should be accomplished by means of an interlock with a fire detection system or the automatic fire extinguishing system for the spray area. This shutoff is normally accomplished by shutting the distribution pumps. In some cases, it is also advisable to limit the flow from the solvent piping system. This can be accomplished with properly specified check valves in the pipe "drops."

A-7 As indicated in Chapter 6, it is inadvisable to keep large quantities of flammable or combustible liquids in areas that expose personnel or important property to injury or loss. The primary reason for this requirement is that fires in flammable liquids are difficult to extinguish by the usual methods and, if large quantities are involved, they can spread the fire by flowing over large areas. For fires in small amounts of flammable or combustible liquids, hand extinguishers or large extinguishers on wheels especially designed for such fires, are effective. If large quantities of liquids are to be protected, suitable automatic equipment should be provided and special attention should be given to proper dikes, curbs, and drains to prevent the flow to other property.

For the extinguishment of fire in spray residues, hand fire extinguishers suitable for fire in ordinary combustibles or hose streams are effective.

A-7-2 Spray application operations should only be located in buildings that are completely protected by an approved system of automatic sprinklers. If located in unsprinklered buildings, sprinklers should be installed to protect spray application processes where practical. Because of the rapidity and intensity of fires that involve spray operations, the available water should be ample to simultaneously supply all sprinkler heads likely to open in one fire without depleting the available water for use by hose streams. Noncombustible draft curtains can be used to limit the number of sprinklers that will open.

Even when areas adjacent to coating operations are considered under reasonably positive fire control by adequate automatic sprinkler protection, damage is possible if operations are conducted on floors above those containing contents that are highly susceptible to water damage. Waterproofing and drainage of spray room floors can assist in reducing water damage on floors below. The proper drainage of the large volume of water frequently necessary to extinguish spray finishing room fires often presents considerable difficulty.

A-7-2.4 Automatic sprinklers in spray areas, including the interior of spray booths and exhaust ducts, should be wet pipe, preaction, or deluge system in order that water can be placed on the fire in the shortest possible time. Automatic sprinklers in spray booths and exhaust ducts should be of the lowest practical temperature rating. Sprinklers outside the booth at ceiling level should be high-temperature rated, 286°F (141°C). The delay in application of water with ordinary dry pipe sprinklers can permit a fire to spread so rapidly that final extinguishment is difficult without large resulting damage.

The location of the sprinkler heads inside spray booths should be selected with care in order to avoid heads being placed in the direct path of spray and yet afford protection for the entire booth interior. When in the direct path of spray even one day's operation can result in deposits on the sprinkler head that insulate the fusible link or choke open head orifices to the extent that sprinklers cannot operate efficiently.

Automatic sprinklers should also be located so that areas subject to substantial accumulations of overspray residue are protected. Generally, sprinklers are located no more than 4 ft (1220 mm) from side walls of booths and rooms and from dry overspray collectors (where applicable). Sprinklers in booths or rooms should be on extra hazard occupancy spacing of 90 ft^2 (8.4 m^2).

Sprinklers or sprinkler systems protecting stacks or ducts should be automatic and of a type not subject to freezing. Dry pendant sprinklers are often used inside buildings near exhaust duct penetrations to the outside. Nonfreeze or dry type sprinkler systems are often used for ducts outside buildings. Sprinklers should be spaced no more than 12 ft (3660 mm) apart in the duct for adequate protection.

All sprinklers in spray areas should be controlled by an accessible control valve, preferably an OS&Y valve.

A-7-3.1 Use of water as the extinguishing agent for solvent and coating material fires might, in some cases, cause problems with splashing and "floating" of flaming liquids and residues. This possibility should be included with the other factors that are normally considered when choosing an extinguishing agent. In addition, water from sprinkler or deluge systems, after coming into contact with coating materials, residues, or solvents might have to be collected and treated as hazardous waste.

A-7-3.2 This is typically accomplished by means of a piping network from the extinguishing system into all parts of the spray area. To avoid potential flashback of an unextinguished fire, modular extinguishing units should not be used to protect areas with ducts, plenums, or areas that exceed the listing of the system. They might, however, be suited for smaller open spray areas that do fall within the limits of the listing.

A-7-5 During the first few seconds in the development of a fire in a dry powder spray booth, the following observations can be made:

(a) Conventional structure equipment (spray booth connected to enclosed collector by duct work).

Airborne powder in the spray plumes of the gun(s) burns vigorously as long as the gun feeder(s) continues to supply powder. Flames from about 2 ft to 6 ft (610 mm to 1830 mm) in length might extend from the guns but do not intrude into the interior of the guns. These flames do not extend into the exhaust ductwork if adequate airflow has been provided to maintain maximum powder concentration in the exhaust stream below the minimum explosive concentration (MEC). The flames are extinguished almost instantly if their supply of airborne fuel is interrupted by shutting down the gun feeders.

Deposits of powder that have accumulated on the interior surfaces of the spray enclosure are not readily ignited, even by direct exposure to flames for a few seconds.

If a fire in a powder spray booth has been sustained for an appreciable period of time (10- to 60-second delays have been observed), propagation proceeds as follows:

Heat exposure effects of the fire, acting upon the deposits of overspray powder that have accumulated on the interior surfaces of the spray enclosure, will modify a layer on the surface of the deposits to form an extremely fragile, tissue-thin structure of powder grains that have been softened only enough to adhere to adjacent grains but not enough to flow together and form a film. This is called a sintered structure. In response to the effects of vibration and rapidly fluctuating temperature (flickering of flames, etc.), this structure will break into a "mud-cracked" pattern and individual platelets in some regions will curl up, presenting their edges to the fire-involved atmosphere. Exposure to this environment's heat and turbulence will char and dislodge platelets to form airborne glowing embers comparable to those formed by burning piles of autumn leaves. These embers, if drawn through exhaust ductwork to the powder collector, could ignite the collector, resulting in an explosion.

If this sequence is interrupted within the first few seconds of a fire's history, then ember formation and propagation by this mechanism can be stopped. The requirements of Section 7-5 are directed toward this result.

(b) Integrated spray booth/"open" collector.

Fire in the spray plumes of the guns is identical to that found in the discussion above. Since there is no exhaust ductwork and no enclosed collector, however, the conditions necessary for generation of an explosion do not exist and the risk is confined only to conventional fire considerations. If powder feed to the spray guns is sustained after ignition and if the exhaust fan is kept in operation, enough heat can be delivered to the region of the cartridge filters to result in ignition of the filters and collected residues, which will then be sustained as a "deep seated" fire producing large quantities of smoke but limited heat.