NFPA 33

Standard for Spray Application Using Flammable or Combustible Materials

2007 Edition

NFPA, 1 Batterymarch Park, Quincy, MA 02169-7471
An International Codes and Standards Organization

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NFPA 33

Standard for

Spray Application Using Flammable or Combustible Materials

2007 Edition

This edition of NFPA 33, *Standard for Spray Application Using Flammable or Combustible Materials*, was prepared by the Technical Committee on Finishing Processes. It was issued by the Standards Council on July 28, 2006, with an effective date of August 17, 2006, and supersedes all previous editions.

This edition of NFPA 33 was approved as an American National Standard on August 17, 2006.

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 the *Standard on Dip Tanks* (now NFPA 34, *Dipping and Coating Processes Using Flammable or Combustible Liquids*). 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, 1995, 2000, 2003, and 2006.

The following major changes were incorporated into the 2003 edition of NFPA 33:

(1) The arrangement of the text was modified to comply with the *Manual of Style for NFPA Technical Committee Documents*, including relocation of Chapter 17, Referenced Publications, to a new Chapter 2 and the addition of a new Chapter 3, Definitions, which incorporated all the definitions previously located in Chapter 1.
(2) Chapter 6 (formerly Chapter 4), Electrical and Other Sources of Ignition, was extensively revised to recognize the Zone concept of area classification. Changes included the addition of appropriate definitions and revisions of the figures illustrating the area classifications in and around spray areas, spray booths, spray rooms, and equipment.
(3) Chapter 9 (formerly Chapter 7), Protection, was extensively revised to more effectively and more clearly present the requirements for fire protection in spray areas. In addition, the requirements for interlocking were clarified and requirements for automated electrostatic spray systems were modified to reflect current operational practices, including extending these concepts to powder application systems.
(4) A new chapter was added that included several changes: Section 10.5 (formerly Section 8.5), Waste Containers, was to provide more specific guidance on the handling of waste materials. Section 10.7 (formerly Section 8.7), Cleaning Operations, was revised to allow the use of any suitable solvent for cleaning of spray equipment, provided it is used safely. The requirements were also applied to spray apparatus cleaning systems. Finally, a new Section 10.8 was added to address the hazards of solvent distillation units.
(5) The fire protection requirements formerly located in Section 9.5, Exception No. 2, of the 2000 edition, were incorporated into Section 9.7 and Section 9.8 of the 2003 edition.
(6) Subsection 14.3.5 (formerly 12.3.5) was revised to incorporate the Zone concept of area classification for use with limited finishing workstations.

The following major changes are incorporated into the 2007 edition of NFPA 33:

(1) In Chapter 3, the definition of *spray area* has been revised to more clearly define the extent of the spray area and to identify those parts of the process that are *not* considered part of the spray area.
(2) In Section 5.5, the allowable materials for vision and observation panels have been expanded to include laminated glass and other listed assemblies. Also, vision and observation panels for powder spray booths are now allowed to be of fire retardant combustible materials.
(3) Chapter 6 has been amended with text extracted from NFPA 70®, *National Electrical Code®*, to reflect changes in NFPA 70 to hazardous locations.
(4) Definitions have been extracted from NFPA 70®, *National Electrical Code®*, and added to Chapter 6 to recognize Class II, Zones 20, 21, and 22 hazardous (classified) locations.
(5) Section 7.7 has been revised to allow fire retardant combustible materials for ducts connected to powder coating booths.

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(6) In Chapter 8, the maximum quantities of flammable and combustible liquids have been changed to correlate with changes to NFPA 30, *Flammable and Combustible Liquids Code*.
(7) In Chapter 9, the requirements for protection of spray area exhaust ducts have been revised, expanded, and clarified.
(8) In Chapters 11, 12, and 15, 11.3.6, 12.5.4, and 15.13.4 have been added to designate certain highly resistive workpieces as grounded, if they meet certain criteria of surface conductivity.
(9) In Chapter 13, more restrictive requirements for high temperature limit switches and interlocks have been added for spray booths and spray rooms that are also used for drying and curing operations.
(10) In Chapter 14, more definitive requirements have been added for drying, curing, and fusion apparatus used in limited finishing workstations.

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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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Changes other than editorial are indicated by a vertical rule beside the paragraph, table, or figure in which the change occurred. These rules are included as an aid to the user in identifying changes from the previous edition. Where one or more complete paragraphs have been deleted, the deletion is indicated by a bullet (•) between the paragraphs that remain.

A reference in brackets [ ] following a section or paragraph indicates material that has been extracted from another NFPA document. As an aid to the user, the complete title and edition of the source documents for extracts in mandatory sections of the document are given in Chapter 2 and those for extracts in informational sections are given in Annex E. Editorial changes to extracted material consist of revising references to an appropriate division in this document or the inclusion of the document number with the division number when the reference is to the original document. Requests for interpretations or revisions of extracted text shall be sent to the technical committee responsible for the source document.

Information on referenced publications can be found in Chapter 2 and Annex E.

Chapter 1 Administration

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:

(1) Compressed air atomization
(2) Airless or hydraulic atomization
(3) Electrostatic application methods
(4) Other means of atomized application

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:

(1) Fluidized bed application methods
(2) Electrostatic fluidized bed application methods
(3) Other means of fluidized application

1.1.3 This standard shall also apply to spray application of water-borne, water-based, and water-reducible materials that contain flammable or combustible liquids or that produce combustible deposits or residues.

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

1.1.5* This standard shall not apply to the use of small portable spraying equipment that is not used repeatedly in the same location.

1.1.6 This standard shall not apply to the use of aerosol products in containers up to and including 710 mL (24 ounces) capacity that are not used repeatedly in the same location. *(See A.1.1.5)*

1.1.7 This standard shall not apply to the spray application of noncombustible materials.

1.1.8 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 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.

1.3 Application. Chapter 4 through Chapter 10 and Chapter 18 shall apply to *all* spray application processes within the scope of this standard. Chapter 11 and Chapter 12 shall apply only to electrostatic spray application processes. Chapter 13 shall apply only to drying, curing, and fusion processes and operations. Chapter 14 shall apply to miscellaneous spray operations. Chapter 15 shall apply only to powder coating application processes and operations. Chapter 16 and Chapter 17 shall apply only to multicomponent coating systems and to processes that involve the use of catalysts, such as organic peroxide formulations.

1.4 Retroactivity. The provisions of this standard reflect a consensus of what is necessary to provide an acceptable degree of protection from the hazards addressed in this standard at the time the standard was issued.

1.4.1 Unless otherwise specified, the provisions of this standard shall not apply to facilities, equipment, structures, or installations that existed or were approved for construction or installation prior to the effective date of the standard. Where specified, the provisions of this standard shall be retroactive.

1.4.2 In those cases where the authority having jurisdiction determines that the existing situation presents an unacceptable degree of risk, the authority having jurisdiction shall be permitted to apply retroactively any portions of this standard deemed appropriate.

1.4.3 The retroactive requirements of this standard shall be permitted to be modified if their application clearly would be

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impractical in the judgment of the authority having jurisdiction, and only where it is clearly evident that a reasonable degree of safety is provided.

1.5 Equivalency. Nothing in this standard is intended to prevent the use of systems, methods, or devices of equivalent or superior quality, strength, fire resistance, effectiveness, durability, and safety over those prescribed by this standard.

1.5.1 Technical documentation shall be submitted to the authority having jurisdiction to demonstrate equivalency.

1.5.2 The system, method, or device shall be approved for the intended purpose by the authority having jurisdiction.

1.6 Units and Formulas. The units of measurement used in this standard shall be the International System of Units, otherwise known as "SI" and "Modernized Metric System." English customary units are given in parentheses following SI units, but shall be considered to be approximate conversions.

1.7 Enforcement. (Reserved)

Chapter 2 Referenced Publications

2.1 General. The documents or portions thereof listed in this chapter are referenced within this standard and shall be considered part of the requirements of this document.

2.2 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 10, *Standard for Portable Fire Extinguishers,* 2007 edition.

NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems,* 2005 edition.

NFPA 13, *Standard for the Installation of Sprinkler Systems,* 2007 edition.

NFPA 16, *Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems,* 2003 edition.

NFPA 17, *Standard for Dry Chemical Extinguishing Systems,* 2002 edition.

NFPA 30, *Flammable and Combustible Liquids Code,* 2003 edition.

NFPA 69, *Standard on Explosion Prevention Systems,* 2002 edition.

NFPA 70, *National Electrical Code®,* 2005 edition.

NFPA 72®, National Fire Alarm Code®, 2007 edition.

NFPA 86, *Standard for Ovens and Furnaces,* 2007 edition.

NFPA 91, *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids,* 2004 edition.

NFPA *101®, Life Safety Code®,* 2006 edition.

NFPA 220, *Standard on Types of Building Construction,* 2006 edition.

NFPA 259, *Standard Test Method for Potential Heat of Building Materials,* 2003 edition.

NFPA 432, *Code for the Storage of Organic Peroxide Formulations,* 2002 edition.

NFPA 496, *Standard for Purged and Pressurized Enclosures for Electrical Equipment,* 2003 edition.

NFPA 701, *Standard Methods of Fire Tests for Flame Propagation of Textiles and Films,* 2004 edition.

NFPA 2001, *Standard on Clean Agent Fire Extinguishing Systems,* 2004 edition.

2.3 Other Publications.

2.3.1 AIHA Publications. American Industrial Hygiene Association, 2700 Prosperity Avenue, Suite 250, Fairfax, VA 22031.

ANSI/AIHA Z9.7, *Recirculation of Air from Industrial Process Exhaust Systems,* 1998.

2.3.2 ASME Publications. American Society of Mechanical Engineers, Three Park Avenue, New York, NY 10016-5990.

ASME *Boiler and Pressure Vessel Code*, Section VIII, 2004.

2.3.3 ASTM Publications. ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959.

ASTM D 5, *Standard Test Method for Penetration of Bituminous Materials*, 1997.

ASTM D 323, *Standard Test Method for Vapor Pressure of Petroleum Products (Reid Method)*, 1999.

ASTM E 136, *Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C,* 1999.

2.3.4 UL Publications. Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, IL 60062-2096.

UL 340, *Test for Comparative Flammability of Liquids*, 1997.

ANSI/UL 900, *Standard for Air Filter Units*, 2004.

ANSI/UL 2208, *Standard for Solvent Distillation Units*, 1998.

2.3.5 Other Publications.

Merriam-Webster's Collegiate Dictionary, 11th edition, Merriam-Webster, Inc., Springfield, MA, 2003.

2.4 References for Extracts in Mandatory Sections.

NFPA 30, *Flammable and Combustible Liquids Code,* 2003 edition.

NFPA 70, *National Electrical Code®,* 2005 edition.

NFPA 220, *Standard on Types of Building Construction,* 2006 edition.

Chapter 3 Definitions

3.1 General. The definitions contained in this chapter shall apply to the terms used in this standard. Where terms are not defined in this chapter or within another chapter, they shall be defined using their ordinarily accepted meanings within the context in which they are used. *Merriam-Webster's Collegiate Dictionary*, 11th edition, shall be the source for the ordinarily accepted meaning.

3.2 NFPA Official Definitions.

3.2.1* Approved. Acceptable to the authority having jurisdiction.

3.2.2* Authority Having Jurisdiction (AHJ). An organization, office, or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure.

3.2.3 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.

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

3.2.5 Standard. A document, the main text of which contains only mandatory provisions using the word "shall" to indicate requirements and which is in a form generally suitable for mandatory reference by another standard or code or for adoption into law. Nonmandatory provisions shall be located in an appendix or annex, footnote, or fine-print note and are not to be considered a part of the requirements of a standard.

3.3 General Definitions.

3.3.1 Area.

3.3.1.1 ***Flash-Off Area.*** An open or enclosed area after a spray application process where vapors are released due to exposure to ambient air or a heated atmosphere.

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

3.3.1.3* ***Spray Area.*** Any fully enclosed, partly enclosed, or unenclosed area in which dangerous quantities of flammable or combustible vapors, mists, residues, dusts, or deposits are present due to the operation of spray processes, including (a) any area in the direct path of a spray application process; (b) the interior of a spray booth or spray room or limited finishing workstation, as herein defined; (c) the interior of any exhaust plenum, eliminator section, or scrubber section; (d) the interior of any exhaust duct or exhaust stack leading from a spray application process; (e) the interior of any air recirculation filter house or enclosure, including secondary recirculation particulate filters; (f) any solvent concentrator (pollution abatement) unit or solvent recovery (distillation) unit.

3.3.1.3.1 ***Unenclosed Spray Area.*** Any spray area that is not confined by a limited finishing workstation, spray booth, or spray room, as herein defined.

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

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

3.3.4 [Electrical] Utilization Equipment. Equipment that utilizes electric energy for electronic, electromechanical, chemical, heating, lighting, or similar purposes. [**70,** 2005]

3.3.5 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.

3.3.5.1 ***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.

3.3.6 Limited Combustible. A building construction material not complying with the definition of noncombustible material that, in the form in which it is used, has a potential heat value not exceeding 8140 kJ/kg (3500 Btu/lb), where tested in accordance with NFPA 259, *Standard Test Method for Potential Heat of Building Materials*, and complies with (a) or (b): (a) materials having a structural base of noncombustible material, with a surfacing not exceeding a thickness of 3 mm (⅛ in.) that has a flame spread index not greater than 50; and (b) materials, in the form and thickness used, other than as described in (a), having neither a flame spread index greater than 25 nor evidence of continued progressive combustion and of such composition that surfaces that would be exposed by cutting through the material on any plane would have neither a flame spread index greater than 25 nor evidence of continued progressive combustion. (Materials subject to increase in combustibility or flame spread index beyond the limits herein established through the effects of age, moisture, or other atmospheric condition shall be considered combustible.)

3.3.7 Liquid. Any material that has a fluidity greater than that of 300 penetration asphalt when tested in accordance with ASTM D 5, *Standard Test Method for Penetration of Bituminous Materials.* [**30,** 2003]

3.3.7.1 ***Combustible Liquid.*** Any liquid that has a closed-cup flash point at or above 100°F (37.8°C), as determined by the test procedures and apparatus set forth in 1.7.4 [of NFPA 30]. Combustible liquids are classified as Class II or Class III as follows: (1) *Class II Liquid* — any liquid that has a flash point at or above 100°F (37.8°C) and below 140°F (60°C); (2) *Class IIIA* — any liquid that has a flash point at or above 140°F (60°C), but below 200°F (93°C); (3) *Class IIIB* — any liquid that has a flash point at or above 200°F (93°C). [**30,** 2003]

3.3.7.2 ***Flammable Liquid.*** Any liquid that has a closed-cup flash point below 100°F (37.8°C), as determined by the test procedures and apparatus set forth in 1.7.4 [of NFPA 30]. Flammable liquids are classified as Class I as follows: *Class I Liquid* — any liquid that has a closed-cup flash point below 100°F (37.8°C) and a Reid vapor pressure not exceeding 40 psia (2068.6 mm Hg) at 100°F (37.8°C), as determined by ASTM D 323, *Standard Test Method for Vapor Pressure of Petroleum Products (Reid Method).* Class I liquids are further classified as follows: (1) Class IA liquids — those liquids that have flash points below 73°F (22.8°C) and boiling points below 100°F (37.8°C); (2) Class IB liquids — those liquids that have flash points below 73°F (22.8°C) and boiling points at or above 100°F (37.8°C); (3) Class IC liquids — those liquids that have flash points at or above 73°F (22.8°C), but below 100°F (37.8°C). [**30,** 2003]

3.3.8 Material.

3.3.8.1 ***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: (1) Flammable Liquid, (2) Combustible Liquid, (3) Combustible Powder.

3.3.8.2 ***Noncombustible Material.*** A material that, 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 that are reported as passing ASTM E 136 are considered noncombustible materials. [**220,** 2006]

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3.3.9 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.

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

3.3.11 Readily Accessible. For the purposes of this standard, capable of being removed or exposed without damaging the equipment or system or the building structure or finish, or not permanently enclosed.

3.3.12* Spray Booth. A power-ventilated enclosure for a spray application operation or process that 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.

3.3.12.1 ***Dry Type Spray Booth.*** A spray booth that is not equipped with a water-washing system to remove overspray from the exhaust airstream and is equipped with one or more of the following: (1) 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; (2) dry media filters, either fixed or on rolls, to remove overspray from the exhaust airstream; (3) powder collection systems that capture powder overspray.

3.3.12.2 ***Water-Wash Spray Booth.*** 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.

3.3.13* Spray Room. A power-ventilated fully enclosed room used exclusively for open spraying of flammable or combustible materials.

3.3.14 Ventilation. For the purposes of this standard, movement of air that is provided for the prevention of fire and explosion and is sufficient to prevent accumulation of vapor–air mixtures in concentrations over 25 percent of the lower flammable limit.

3.3.15 Workstation.

3.3.15.1 ***Limited Finishing Workstation.*** An apparatus that is capable of confining the vapors, mists, residues, dusts, or deposits that are generated by a spray application process and that meets the requirements of Section 14.3, but does not meet the requirements of a spray booth or spray room, as herein defined.

3.3.15.2 ***Preparation Workstation.*** An enclosed, partially enclosed, or unenclosed power-ventilated apparatus that is used to control the dusts and residues generated by surface preparation activities, such as sanding. A preparation workstation is not a limited finishing workstation, spray booth, or spray room, as herein defined.

Chapter 4 Location of Spray Application Operations

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

4.2 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. The room shall be protected by an approved automatic sprinkler system designed and installed in accordance with NFPA 13, *Standard for the Installation of Sprinkler Systems.*

Chapter 5 Construction and Design of Spray Areas, Spray Rooms, and Spray Booths

5.1* Walls and Ceilings. Walls, doors, 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.

5.1.1 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 ANSI/UL 900, *Standard for Air Filter Units.*

5.1.2 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.

5.1.3 Aluminum shall not be used for structural support members or the walls or ceiling of a spray booth or spray room enclosure. Aluminum also shall not be used for ventilation ductwork associated with a spray booth or spray room. Aluminum shall be permitted to be used for interior components, such as platforms, spray apparatus components, and other ancillary devices.

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

5.1.5 Structural sections of spray booths shall be permitted to be sealed with a caulk or sealant to minimize air leakage.

5.1.6 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.

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

5.1.8 Spray booths that are used exclusively for powder coating shall meet the requirements of Chapter 15. They shall be permitted to be constructed of 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.

5.2 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.

5.3* Separation from Other Operations. Spray booths shall be separated from other operations by a minimum distance of 915 mm (3 ft) or by a partition, wall, or floor/ceiling assembly having a minimum fire resistance rating of 1 hour. Multiple

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connected spray booths shall not be considered as "other operations" except as provided for in Section 13.3.

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

5.3.2 A clear space of not less than 915 mm (3 ft) shall be maintained on all sides and above 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 915 mm (3 ft) 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 maintained and cleaned.

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

5.4 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.

5.5 Vision and Observation Panels.

5.5.1 Panels for light fixtures or for observation shall be of heat-treated glass, laminated glass, wired glass, or hammered-wired glass and shall be sealed to confine vapors, mists, residues, dusts, and deposits to the spray area.

Exception: Listed spray booth assemblies that have vision panels constructed of other materials shall be permitted.

5.5.2 Panels for light fixtures shall be separated from the fixture to prevent the surface temperature of the panel from exceeding 93°C (200°F).

5.5.3 The panel frame and method of attachment shall be designed to not fail under fire exposure before the vision panel fails.

5.5.4 Observation panels for spray booths that are used exclusively for powder coating processes shall be permitted to be constructed of fire-resistant combustible materials.

5.6 Ventilation. Spray areas that are equipped with ventilation distribution or baffle plates or with dry overspray collection filters shall meet the requirements of 5.6.1 through 5.6.5.

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

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

5.6.3 Supports and holders for filters shall be constructed of noncombustible materials.

5.6.4 Overspray collection filters shall be readily removable or accessible for cleaning or replacement.

5.6.5 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 10.9.)*

Chapter 6 Electrical and Other Sources of Ignition

6.1 Scope. This chapter shall apply to electrical wiring and electrical utilization equipment that is used in the spray area or in the vicinity of the spray area. This chapter shall also apply to other sources of ignition.

6.2* General.

6.2.1 Electrical wiring and utilization equipment shall meet all applicable requirements of Articles 500, 501, 502, 505, and 516 of NFPA 70, *National Electrical Code*, and all applicable requirements of this chapter.

Exception No. 1: Powered vehicles shall meet the requirements of Section 5.4.

Exception No. 2: Resin application operations shall meet the requirements of Chapter 17.

6.2.2* For the purposes of this standard, the Zone system of electrical area classification shall be applied as follows:

(1) The inside of open or closed containers or vessels shall be considered a Class I, Zone 0 location.
(2) A Class I, Division 1 location shall be permitted to be alternatively classified as a Class I, Zone 1 location.
(3) A Class I, Division 2 location shall be permitted to be alternatively classified as a Class I, Zone 2 location.

6.2.3 For the purposes of electrical area classification, the Division system and the Zone system shall not be intermixed for any given source of release.

6.2.4 In instances of areas within the same facility classified separately, Class I, Zone 2 locations shall be permitted to abut, but not overlap, Class I, Division 2 locations. Class I, Zone 0 or Zone 1 locations shall not abut Class I, Division 1 or Division 2 locations. [**70:**505.7(B)]

6.2.5* 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 a spray area or in any surrounding area that is classified as Division 2 or Zone 2.

Exception: This requirement shall not apply to drying, curing, or fusing apparatus covered by Chapter 13.

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

6.3 Electrical Area Classification.

6.3.1* Class I Locations. A Class I location shall be any location where a flammable gas or vapor is present or might be present in the air in quantities sufficient to produce an explosive or ignitible mixture.

6.3.1.1* Class I, Division 1 Locations. As defined in 500.5(B)(1) of NFPA 70, *National Electrical Code*, a Class I, Division 1 location shall be any location where one of the following conditions exists:

(1) An ignitible concentration of flammable gas or vapor can exist under normal operating conditions.

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(2) An ignitible concentration of flammable gas or vapor can exist frequently because of repair or maintenance operations or because of leakage.
(3) Breakdown or faulty operation of equipment or processes might release an ignitible concentration of flammable gas or vapor and might also cause simultaneous failure of electrical equipment in such a way as to directly cause the electrical equipment to become a source of ignition.

6.3.1.2* Class I, Division 2 Locations. As defined in 500.5(B)(2) of NFPA 70, *National Electrical Code*, a Class I, Division 2 location shall be any location where one of the following conditions exists:

(1) A flammable gas or a volatile flammable liquid is handled, processed, or used, but any flammable gas, vapor, or liquid is confined within a closed container or a closed system from which it can escape only in case of accidental rupture or breakdown of the container or system or in case of abnormal operation of the equipment.
(2) An ignitible concentration of flammable gas or vapor is normally prevented by positive mechanical ventilation but might exist because of failure or abnormal operation of the ventilating equipment.
(3) An ignitible concentration of flammable gas or vapor might occasionally be transmitted from an adjacent Class I, Division 1 location, unless such transmission is prevented by positive pressure ventilation from a source of clean air and effective safeguards against ventilation failure are provided.

6.3.1.3* Class I, Zone 0 Locations. As defined in 505.5(B)(1) of NFPA 70, *National Electrical Code*, a Class I, Zone 0 location shall be any location where an ignitible concentration of flammable gas or vapor is present either continuously or for long periods of time.

6.3.1.4* Class I, Zone 1 Locations. As defined in 505.5(B)(2) of NFPA 70, *National Electrical Code*, a Class I, Zone 1 location shall be any location where one of the following conditions exists:

(1) An ignitible concentration of flammable gas or vapor is likely to exist under normal operating conditions.
(2) An ignitible concentration of flammable gas or vapor might exist frequently because of repair or maintenance operations or because of leakage.
(3) Breakdown or faulty operation of equipment or processes might release an ignitible concentration of flammable gas or vapor and might also cause simultaneous failure of electrical equipment in such a way as to directly cause the electrical equipment to become a source of ignition.
(4) An ignitible concentration of flammable gas or vapor might occasionally be transmitted from an adjacent Class I, Zone 0 location, unless such transmission is prevented by positive pressure ventilation from a source of clean air and effective safeguards against ventilation failure are provided.

6.3.1.5 Class I, Zone 2 Locations. As defined in 505.5(B)(3) of NFPA 70, *National Electrical Code*, a Class I, Zone 2 location shall be any location where one of the following conditions exists:

(1) An ignitible concentration of a flammable gas or vapor is not likely to exist under normal operating conditions, and if an ignitible concentration does exist, will exist only for a short period of time.
(2) A flammable gas or a volatile flammable liquid is handled, processed, or used, but any flammable gas, vapor, or liquid is confined within a closed container or a closed system from which it can escape only in case of accidental rupture or breakdown of the container or system or in case of abnormal operation of the equipment.
(3) An ignitible concentration of flammable gas or vapor is normally prevented by positive mechanical ventilation but might exist because of failure or abnormal operation of the ventilating equipment.
(4) An ignitible concentration of flammable gas or vapor might occasionally be transmitted from an adjacent Class I, Zone 1 location, unless such transmission is prevented by positive pressure ventilation from a source of clean air and effective safeguards against ventilation failure are provided. *(See also A.6.3.1.2.)*

6.3.2 Class II Locations. A Class II location shall be any location that might be hazardous because of the presence of a combustible dust.

6.3.2.1* Class II, Division 1 Locations. As defined in 500.5(C)(1) of NFPA 70, *National Electrical Code*, a Class II, Division 1 location shall be any location where one of the following conditions exists:

(1) Combustible dust is in the air in quantities sufficient to produce explosive or ignitible mixtures under normal operating conditions.
(2) Mechanical failure or abnormal operation of machinery or equipment might cause an explosive or ignitible mixture of combustible dust in air and might also provide a source of ignition through simultaneous failure of electrical equipment, operation of protection devices, or from other causes.
(3) Group E combustible dusts might be present in quantities sufficient to be hazardous.

6.3.2.2* Class II, Division 2 Locations. As defined in 500.5(C)(2) of NFPA 70, *National Electrical Code*, a Class II, Division 2 location shall be a location in which one of the following conditions exists:

(1) Combustible dust due to abnormal operations might be present in the air in quantities sufficient to produce explosive or ignitible mixtures.
(2) Combustible dust accumulations are present but are normally insufficient to interfere with the normal operation of electrical equipment or other apparatus, but could as a result of infrequent malfunctioning of handling or processing equipment become suspended in the air.
(3) Combustible dust accumulations on, in, or in the vicinity of the electrical equipment could be sufficient to interfere with the safe dissipation of heat from electrical equipment, or could be ignitible by abnormal operation or failure of electrical equipment.

6.3.2.3* Class II, Zone 20. As defined in 506.5(B)(1) of NFPA 70, *National Electrical Code*, a Class II, Zone 20 location shall be any location where one of the following conditions exists:

(1) An ignitible concentration of combustible dust is present continuously.
(2) An ignitible concentration of combustible dust is present for long periods of time.

6.3.2.4* Class II, Zone 21. As defined in 506.5(B)(2) of NFPA 70, *National Electrical Code*, a Class II, Zone 21 location shall be any location where one of the following conditions exists:

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(1) An ignitible concentration of combustible dust is likely to exist occasionally under normal operating conditions.
(2) An ignitible concentration of combustible dust might exist frequently because of repair or maintenance operations or because of leakage.
(3) Equipment is operated or processes are carried on, of such a nature that equipment breakdown or faulty operations could result in the release of an ignitible concentration of combustible dust and also cause simultaneous failure of electrical equipment in a mode to cause the electrical equipment to become a source of ignition.
(4) An ignitible concentration of combustible dust could be communicated from an adjacent Class II, Zone 20 location, unless communication is prevented by adequate positive pressure ventilation from a source of clean air and effective safeguards against ventilation failure are provided.

6.3.2.5* Class II, Zone 22. As defined in 506.5(B)(3) of NFPA 70, *National Electrical Code*, a Class II, Zone 22 location shall be any location where one of the following conditions exists:

(1) An ignitible concentration of combustible dust is not likely to occur in normal operation, and if it does occur, will only persist for a short period.
(2) A combustible dust is handled, processed, or used, but the dust is normally confined within closed containers or closed systems from which it can escape only as a result of the abnormal operation of the equipment with which the dust is handled, processed, or used.
(3) An ignitible concentration of combustible dust could be communicated from an adjacent Class II, Zone 21 location, unless communication is prevented by adequate positive pressure ventilation from a source of clean air and effective safeguards against ventilation failure are provided.

6.4 Electrical Devices in Spray Areas.

6.4.1 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; Class I, Zone 1; or Class II, Division 1 locations, whichever is applicable.

6.4.2* 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; Class I, Zone 1; or Class II, Division 1 locations, whichever is applicable.

6.5 Electrical Devices Adjacent to Spray Areas. Electrical wiring and utilization equipment located adjacent to the spray area shall be classified in accordance with 6.5.1 through 6.5.5.

6.5.1 Electrical wiring and utilization equipment located outside, but within 6100 mm (20 ft) horizontally and 3050 mm (10 ft) 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 or Zone 2 in Figure 6.5.1 shall be suitable for Class I, Division 2; Class I, Zone 2; or Class II, Division 2 locations, whichever is applicable.

6.5.2 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 the booth or room but within the boundaries designated as Division 2 or Zone 2 in Figure 6.5.2(a) and Figure 6.5.2(b) shall be suitable for Class I, Division 2; Class I, Zone 2; or Class II, Division 2 locations, whichever is applicable.

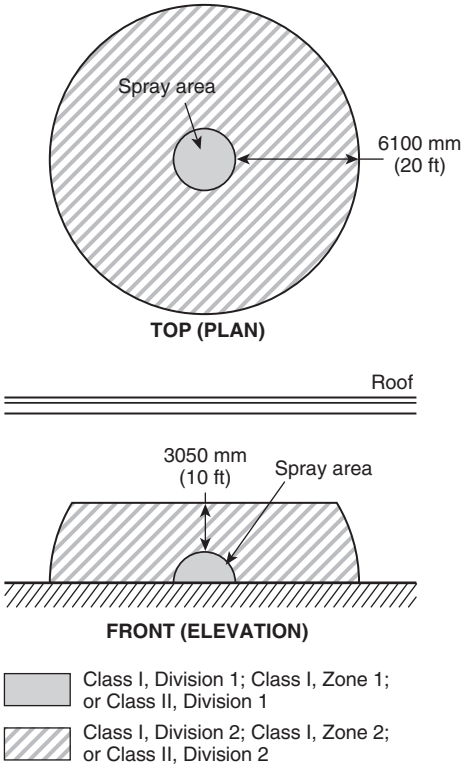


FIGURE 6.5.1 Electrical Area Classification for Open Spray Areas.

6.5.2.1 The Class I, Division 2; Class I, Zone 2; or Class II, Division 2 locations shown in Figure 6.5.2(a) and Figure 6.5.2(b) shall extend from the edges of the open face or open front of the booth or room in accordance with the following:

(1) If the exhaust ventilation system is interlocked with the spray application equipment, then the Division 2 or Zone 2 location shall extend 1525 mm (5 ft) horizontally and 915 mm (3 ft) vertically from the open face or open front of the booth or room, as shown in Figure 6.5.2(a).
(2) If the exhaust ventilation system is not interlocked with the spray application equipment, then the Division 2 or Zone 2 location shall extend 3050 mm (10 ft) horizontally and 915 mm (3 ft) vertically from the open face or open front of the booth or room, as shown in Figure 6.5.2(b).

6.5.2.2 For the purposes of 6.5.2, *interlocked* shall mean that the spray application equipment cannot be operated unless the exhaust ventilation system is operating and functioning as designed and spray application is automatically stopped if the exhaust ventilation system fails.

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

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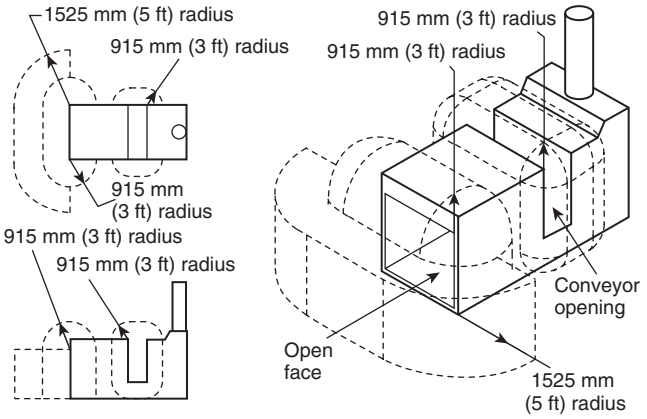


FIGURE 6.5.2(a) Class I, Division 2; Class I, Zone 2; or Class II, Division 2 Locations Adjacent to an Open-Face or Open-Front Spray Booth or Spray Room with Exhaust Ventilation Interlocked with Spray Application Equipment.

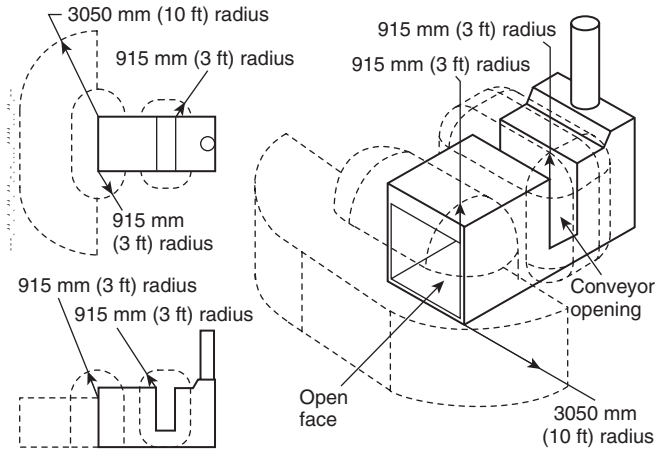


FIGURE 6.5.2(b) Class I, Division 2; Class I, Zone 2; or Class II, Division 2 Locations Adjacent to an Open-Face or Open-Front Spray Booth or Spray Room with Exhaust Ventilation NOT Interlocked with Spray Application Equipment.

Division 2; Class I, Zone 2; or Class II, Division 2 locations, whichever is applicable.

6.5.4 If spray application operations are confined to an enclosed spray booth or room, any electrical wiring or utilization equipment located within 915 mm (3 ft) of any opening shall be suitable for Class I, Division 2; Class I, Zone 2; or Class II, Division 2 locations, whichever is applicable, as shown in Figure 6.5.4.

6.5.5 Open containers, supply containers, waste containers, spray gun cleaners, and solvent distillation units that contain Class I liquids shall be located in areas ventilated in accordance with applicable requirements of Chapter 7.

6.5.5.1 Electrical area classification shall be as follows:

(1) The area within 915 mm (3 ft) in all directions from any such container or equipment and extending to the floor or grade level shall be classified as Class I, Division 1 or Class I, Zone 1, whichever is applicable.
(2) The area extending 610 mm (2 ft) beyond the Division 1 or Zone 1 location shall be classified as Class I, Division 2 or Class I, Zone 2, whichever is applicable.
(3) The area extending 1525 mm (5 ft) horizontally beyond the area described in 6.5.5.1(2) up to a height of 460 mm (18 in.) above the floor or grade level shall be classified as Class I, Division 2 or Class I, Zone 2, whichever is applicable.
(4) The area inside any tank or container shall be classified as Class I, Division 1 or Class I, Zone 0, whichever is applicable.

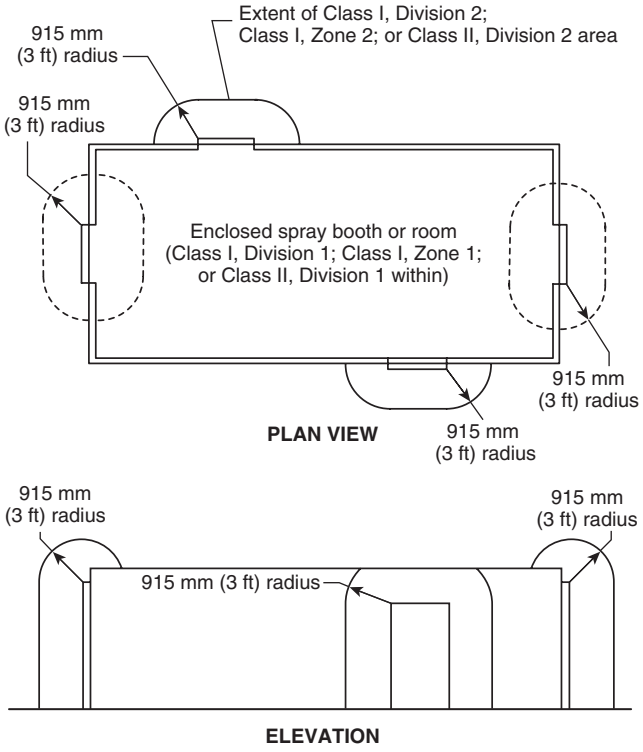


FIGURE 6.5.4 Class I, Division 2; Class I, Zone 2; or Class II, Division 2 Locations Adjacent to an Enclosed Spray Booth or Spray Room.

6.5.5.2 Electrical wiring and utilization equipment installed in these areas shall be suitable for the location, as shown in Figure 6.5.5.2.

6.6 Light Fixtures.

6.6.1 Light fixtures, like that shown in Figure 6.6.1, that are attached to the walls or ceiling of a spray area but that are outside any classified area and are separated from the spray area by glass panels that meet the requirements of Section 5.5 shall be suitable for use in unclassified locations. Such fixtures shall be serviced from outside the spray area.

6.6.2 Light fixtures, like that shown in Figure 6.6.1, that are attached to the walls or ceiling of a spray area; that are separated from the spray area by glass panels that meet the requirements of Section 5.5; and that are located within a Class I, Division 2, a Class I, Zone 2, or a Class II, Division 2 location shall be suitable for such location. Such fixtures shall be serviced from outside the spray area.

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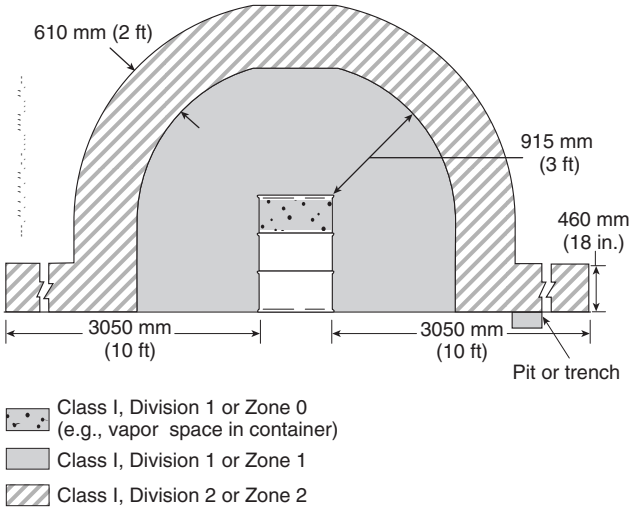


FIGURE 6.5.5.2 Electrical Area Classification for Class I Liquid Operations Around Open Containers, Supply Containers, Waste Containers, Spray Gun Cleaners, and Solvent Distillation Units.

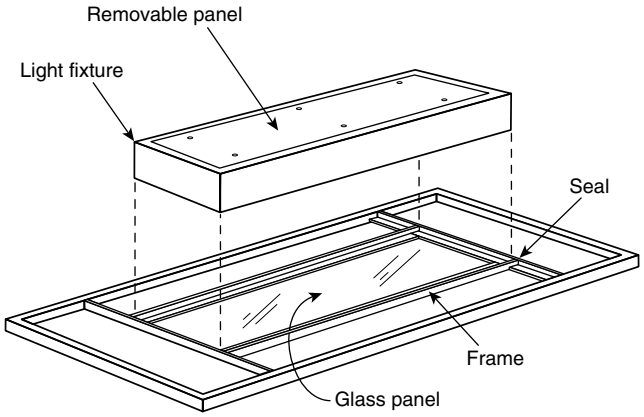
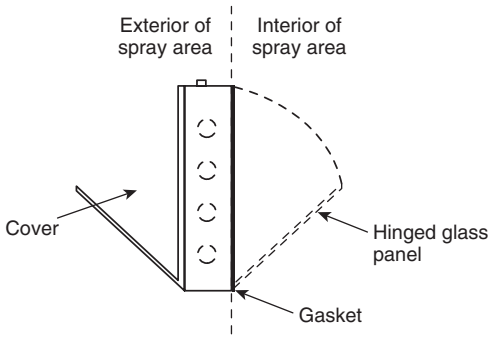


FIGURE 6.6.1 Example of a Light Fixture Mounted Outside the Spray Area and Serviced from Outside the Spray Area.

6.6.3 Light fixtures, like that shown in Figure 6.6.3, 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; Class I, Zone 2; or Class II, Division 2 locations, whichever is applicable, and also shall be listed for accumulations of deposits of combustible residues. Such fixtures shall be permitted to be serviced from inside the spray area.

6.6.4 Light fixtures that are located inside the spray area shall meet the requirements of Section 6.4 and Section 6.7.

6.7* Static Electricity. All persons, all electrically conductive parts of the spray room or spray booth, 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 to prevent sparks from the accumulation of static electricity.



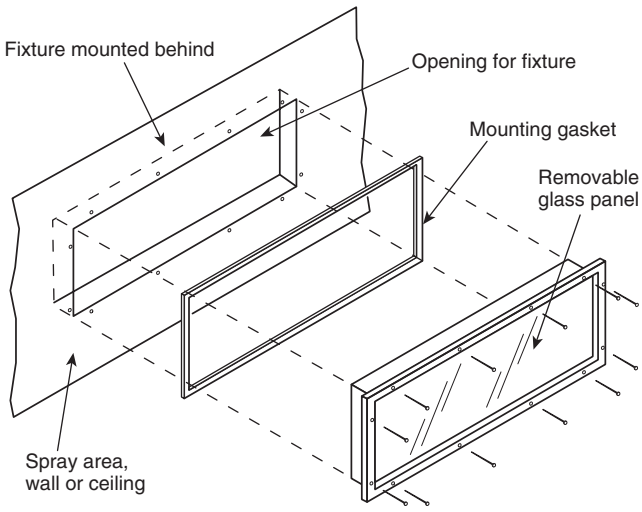


FIGURE 6.6.3 Examples of Light Fixtures That Are Integral Parts of the Spray Area and That Are Serviced from Inside the Spray Area.

6.8 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:

(1) They are approved for extra-hard usage.
(2) They are equipped with a grounding conductor that meets the requirements of Section 400.2 of NFPA 70, *National Electrical Code.*
(3) They are connected to terminals or conductors in an approved manner.
(4) 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.
(5) They are provided with explosionproof seals where the cord enters junction boxes, fittings, or enclosures.
(6) They are listed for deposits of combustible residues.

6.9 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 illuminated by fixed light fixtures within the spray area, they shall meet the requirements of 6.2.2.

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Chapter 7 Ventilation

7.1 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 Vapors, Gases, Mists, and Noncombustible Particulate Solids*, except as amended by the requirements of this chapter.

7.2 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. *(See Annex B for additional guidance on determining 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.

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

7.2.2 Powder Coating Systems. Powder coating systems also shall meet the requirements of Section 15.8.

7.2.3 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.

7.3* 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.

7.4 Routing of Exhaust Ducts. Air exhausted to the atmosphere from liquid 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 1830 mm (6 ft) from any exterior wall or roof. The exhaust duct shall not discharge in the direction of any combustible construction that is within 7625 mm (25 ft) 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 7625 mm (25 ft) of the exhaust duct discharge point.

7.5 Recirculation of Exhaust.

7.5.1* Air exhausted from spray areas shall not be recirculated unless all of the following requirements are met:

(1) Recirculation shall be allowed only for unmanned spray operations and for cascading to subsequent unmanned spray operations.
(2) Solid particulates shall be removed from the recirculated air.
(3) The concentration of vapors in the exhaust airstream shall not exceed 25 percent of the lower flammable limit.
(4) Listed equipment shall be used to monitor the concentration of vapors in all exhaust airstreams.
(5) The equipment specified in 7.5.1(4) shall sound an alarm and shall automatically shut down the spray operation if the concentration of any vapor in the exhaust airstream exceeds 25 percent of the lower flammable limit.
(6) All equipment installed to process and remove contaminants from the air exhausted from spray operations shall be approved.

7.5.2* The provisions of 7.5.1 shall not disallow recirculation of air to occupied spaces. However, other requirements addressing the toxicity and permissible exposure limits shall also apply. *(See ANSI/AIHA Z9.7, Recirculation of Air from Industrial Process Exhaust Systems.)*

7.6* 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 1.7 m^2 (18 ft^2) shall be permitted to be manifolded if the sprayed materials used will not 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:

(1) The sprayed materials used will not react and cause ignition of the residue in the ducts.
(2) No nitrocellulose-based finishing material is used.
(3) An air-cleaning system is provided to reduce the amount of overspray carried into the duct manifold.
(4) Automatic sprinkler protection is provided at the junction of each booth exhaust with the manifold, in addition to the protection required by Chapter 9.
(5) The installation is approved by the authority having jurisdiction.

7.7* Materials of Construction. Exhaust ducts and fasteners shall be constructed of steel, except as allowed in 7.7.1 and 7.7.2.

7.7.1 For spray booths used exclusively for powder coating, ducts shall be permitted to be constructed of fire-retardant combustible materials.

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

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

7.8.1 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.

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

7.8.3 Hangers and supports shall be designed to allow for expansion and contraction.

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

7.9 Exhaust Duct Access Openings. Exhaust ducts shall be provided with doors, panels, or other means to facilitate inspection, maintenance, cleaning, and access to fire protection devices.

7.10 Exhaust Fans and Drives.

7.10.1 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 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.

7.10.2 Electric motors that drive exhaust fans shall not be placed inside any spray area unless they meet the provisions of 6.2.2.

7.10.3 Belts shall not enter any spray area unless the belt and pulley within the spray area are completely enclosed.

7.11* 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 13.)*

Chapter 8 Storage, Handling, and Distribution of Flammable and Combustible Liquids

8.1* 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 in process areas shall also meet the requirements of this chapter.

8.2 Storage in Process Areas.

8.2.1 The volume of Class I, Class II, and Class IIIA liquids stored in a storage cabinet shall not exceed 454 L (120 gal).

8.2.1.1 The total aggregate volume of Class I, Class II, and Class IIIA liquids in storage cabinets stored in a single fire area shall not exceed 1362 L (360 gal).

8.2.1.2 In an industrial occupancy, additional storage cabinets shall be permitted to be located in the same fire area if a minimum separation of 30 m (100 ft) is maintained between each group and the total aggregate volume of each group complies with 8.2.1.1.

8.2.1.3 In an industrial occupancy that is protected by an automatic sprinkler system designed and installed in accordance with NFPA 13, *Standard for the Installation of Sprinkler Systems*, the total aggregate volume of Class I, Class II, and Class IIIA liquids in storage cabinets stored in the same fire area shall be permitted to be increased to 2725 L (720 gal).

8.2.2 The quantity of liquid located in the vicinity of spraying operation but outside a storage cabinet, an inside storage room, a cutoff 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 of the following, whichever is greater:

(1) A supply for one day
(2) 95 L (25 gal) of Class IA liquids in containers, plus 454 L (120 gal) of Class IB, Class IC, Class II, or Class III liquids in containers, plus two portable tanks each not exceeding 2500 L (660 gal) of Class IB, Class IC, Class II, or Class IIIA liquids, plus 20 portable tanks each not exceeding 2500 L (660 gal) of Class IIIB liquids

8.2.3 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 8.3.

8.3 Mixing.

8.3.1 Dispensing or transfer of liquids from containers, mixing of liquids, and filling of containers, including portable mixing tanks and "pressure pots," shall be done only in a mixing room or in a spray area.

8.3.2 Mixing rooms shall meet all of the following requirements:

(1) The mixing room shall meet the construction requirements of Section 5.1.
(2) The area of the mixing room shall not exceed 14 m^2 (150 ft^2).
(3) The mixing room shall be designed to contain a spill of the contents in the room.
(4) The mixing room or a spray area used for mixing and dispensing operations shall be provided with continuous mechanical ventilation capable of providing air movement of not less than 0.3 m^3/min per square meter of floor area (1 ft^3/min/ft^2) or 4 m^3/min (150 ft^3/min), whichever is greater. The ventilation system shall be in operation at all times.
(5) Dispensing and mixing rooms shall be classified, for purposes of electrical area classification, the same as enclosed spray booths, in accordance with 6.5.4.
(6) The mixing room shall be provided with an approved automatic fire protection system that meets all applicable requirements of Chapter 9.
(7) The mixing room shall be provided with portable fire extinguishers located in accordance with NFPA 10, *Standard for Portable Fire Extinguishers.*

Exception: See 8.3.6.

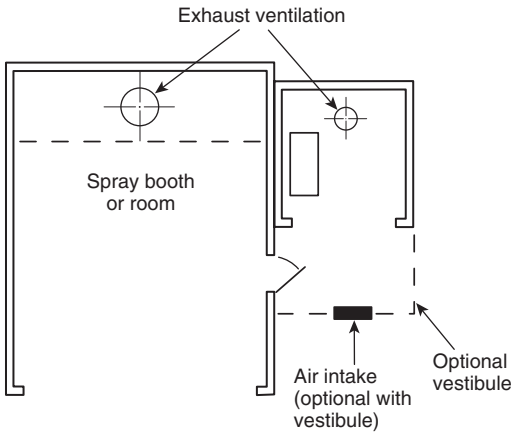
8.3.3 The amount of liquid permitted in a single spray area shall not exceed 227 L (60 gal).

8.3.4 Where a separate mixing room is provided and the mixing room is located adjacent to or within 1830 mm (6 ft) of an adjacent spray area or areas, as shown in Figure 8.3.4(a) and Figure 8.3.4(b), the combined quantities of liquids located in the spray areas and the mixing room shall not exceed 454 L (120 gal).

Exception: See 8.3.6.

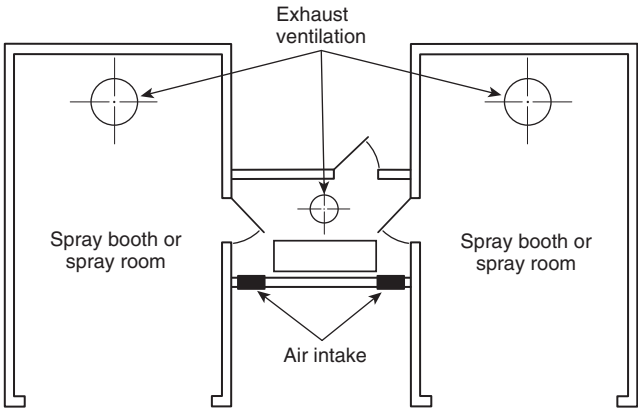
8.3.5 Where a separate mixing room is provided and the mixing room is located 1830 mm (6 ft) or more from an adjacent spray area or areas, the quantity of liquid permitted in the

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Maximum volumes of liquid allowed:
Spray area, 227 L (60 gal)
Spray area and mix room, 454 L (120 gal)

FIGURE 8.3.4(a) Mixing Room Within 1830 mm (6 ft) of Spray Area, Including Maximum Volume of Liquid Allowed.



Maximum volumes of liquid allowed:
Spray area, 227 L (60 gal)
Spray area and mix room, 454 L (120 gal)

FIGURE 8.3.4(b) Mixing Room Within 1830 mm (6 ft) of Spray Area and with Direct Entry to Spray Area, Including Maximum Volume of Liquid Allowed.

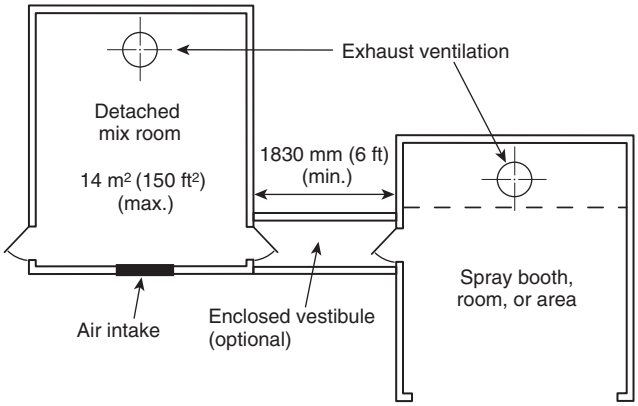
mixing room shall not exceed 80 L/m^2 (2 gal/ft^2), up to a maximum of 1135 L (300 gal), as shown in Figure 8.3.5.

Exception: See 8.3.6.

8.3.6 Where the quantities of liquids required or the floor area necessary to provide a suitable mixing room exceeds the limits specified in 8.3.2 through 8.3.5, the mixing room shall meet all applicable requirements of NFPA 30, *Flammable and Combustible Liquids Code.*

8.4 Distribution Systems — Piping.

8.4.1* 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. Piping systems shall be properly bonded and grounded.



Maximum volumes of liquid allowed:
Spray area, 227 L (60 gal)
Spray area and mix room, 454 L (120 gal)

FIGURE 8.3.5 Mixing Room 1830 mm (6 ft) or More from Spray Area, Including Maximum Volume of Liquid Allowed.

8.4.2* 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 shutoff valve shall be provided on the steel pipe at the connection.

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

8.4.4 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.

8.4.5* 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 fire. When pressurized tanks larger than 19 L (5 gal) 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.

8.4.6 All pressure tubing, hose, and couplings shall be inspected at regular intervals. 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.

8.5 Distribution Systems — General.

8.5.1 Liquids shall be transported by means of closed containers, approved safety cans, or approved portable tanks or shall be transferred by means of a piping system. Open containers shall not be used for moving or storing liquids.

8.5.2* Wherever liquids are transferred from one container to another, both containers shall be effectively bonded and grounded to dissipate static electricity.

8.5.3 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 supports or shall be suspended by wire cables. Containers that supply spray nozzles by gravity flow shall not exceed 38 L (10 gal) capacity.

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8.5.4 Original shipping containers shall not be subjected to air pressure for supplying spray nozzles.

8.5.5 Containers that are pressurized to supply spray nozzles, air storage tanks, and coolers shall comply with all applicable requirements of the ASME *Boiler and Pressure Vessel Code*, Section VIII, for construction, tests, and maintenance.

Exception: The following need not meet this requirement:

(1) Pressure containers less than 150 mm (6 in.) in diameter
(2) Pressure containers that operate at less than a gauge pressure of 1.03 kPa (15 psi)
(3) Siphon-type spray cups

8.5.6 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 6.)* 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 the agitators are powered by an electric motor, the motor shall meet the requirements of Chapter 6.

8.5.7 Methods for cleaning paint circulation systems shall meet the requirements of 7.3.7 of NFPA 30, *Flammable and Combustible Liquids Code*.

8.5.8 Compressed air shall be permitted to be used for cleaning paint delivery hoses for individual applicators in a spray booth, provided both of the following requirements are met:

(1) The booth ventilation is operating.
(2) The maximum air pressure does not exceed the maximum working pressure of any component of the piping or hose system.

Chapter 9 Protection

9.1* General. Spray areas, which include by definition any associated exhaust plenums and exhaust ductwork, any particulate filters, any solvent concentrator units, any recirculation air supply units, and mixing rooms, shall be protected with an approved automatic fire protection system.

9.1.1 The automatic fire protection system shall be permitted to be, and shall be installed in accordance with, any of the following:

(1) An automatic water sprinkler system that meets all applicable requirements of NFPA 13, *Standard for the Installation of Sprinkler Systems*
(2) An automatic foam water sprinkler system that meets all applicable requirements of NFPA 16, *Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems*
(3) A carbon dioxide extinguishing system that meets all applicable requirements of NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems*
(4) A dry chemical extinguishing system that meets all applicable requirements of NFPA 17, *Standard for Dry Chemical Extinguishing Systems*
(5) A gaseous agent extinguishing system that meets all applicable requirements of NFPA 2001, *Standard on Clean Agent Fire Extinguishing Systems*

9.1.2 The automatic fire protection system shall also meet all applicable requirements of Section 9.2 and Section 9.3.

9.1.3 The fire alarm and fire protection system shall be supervised in accordance with *NFPA 72, National Fire Alarm Code*.

9.2 Continuous Spray Application Operations.

9.2.1 For continuous spray application operations, activation of the automatic fire protection system shall automatically accomplish all of the following:

(1) Activate a local alarm in the vicinity of the spraying operation
(2) Transmit an alarm signal to the facility's fire alarm system, if such a system is provided
(3) Shut down the coating material delivery system
(4) Shut down all spray application operations
(5) Stop any conveyors into and out of the spray area

9.2.1.1 For continuous spray application operations, the additional requirements of Section 9.7, for automated powder application equipment, or Section 9.8, for automated liquid electrostatic spray application equipment, whichever is applicable, shall also apply.

9.2.2 Emergency Shutdown. For continuous spray application operations, one or more manual emergency system shutdown stations shall be installed to serve each spray area. When activated, the stations shall accomplish at least the functions listed in 9.2.1(1) and 9.2.1(3) through 9.2.1(5). 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.

9.3 Ventilation Systems. Air make-up systems and spray area exhaust systems shall remain functioning during any fire alarm condition.

Exception No. 1: Where the type of automatic fire protection system requires that ventilation be discontinued, air make-up systems and spray area 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 9.7 shall be met instead of those of this section.

9.4* Automatic Sprinkler Systems.

9.4.1* The automatic sprinkler system shall be a wet pipe system, a dry pipe system, a preaction system, or an open-head deluge system, whichever is most appropriate for the portion of the spray operation being protected.

9.4.2 The automatic sprinkler system shall be designed for Extra Hazard (Group 2) occupancies, as defined in NFPA 13, *Standard for the Installation of Sprinkler Systems*.

Exception No. 1: For spray application of styrene cross-link thermoset resins, Section 17.3 shall apply.

Exception No. 2: Automatic sprinkler systems for powder coating operations shall be designed for Ordinary Hazard (Group 2), as defined in NFPA 13, Standard for the Installation of Sprinkler Systems.

9.4.3 The water supply 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.

9.4.4 Where sprinklers are installed to protect spray areas and mixing rooms only, water shall be permitted to be supplied from domestic water systems, provided the domestic supply can meet the demand for the design criteria of 9.4.2.

9.4.5 The sprinkler system shall be controlled by a separate, listed indicating valve(s), operable from floor level.

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9.4.6* Sprinkler systems protecting stacks or ducts shall meet all of the following requirements:

(1) Sprinklers shall be spaced no more than 3.7 m (12 ft) apart.
(2) If exhaust ducts are manifolded, a sprinkler shall be located in the manifold at the junction of each exhaust duct with the manifold.
(3) Sprinklers shall provide a minimum flow of 114 L/min (30 gpm) per head at a minimum of 1 bar (15 psi) pressure.
(4) Sprinklers shall be ordinary temperature rated, unless required to be higher due to operating temperatures measured in the ducts, in which case the operating temperature shall be at least 28°C (50°F) above the inside temperature of the duct.

9.4.6.1 Stacks and exhaust ducts shall be provided with access openings for inspection and cleaning of sprinklers.

9.4.6.2 Sprinkler systems protecting stacks and ducts that are subject to freezing shall be of a nonfreezing type or be a manually controlled open-head system.

9.4.7 Sprinklers shall be protected against overspray residue, either by location or covering, so that they will operate quickly in event of fire.

9.4.7.1 Sprinklers shall be permitted to be covered only by cellophane bags having a thickness of 0.08 mm (0.003 in.) or less or by thin paper bags. These coverings shall be replaced frequently so that heavy deposits of residue do not accumulate.

9.4.7.2 Sprinklers that have been painted or coated by overspray or residues shall be replaced with new sprinklers.

9.5* Automatic Carbon Dioxide, Dry Chemical, and Clean Agent Systems. The fire protection system shall be capable of discharging its contents into the entire protected area simultaneously, including the exhaust plenum and exhaust ductwork.

9.6 Portable Fire Extinguishers. Portable fire extinguishers shall be provided and located in accordance with NFPA 10, *Standard for Portable Fire Extinguishers*.

9.7* Protection for Automated Powder Application Equipment.

9.7.1 Automated powder application equipment, both listed and unlisted, shall be further protected by listed optical flame detection, installed and supervised in accordance with *NFPA 72, National Fire Alarm Code*. The optical flame detection shall, in event of ignition, react to the presence of flame within one-half (0.5) second and shall accomplish all of the following:

(1) Stop any conveyors into and out of the spray area
(2) Shut off ventilation
(3) Shut off application, transfer, and powder collection equipment
(4) Close segregation dampers in associated ductwork to interrupt airflows from application equipment to powder collectors
(5) Disconnect power to the high voltage elements in the spray area and de-energize the system

9.7.2 Automated powder application equipment that is unlisted shall be further protected by the following:

(1) In addition to meeting the requirements in 9.2.1 and 9.7.1, the optical flame detection system shall also activate the automatic fire protection system, if provided.
(2) Automatic electrostatic equipment enclosures inside the booth shall be protected with an approved automatic fire protection system. Activation of this system shall automatically accomplish the requirements of 9.2.1 and 9.7.1.
(3) Manual activation stations shall be installed. 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. These devices shall activate the fire protection system as specified in 9.1.1 for the affected automated zone, if applicable, and accomplish the requirements in 9.7.1.

Exception: This requirement shall not apply to a closed-head wet pipe automatic sprinkler system.

9.8* Protection for Automated Liquid Electrostatic Spray Application Equipment.

9.8.1 Automated liquid electrostatic spray application equipment, both listed and unlisted, shall be further protected by listed optical flame detection, installed and supervised in accordance with *NFPA 72, National Fire Alarm Code*. The optical flame detection shall, in event of ignition, react to the presence of flame within one-half (0.5) second and shall accomplish all of the following:

(1) Meet all the requirements of 9.2.1
(2) Disconnect power to the high-voltage elements in the spray area and de-energize the system

9.8.2 Automated liquid electrostatic spray application equipment that is unlisted shall be protected further by the following:

(1) In addition to meeting the requirements in 9.8.1, the optical flame detection system shall also activate one of the following over each zone in which fire has been detected:
   (a) An open head deluge system designed to discharge a minimum density of 24.4 mm/min (0.6 gpm/ft^2)
   (b) A carbon dioxide extinguishing system
   (c) A dry chemical extinguishing system
   (d) A gaseous agent extinguishing system
(2) Manual activation stations shall be installed. 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. These devices shall activate the fire protection system as specified in 9.8.2(1) and accomplish the requirements of 9.2.1 and 9.8.1(2).
(3) A wet pipe sprinkler system shall also be provided throughout the spray booth. This system shall meet all the applicable requirements of NFPA 13 for Extra Hazard (Group 2) occupancies.
(4) Automatic electrostatic equipment enclosures inside the booth systems shall be protected with an approved automatic fire protection system. Activation of this system shall automatically accomplish the requirements of 9.2.1 and 9.8.1(2).

Chapter 10 Operations and Maintenance

10.1* 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. Maintenance shall be the responsibility of the users of the apparatus and processes.

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10.1.1* Spray application operations shall not be conducted outside predetermined spray areas.

10.1.2 Inspection of extinguishing systems shall be conducted to ensure that the performance of the extinguishing system components will not be affected by overspray and residues.

10.2* Combustible Deposits.

10.2.1 All spray areas shall be kept free of excessive accumulation of deposits of combustible residues.

10.2.2 Combustible coverings (thin paper, plastic) and strippable coatings shall be permitted to be used to facilitate cleaning operations in spray areas.

10.2.2.1 When plastic covering is used, it shall be of a static dissipative nature or shall have a maximum breakdown voltage of 4 kV to prevent accumulation of a hazardous static electric charge.

10.2.3 If residue accumulates to excess in booths, duct or duct discharge points, or other spray areas, all spraying operations shall be discontinued until conditions have been corrected.

10.3 High-Pressure Hose Lines. High-pressure hose lines that convey flammable or combustible coating material in "airless" spray application operations shall be inspected frequently and shall be repaired or replaced as necessary. 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.

10.4 Maintenance Procedures.

10.4.1 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.

10.4.2 At the close of the day's operation, all discarded overspray collector filters, residue scrapings, and debris contaminated with residue shall be removed immediately to a designated storage location, placed in a noncombustible container with a tight-fitting lid, or placed in a water-filled metal container.

10.5* Waste Containers.

10.5.1 Approved waste containers shall be provided wherever rags or waste are impregnated with sprayed material, and all such rags or waste shall be deposited therein immediately after use. The contents of waste containers shall be placed in a designated storage location.

10.5.2 Waste containers containing flammable liquids shall be located in ventilated areas that meet the requirements of Chapter 7. Such areas shall also meet the electrical area classification requirements of 6.5.5.

10.5.3* Waste containers for flammable liquids shall be constructed of conductive materials and shall be bonded and grounded.

10.5.4 Waste containers for flammable liquids shall be handled and stored in accordance with Chapter 8.

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

10.7 Cleaning Operations.

10.7.1 Scope. This section shall apply to the use of flammable or combustible liquids for the flushing and cleaning of equipment.

10.7.2 Liquids. Class I and Class II liquids used in cleaning operations shall be in original shipping containers or in listed safety containers.

10.7.3 Location. Cleaning operations using flammable or combustible liquids shall be conducted inside a spray area with ventilating equipment operating or in ventilated areas that meet the requirements of Chapter 7. Such areas shall also meet the electrical area classification requirements of 6.5.5.

10.7.4* Equipment. Equipment using flammable or combustible liquids shall meet the requirements of 6.5.5 and shall be bonded and grounded.

10.7.5 Manual Cleaning. Individual manual cleaning operations shall be limited to not more than 4 L (1 gal) of flammable or combustible liquid for each cleaning operator.

10.7.6 Liquid Storage. Flammable and combustible liquids shall be handled and stored in accordance with Chapter 8. Containers used for handling, storage, or recovery of Class I liquids shall be constructed of conductive materials and shall be bonded and grounded.

10.8 Solvent Distillation Units (Solvent Recyclers).

10.8.1 Scope.

10.8.1.1 Section 10.8 shall apply to solvent distillation units having distillation chambers or still pots that do not exceed 230 L (60 gal) capacity and are used to recycle Class I, Class II, and Class IIIA liquids. [**30:**7.11.1.1]

10.8.1.2 This section shall not apply to research, testing, or experimental processes; to distillation processes carried out in petroleum refineries, chemical plants, or distilleries; or to distillation equipment used in dry cleaning operations. [**30:**7.11.1.2]

10.8.2 Equipment. Solvent distillation units shall be approved or shall be listed in accordance with ANSI/UL 2208, *Standard for Solvent Distillation Units*. [**30**:7.11.2]

10.8.3 Solvents. Solvent distillation units shall only be used to distill liquids for which they have been investigated and which are indicated on the unit's marking or instruction manual. Unstable or reactive liquids or materials shall not be processed unless they have been specifically indicated on the system's markings or in the instruction manual. [**30:**7.11.3]

10.8.4 Location. Solvent distillation units shall only be used in locations in accordance with their approval or listing. They shall not be used in basements. They shall be located away from potential sources of ignition, as indicated on the unit's marking. [**30:**7.11.4]

10.8.5 Liquid Storage. Distilled liquids and liquids awaiting distillation shall be stored in accordance with Chapter 6 of NFPA 30, *Flammable and Combustible Liquids Code*.

10.9* 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.

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10.10* 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.

10.11 Smoking. Signs stating NO SMOKING OR OPEN FLAMES in large letters on contrasting color background shall be conspicuously posted at all spray areas and paint storage rooms.

10.12* Hot Work. Welding, cutting, and other 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 precautions have been taken and will be followed until the job is completed.

Chapter 11 Automated Electrostatic Spray Equipment

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

11.2 General.

11.2.1 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.

11.2.2 Where robot programming procedures involve manual manipulation of the robot arm while spraying with the high-voltage components energized, the provisions of Section 12.5 also shall apply.

11.3 Automated Electrostatic Systems. All automated electrostatic equipment systems shall comply with the requirements of 11.3.1 through 11.3.11.

11.3.1 Transformers, high-voltage supplies, control apparatus, and all other electrical portions of the equipment shall be located outside the spray area, as defined in 3.3.1.3, or shall otherwise meet the requirements of Chapter 6 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.

11.3.2 Electrodes and electrostatic atomizing heads 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 requirement.

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

11.3.4* 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 who enter the spray area.

11.3.5 Conductive 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.

11.3.6 Highly resistive objects (i.e., surface conductivity between 10^8 and 10^{11} ohms per square) that exhibit a surface voltage below 2500 volts, as measured using a nonloading kilovoltmeter and when subjected to coronal current not less than that expected in the application process, shall be considered adequately grounded.

11.3.7 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 grounding.

11.3.8 Electrostatic apparatus shall be equipped with automatic means to rapidly de-energize the high-voltage elements under any one of the following conditions:

(1) Shutdown of ventilating fans or failure of ventilating equipment from any cause
(2) Stopping of the conveyor carrying objects or material through the high-voltage field unless stopping is required by the spray process
(3) De-energizing the primary voltage input to the power supply
(4) Occurrence of excessive current leakage at any point on the high-voltage system

11.3.9 Safeguards such as 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.

11.3.10 Signs shall be conspicuously posted for the following purposes:

(1) To designate the process zone as dangerous with regard to fire and accident
(2) To identify the grounding requirements for all electrically conductive objects in the spray area, including persons
(3) To restrict access to qualified personnel only

11.3.11 All insulators shall be kept clean and dry.

11.4 Incendive Equipment. Spray equipment that is not considered to be nonincendive shall comply with 11.4.1 and 11.4.2.

11.4.1 Conveyors, hangers, and application equipment shall be arranged so that a minimum separation of at least twice the sparking distance is maintained between the workpiece or material being sprayed and the electrodes, electrostatic atomizing heads, or charged conductors. Warnings defining this safe distance shall be provided.

11.4.2 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

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the electrodes or electrostatic atomizing heads falls below that specified in 11.4.1.

11.5 Listing and Approval of Equipment. Spray equipment shall be listed.

Exception No. 1: Spray equipment that was installed prior to December 31, 1997, shall be listed or approved.

Exception No. 2: This requirement shall not apply to automatic electrostatic spray equipment protected in accordance with Section 9.7 and Section 9.8.

Chapter 12 Handheld Electrostatic Spray Equipment

12.1 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 purposes in which the charging or atomizing device is handheld and manipulated during the spraying operation.

12.2 General. The installation and use of handheld electrostatic spray application apparatus shall comply with the requirements of this chapter and also shall comply with the applicable requirements of all other chapters.

12.3 Handheld Apparatus. Handheld electrostatic spray apparatus and devices shall be listed. The high-voltage circuits shall be designed so that they cannot produce a spark capable of igniting the most hazardous vapor–air mixture or powder–air mixture likely to be encountered and so that they cannot result in an ignition hazard upon coming into contact with a grounded object under all normal operating conditions.

12.3.1 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.

12.3.2 Where the liquid coating material is electrically energized, precautions shall be taken to prevent electric shock.

12.4 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 the spray area or shall otherwise meet the requirements of Chapter 6.

12.5 Grounding.

12.5.1* 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.

12.5.2 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 who enter the area.

12.5.3 Conductive 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.

12.5.4 Highly resistive objects (i.e., surface conductivity between 10^8 and 10^{11} ohms per square) that exhibit a surface voltage below 2500 volts, as measured using a nonloading kilovoltmeter and when subjected to coronal current not less than that expected in the application process, shall be considered adequately grounded.

12.5.5 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 to ensure grounding.

Chapter 13 Drying, Curing, and Fusion Processes

13.1 General.

13.1.1 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.*

13.1.2 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 Section 13.2 and Section 13.3.

13.2 Spray Booths and Spray Rooms Used for Ambient Air Drying. If a spray booth or spray room 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.

13.3* Spray Booths and Spray Rooms Used for Drying at Elevated Temperatures.

13.3.1 Spray booths or spray rooms used for batch-type spray application operations, including automobile refinishing operations, shall be permitted to be used alternately for drying, curing, or fusing operations, provided they meet all applicable requirements of this standard and the requirements of NFPA 86, *Standard for Ovens and Furnaces*, as well as the requirements of 13.3.1.1 through 13.3.1.8.

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

13.3.1.2 For fully enclosed spray booths and spray rooms, a high temperature limit switch shall be provided to automatically shut off the drying apparatus if the air temperature in the spray area exceeds 93°C (200°F). When industrial air heaters are used to elevate the air temperature for drying or curing in a closed-top, open-front, or open-face spray booth, as described in 6.5.2, a high limit switch shall be provided to automatically shut off the drying apparatus if the air temperature in the spray booth exceeds the maximum discharge air temperature allowed by the standard under which the heater is listed or 93°C (200°F), whichever is less.

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13.3.1.3 When a spray booth or spray room is used for drying, curing, or fusing operations, the interlocks specified in 13.3.1.3.1 and 13.3.1.3.2 shall be provided.

13.3.1.3.1 Spraying apparatus, drying apparatus, and the ventilating system shall be equipped with interlocks arranged so that the spraying apparatus cannot be operated when drying apparatus is in operation or is energized.

13.3.1.3.2 When industrial air heaters are used to elevate the air temperature for drying, curing, or fusing operations, means shall be provided to deter entry into the spray booth or spray room during the drying, cuing, or fusing operation. Interlocks shall be provided to shut down the drying, curing, or fusing operation if entry is made.

13.3.1.4 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.

13.3.1.5 Radiant drying, curing, or fusion apparatus that is permanently attached to the structure of a spray booth and is movable but is suitable only for use in an Ordinary Hazard (general purpose) location, that is, is not suitable for a hazardous (classified) location as defined in NFPA 70, *National Electrical Code*, shall be permitted to be used provided the following conditions apply:

(1) The apparatus can be moved into a pressurized enclosure that meets the requirements for Type X pressurizing, as specified in NFPA 496, *Standard for Purged and Pressurized Enclosures for Electrical Equipment*.
(2) Interlocks are provided both to prevent the use of the spray application equipment unless the drying, curing, or fusion apparatus has been moved into the pressurized enclosure and the enclosure has been purged and pressurized in accordance with NFPA 496, *Standard for Purged and Pressurized Enclosures for Electrical Equipment*, and to prevent the actuation of the drying, curing, or fusion apparatus when it is located in the enclosure.

13.3.1.6 Radiant drying, curing, or fusion apparatus that is permanently attached to the structure of a spray booth and is pendent-mounted or employs the use of a track or similar system but is suitable only for use in an Ordinary Hazard (general purpose) location, that is, is not suitable for a hazardous (classified) location as defined in NFPA 70, *National Electrical Code*, shall be permitted to be used provided that all requirements of 13.3.1.5 have been met.

13.3.1.6.1 In addition, pendent-mounted apparatus shall be arranged to allow the apparatus, its power cord, and its pendent-mount system to be moved into a pressurized enclosure that meets the requirements for Type X pressurizing, as specified in NFPA 496, *Standard for Purged and Pressurized Enclosures for Electrical Equipment*. Track-mounted systems shall also meet the requirements for Type X pressurizing, as specified in NFPA 496.

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

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

13.3.2 Spray booths or spray rooms 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 93°C (200°F).

13.4 Flash-Off Areas.

13.4.1 The electrical area classification extending into a flash-off area shall meet the requirements for openings specified in 6.5.4.

13.4.2 Flash-off areas that are heated above ambient temperatures to accelerate release of vapors shall meet the requirements of NFPA 86, *Standard for Ovens and Furnaces*.

13.4.3 Open or enclosed, unheated flash-off areas shall be ventilated in accordance with Section 7.11.

13.4.4 Open flash-off areas shall be protected in accordance with the requirements of the occupancy in which they are located.

13.4.5 Enclosed flash-off areas shall be provided with an approved automatic fire protection system.

13.5* Ventilation. Fusion apparatus shall be ventilated at a rate that is sufficient to maintain the concentration of ignitible vapors in the area at or below 25 percent of the lower flammable limit.

13.6 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.

Chapter 14 Miscellaneous Spray Operations

14.1 Vehicle Undercoating and Body Lining.

14.1.1 Spray undercoating or spray body lining of vehicles that is conducted in an area that has adequate natural or mechanical ventilation shall be exempt from the provisions of this standard, if all the requirements of 14.1.1.1 through 14.1.1.4 are met.

14.1.1.1 There shall be no open flames or spark-producing equipment within 6100 mm (20 ft) of the spray operation while the spray operation is being conducted.

14.1.1.2 There shall be no drying, curing, or fusion apparatus in use within 6100 mm (20 ft) of the spray operation while the spray operation is being conducted.

14.1.1.3 Any solvent used for cleaning procedures shall have a flash point not less than 37.8°C (100°F).

14.1.1.4 The coating or lining materials used shall meet one of the following criteria:

(1) Be no more hazardous than UL Class 30-40, when tested in accordance with UL 340, *Test for Comparative Flammability of Liquids*
(2) Not contain any solvent or component that has a flash point below 37.8°C (100°F)

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(3) Consist only of Class IIIB liquids and not include any organic peroxide catalyst

14.1.2 Noncomplying Undercoating Operations. Spray undercoating operations that do not meet the requirements of Section 14.1 shall meet all applicable requirements of this standard pertaining to spray finishing operations.

14.2 Preparation Workstations. If spray finishing operations are performed at or in a preparation workstation, the preparation workstation shall be considered an unenclosed spray area and shall meet all requirements of an unenclosed spray area.

Exception: A preparation workstation that is designed and operated in accordance with Section 14.3 shall be considered a limited finishing workstation and not an unenclosed spray area.

14.3 Limited Finishing Workstations. A limited finishing workstation shall be designed and operated in accordance with the requirements of 14.3.1 through 14.3.9.

14.3.1 A limited finishing workstation shall be designed and constructed to have all the following:

(1) A dedicated make-up air supply and air supply plenum
(2) Curtains or partitions that are noncombustible or limited combustible, as defined in NFPA 220, *Standard on Types of Building Construction*, or that can successfully pass Test Method 2 of NFPA 701, *Standard Methods of Fire Tests for Flame Propagation of Textiles and Films*
(3) A dedicated mechanical exhaust and filtration system
(4)*An approved automatic extinguishing system that meets the requirements of Chapter 9

14.3.2 The amount of material sprayed in a limited finishing workstation shall not exceed 3.8 L (1 gal) in any 8-hour period.

14.3.3 The limited finishing workstation shall meet all applicable requirements of Chapter 4 through Chapter 10 and Chapter 18 of this standard.

14.3.4 Curtains or partitions shall be fully closed during any spray application operations.

14.3.5 The area inside the curtains or partitions shall be considered a Class I, Division 1; Class I, Zone 1; or Class II, Division 1 hazardous (classified) location, as defined by NFPA 70, *National Electrical Code*.

14.3.5.1 A Class I, Division 2; Class I, Zone 2; or Class II, Division 2 hazardous (classified) location, as applicable, shall extend horizontally and vertically beyond the volume enclosed by the outside surface of the curtains or partitions as follows:

(1) 1525 mm (5 ft) horizontally and 915 mm (3 ft) vertically, as shown in Figure 14.3.5.1(a), if the spray application equipment is interlocked with the exhaust ventilation system
(2) 3050 mm (10 ft) horizontally and 915 mm (3 ft) vertically, as shown in Figure 14.3.5.1(b), if the spray application equipment is not interlocked with the exhaust ventilation system

14.3.5.2 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.

14.3.6 Any limited finishing workstation used for spray application operations shall not be used for any operation that is capable of producing sparks or particles of hot metal or for operations that involve open flames or electrical utilization equipment capable of producing sparks or particles of hot metal.

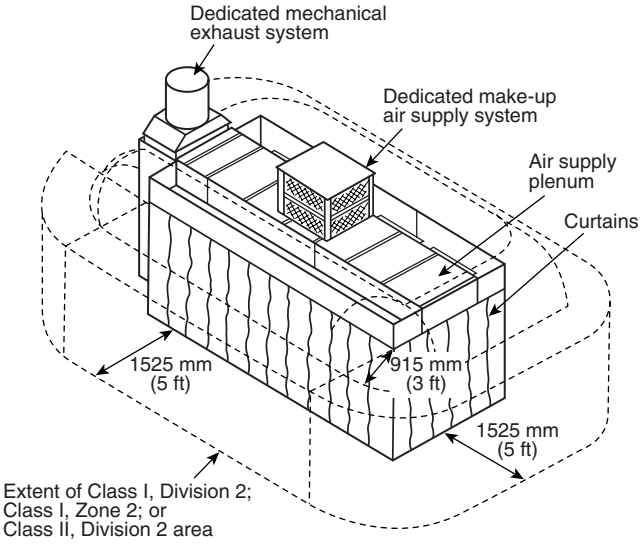


FIGURE 14.3.5.1(a) Class I, Division 2; Class I, Zone 2; or Class II, Division 2 Locations Adjacent to a Limited Finishing Workstation with Exhaust Ventilation Interlocked with Spray Equipment.

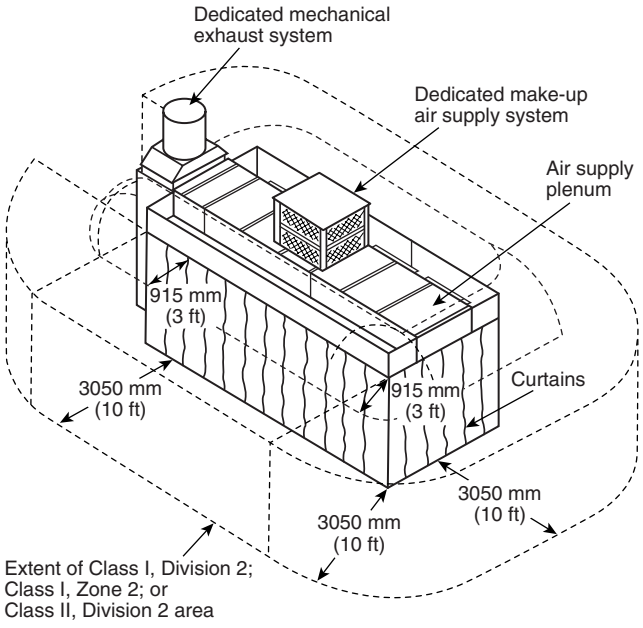


FIGURE 14.3.5.1(b) Class I, Division 2; Class I, Zone 2; or Class II, Division 2 Locations Adjacent to a Limited Finishing Workstation with Exhaust Ventilation NOT Interlocked with Spray Equipment.

14.3.7 Drying, curing, or fusion apparatus shall be permitted to be used in a limited finishing workstation if they meet the requirements of Chapter 13 and the requirements of 14.3.7.1 through 14.3.7.3.

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14.3.7.1 When industrial air heaters are used to elevate the air temperature for drying, curing, or fusing operations, a high limit switch shall be provided to automatically shut off the drying apparatus if the air temperature in the limited finishing workstation exceeds the maximum discharge-air temperature allowed by the standard that the heater is listed to or 93°C (200°F), whichever is less.

14.3.7.2* A means shall be provided to show that the limited finishing workstation is in the drying or curing mode of operation and that the limited finishing work station is to be unoccupied.

14.3.7.3 Any containers of flammable or combustible liquids shall be removed from the limited finishing workstation before the drying apparatus is energized.

14.3.8 Portable spot-drying, curing, or fusion apparatus shall be permitted to be used in a limited finishing workstation, provided that it is not located within the hazardous (classified) location defined in 14.3.5 when spray application operations are being conducted.

14.3.9 Recirculation of exhaust air shall be permitted only if all provisions of Section 7.5 are met.

Chapter 15 Powder Coating

15.1* Scope. This chapter shall apply to processes in which combustible dry powders are applied.

15.2 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.

15.3 Applicability. Section 15.4 through Section 15.10 are general and shall apply to all methods of powder coating application. Section 15.11 through Section 15.13 shall apply to the specific method indicated therein.

15.4 Location. Powder coating operations shall be confined to enclosures that are located in accordance with Chapter 4.

15.5 Protection. Powder coating operations shall be protected in accordance with Chapter 9.

15.6 Enclosures. Powder shall be confined by conducting coating operations within one of the following:

(1) A completely enclosed, ventilated room of noncombustible or limited-combustible construction with smooth surfaces designed to prevent accumulation of powder and to facilitate cleaning
(2) A ventilated spray booth meeting the requirements of Section 5.1 through Section 5.5, and having enclosed, ventilated containers (tanks, bins, etc.)

15.7 Electrical and Other Sources of Ignition.

15.7.1 Electrical utilization equipment and other sources of ignition shall meet both the requirements of Chapter 6 of this standard and Articles 500, 502, 504, and 516 of NFPA 70, *National Electrical Code*, as applicable.

15.7.2 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 28°C (50°F) of the autoignition temperature of the powder used.

15.7.3 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 shall also apply to any personnel who enter the area.

15.8 Ventilation, Dust Collection, and Explosion Protection. See Annex C.

15.8.1* Ductwork. Where nondeposited, air-suspended powder (powder overspray) is conveyed by ductwork to a remote recovery system, sufficient airflow shall be provided in the ductwork to maintain the powder concentration in the ductwork at not more than one-half of the minimum explosive concentration (MEC) of the powder in use. If the MEC of the powder has not been established, then the exhaust duct powder concentration shall be maintained below 15 g/m^3 (0.015 oz/ft^3). Exhaust equipment shall bear an identification plate stating the ventilation rate for which it was designed.

Exception: 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.

15.8.2 Air exhausted from the recovery system of a powder operation shall not be recirculated unless the concentration of particulate matter in the exhaust air has been reduced to a level that is considered safe for personnel occupational exposure 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.

15.8.3* Enclosures. Enclosures either shall be listed for the specific application or shall be designed to resist the destructive effects of an internal deflagration. Any enclosure that is not so listed and is effectively tight, such as a spray booth, dust collector, powder recovery device, or other enclosure, shall be provided with one of the following:

(1) Deflagration venting
(2) A deflagration suppression system that meets the requirements of NFPA 69, *Standard on Explosion Prevention Systems*

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

15.8.5 The ventilation system shall confine air-suspended powder to the booth and the recovery system at all times.

15.9 Drying, Curing, and Fusing Equipment.

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

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

15.10 Operation and Maintenance.

15.10.1 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.

15.10.2 Surfaces shall be cleaned in a manner that does not scatter powder or create dust clouds. Vacuum sweeping equip-

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ment, where used, shall be of a type approved for use in hazardous locations.

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

15.10.4 Signs stating NO SMOKING OR OPEN FLAMES in large letters on contrasting color background shall be conspicuously posted at all powder coating areas and powder storage rooms.

15.11 Automated Electrostatic Powder Spraying Equipment. The provisions of Chapter 11 and other sections of Chapter 15 shall apply to fixed electrostatic equipment, except that electrical equipment not covered therein shall comply with Section 15.7.

15.12 Handheld Electrostatic Powder Spraying Equipment. The provisions of Chapter 12 and other sections of Chapter 15 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 capable of igniting 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 comply with Section 15.7.

15.13 Electrostatic Fluidized Beds.

15.13.1 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 cannot produce a spark that is capable of igniting the most hazardous powder–air mixture likely to be encountered and so that they cannot result in a shock hazard.

15.13.2 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 the area classified as hazardous or otherwise shall conform to the requirements of Section 15.7.

15.13.3 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 shall also apply to any personnel who might enter the area. The powder coating equipment shall carry a prominent, permanently installed warning regarding the necessity for grounding these objects.

15.13.4 Highly resistive objects (i.e., surface conductivity between 10^8 and 10^{11} ohms per square) that exhibit a surface voltage below 2500 volts, as measured using a nonloading kilovoltmeter and when subjected to coronal current not less than that expected in the application process shall be considered adequately grounded.

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

15.13.6 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 16 Organic Peroxides and Plural Component Coatings

16.1* 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 17.

16.2 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 9.

16.3 Prevention of Contamination. Measures shall be taken 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.

16.3.1 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.

16.3.2* Measures shall be taken to prevent contamination of organic peroxide formulations with dusts or overspray residues resulting from the sanding or spray application of finishing materials.

16.3.3 Spills of organic peroxide formulations shall be promptly removed so there are no residues. Spilled material shall be permitted to be absorbed by use of a noncombustible absorbent, which is then disposed of promptly in accordance with the manufacturer's recommendations.

16.4 Storage of Organic Peroxides. Organic peroxide formulations shall be stored in accordance with the requirements of NFPA 432, *Code for the Storage of Organic Peroxide Formulations*, and with the manufacturers' recommendations.

16.5 Handling of Organic Peroxides. Measures shall be taken to prevent handling of organic peroxide formulations to avoid shock and friction, which can cause decomposition and violent reaction.

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

16.7 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.

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

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

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Chapter 17 Styrene Cross-Linked Composites Manufacturing (Glass Fiber–Reinforced Plastics)

17.1* 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, that is, resin application areas, and where the processes do not produce vapors that exceed 25 percent of the lower flammable limit.

17.2 Resin Application Equipment. The equipment and apparatus for spray application of the resin shall be installed and used in accordance with the requirements of Chapter 16 and Chapter 17.

17.3* 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.

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

(1) A supply for one day
(2) The sum of 95 L (25 gal) of Class IA liquids in containers and 454 L (120 gal) of Class IB, IC, II, or III liquids in containers
(3) One approved portable tank not exceeding 2500 L (660 gal) of Class IB, IC, II, or III liquids

17.5 Electrical and Other Hazards.

17.5.1 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.

17.5.2 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; Class I, Zone 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 hazardous (classified) location involved.

17.5.3* 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.

17.5.4 Space heating appliances or other hot surfaces in resin application areas shall not be located where deposits or residues accumulate.

17.6 Ventilation.

17.6.1 Mechanical ventilation shall be designed and installed throughout the resin application area in accordance with the requirements of Chapter 7.

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

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

17.7 Use and Handling.

17.7.1 The storage and use of organic peroxide formulations shall meet the requirements of Chapter 16.

17.7.2 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 50 mm (2 in.).

17.7.3 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 removed. When the accumulated overchop has reached an average thickness of 50 mm (2 in.), 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 50 mm (2 in.) shall be permitted, provided that it is properly cured and disposed of before operations are resumed.

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

Chapter 18 Training

18.1* General. All personnel involved in the spray application processes covered by this standard shall be instructed in the following:

(1) Potential safety and health hazards
(2) Operational, maintenance, and emergency procedures required
(3) Importance of constant operator awareness

18.1.1 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 emergency procedures.

18.1.2* 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 the use of protective and emergency equipment required.

18.1.3 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.

18.1.4 Documentation shall be employed to record the type and date of training provided to each individual involved in these processes.

Annex A Explanatory Material

Annex A is not a part of the requirements of this NFPA document but is included for informational purposes only. This annex 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 varies depending on the arrangement and operation of the particular process and on the nature of the material being sprayed. The principal hazards addressed in this standard are those of the materials being sprayed: flammable and combustible liquids and combustible powders, as

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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, is 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.1.1.4 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 ignitible vapor–air or dust–air mixture is very limited due to atmospheric dilution.

A.1.1.5 The occasional use of small portable spray equipment or aerosol spray containers 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:

(1) Adequate ventilation should be provided at all times, particularly where spray application is conducted in relatively small rooms or enclosures.
(2) 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.
(3) Containers of coating materials, thinners, or other hazardous materials should be kept tightly closed when not actually being used.
(4) 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.
(5) The same fundamental rules for area cleanliness and housekeeping that are required for industrial spray application operations should be observed.

A.1.2.2 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.

A.3.2.1 Approved. 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 installations, 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 that is concerned with product evaluations and is thus in a position to determine compliance with appropriate standards for the current production of listed items.

A.3.2.2 Authority Having Jurisdiction (AHJ). The phrase "authority having jurisdiction," or its acronym AHJ, is used in NFPA documents in a broad manner, since jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is primary, the authority having jurisdiction 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 departmental official may be the authority having jurisdiction.

A.3.2.4 Listed. The means for identifying listed equipment may vary for each organization concerned with product evaluation; some organizations 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.

A.3.3.1.3 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. Where 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 ordinarily will 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.

The following are not considered part of the spray area:

(1) Fresh air make-up units
(2) Air supply ducts and air supply plenums
(3) Recirculation air supply ducts downstream of secondary filters
(4) Exhaust ducts from solvent concentrator (pollution abatement) units

A.3.3.12 Spray Booth. 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 part of the spray area. A spray booth is not a spray room.

A.3.3.13 Spray Room. The entire spray room is considered part of the spray area. A spray booth is not a spray room.

A.4.1 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:

(1) 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.

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(2) Spray application operations that incorporate assembly lines or conveyor systems 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 460 mm (18 in.)] draft curtains on the underside of the floor deck and might even be provided with automatic high-velocity spray nozzles arranged to create a counterdraft. 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.
(3) Rooms that house spray application operations should be separated from other occupancies or operations by construction that meets the requirements of Chapter 5 of this standard.
(4) 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 460 mm (18 in.) from the ceiling, but deeper if practical. The 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.
(5) 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.
(6) Finally, spray application operations should not be located in a basement area.

A.5.1 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 3.3.1.3, 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.5.3 The "other" operations referred to in this section are those that do not involve spray application processes.

A.6.2 Because of the requirements for special safeguards, electrostatic apparatus, drying, curing, and fusing apparatus, and vehicle undercoating and body lining operations are covered in other chapters of this standard.

A.6.2.2 In the Division system, areas are classified as either Division 1 or Division 2 depending on whether ignitible gases or vapors are always present or likely to be present (Division 1) or whether ignitible gases or vapors are not normally present (Division 2). The Zone system identifies hazardous locations as Zone 0, Zone 1, or Zone 2, depending on whether the ignitible atmosphere will always be present (Zone 0), is likely to be present (Zone 1), or is not normally present (Zone 2). The Zone system is based on International Electrotechnical Commission (IEC) standards and was incorporated into NFPA 70, *National Electrical Code*, in 1996.

Although there are requirements in international standards for Zone classification of dust locations, NFPA 70 permits only ignitible gas and vapor atmospheres to be classified using the Zone system. Therefore, powder coating applications are not permitted to be classified using the Zone system.

A.6.2.5 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.6.2.6 Areas that are above or adjacent to spray areas and 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.6.3.1 See NFPA 70, *National Electrical Code*.

A.6.3.1.1 This classification usually includes the following locations:

(1) Where volatile flammable liquids are transferred from one container to another
(2) Interiors of spray booths and areas in the vicinity of spraying and painting operations where volatile flammable solvents are used
(3) Locations containing open tanks or vats of volatile flammable liquids
(4) Drying rooms or compartments for the evaporation of flammable solvents
(5) All other locations where ignitible concentrations of flammable vapors or gases are likely to occur in the course of normal operations [**70:**500.5(B)(1) FPN No. 1]

In some Division 1 locations, ignitible concentrations of flammable gases or vapors may be present continuously or for long periods of time. Examples include the following:

(1) The inside of vented tanks containing volatile flammable liquids
(2) Inadequately ventilated areas within spraying or coating operations using volatile flammable fluids
(3) The interior of an exhaust duct that is used to vent ignitible concentrations of vapors [**70:**500.5(B)(1) FPN No. 2]

A.6.3.1.2 This classification usually includes locations where volatile flammable liquids or ignitible vapors are used but that, in the judgment of the authority having jurisdiction, would become hazardous only in case of an accident or of some unusual operating condition. The quantity of flammable material that might escape in case of accident, the adequacy of ventilating equipment, the total area involved, and the record of the industry or business with respect to explosions or fires are all factors that merit consideration in determining the classification and extent of each location. [**70:**500.5(B)(2) FPN No. 1]

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Piping without valves, checks, meters, and similar devices would not ordinarily introduce a hazardous condition even though used for flammable liquids. Depending on factors such as the quantity and size of the containers and ventilation, locations used for the storage of flammable liquids in sealed containers may be considered either hazardous (classified) or unclassified locations. See NFPA 30, *Flammable and Combustible Liquids Code*. [**70:**500.5(B)(2) FPN No. 2]

A.6.3.1.3 This classification includes locations inside vented tanks or vessels that contain volatile flammable liquids; inside inadequately vented spraying or coating enclosures, where volatile flammable solvents are used; inside open vessels, tanks and pits containing volatile flammable liquids; and the interior of an exhaust duct that is used to vent ignitible concentrations of vapors.

It is not good practice to install electrical equipment in Zone 0 locations except when the equipment is essential to the process or when other locations are not feasible. [See NFPA 70, 505.5(A) FPN No. 2.] If it is necessary to install electrical systems in a Zone 0 location, it is good practice to install intrinsically safe systems as described by NFPA 70, Article 504. [**70:**505.5(B)(1) FPN No. 2]

A.6.3.1.4 Normal operation is considered the situation when plant equipment is operating within its design parameters. Minor releases of flammable material may be part of normal operations. Minor releases include the releases from mechanical packings on pumps. Failures that involve repair or shutdown (such as the breakdown of pump seals and flange gaskets, and spillage caused by accidents) are not considered normal operation. [**70:**505.5(B)(2) FPN No. 1]

This classification usually includes locations where volatile flammable liquids are transferred from one container to another; areas in the vicinity of spraying and painting operations where flammable solvents are used; adequately ventilated drying rooms or compartments for evaporation of flammable solvents; inadequately ventilated pump rooms for volatile flammable liquids; … and other locations where ignitible concentrations of flammable vapors or gases are likely to occur in the course of normal operation but not classified Zone 0. [**70:**505.5(B)(2) FPN No. 2]

A.6.3.2.1 Dusts containing magnesium or aluminum are particularly hazardous, and the use of extreme precaution is necessary to avoid ignition and explosion. [**70:**500.5(C)(1) FPN]

A.6.3.2.2 The quantity of combustible dust that may be present and the adequacy of dust removal systems are factors that merit consideration in determining the classification and may result in an unclassified area. [**70:**500.5(C)(2) FPN No. 1]

Where products are handled in a manner that produces low quantities of dust, the amount of dust deposited may not warrant classification. [**70:**500.5(C)(2) FPN No. 2]

A.6.3.2.3 As a guide to classification of Zone 20, 21, and 22 locations, refer to ANSI/ISA-61241 (12.10.05), *Electrical Apparatus for Use in Zone 20, Zone 21 and Zone 22 Hazardous (Classified) Locations — Classification of Zone 20, Zone 21, and Zone 22 Hazardous (Classified) Locations*. [**70:**506.5(B)(1) FPN No. 1]

Zone 20 classification includes locations inside dust containment systems; inside hoppers, silos, cyclones and filter houses, dust transport systems, except some parts of belt and chain conveyors, etc.; inside blenders, mills, dryers, bagging equipment, etc. [**70:**506.5(B)(1) FPN No. 2]

A.6.3.2.4 This classification usually includes locations outside dust containment and in the immediate vicinity of access doors subject to frequent removal or opening for operation purposes when internal combustible mixtures are present; locations outside dust containment in the proximity of filling and emptying points, feed belts, sampling points, truck dump stations, belt dump over points, etc. where no measures are employed to prevent the formation of combustible mixtures; locations outside dust containment where dust accumulates and where due to process operations the dust layer is likely to be disturbed and form combustible mixtures; locations inside dust containment where explosive dust clouds are likely to occur (but neither continuously, nor for long periods, nor frequently) as, for example, silos (if filled and/or emptied only occasionally) and the dirty side of filters if large self-cleaning intervals are occurring. *(See also A.6.3.2.3.)* [**70:**506.5(B)(2) FPN No. 2]

A.6.3.2.5 Zone 22 locations usually include outlets from bag filter vents, because in the event of a malfunction there can be emission of combustible mixtures; locations near equipment that has to be opened at infrequent intervals or equipment that from experience can easily form leaks where, due to pressure above atmospheric, dust will blow out; pneumatic equipment, flexible connections that can become damaged, etc.; storage locations for bags containing dusty product, since failure of bags can occur during handling, causing dust leakage; and locations where controllable dust layers are formed that are likely to be raised into explosive dust/air mixtures. Only if the layer is removed by cleaning before hazardous dust–air mixtures can be formed is the area designated non-hazardous. [**70:**506.5(B)(3) FPN No. 2]

Locations that normally are classified as Zone 21 can fall into Zone 22 when measures are employed to prevent the formation of explosive dust–air mixtures. Such measures include exhaust ventilation. The measures should be used in the vicinity of (bag) filling and emptying points, feed belts, sampling points, truck dump stations, belt dump over points, etc. *(See also A.6.3.2.3.)* [**70:**506.5(B)(3) FPN No. 3]

A.6.4.2 Equipment that is listed for both Class I, Division 1; Class I, Zone 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. *(See NFPA 70, National Electrical Code.)*

A.6.7 During operation of any electrostatic equipment, 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. See NFPA 77, *Recommended Practice on Static Electricity*, for additional information.

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A.7.3 All spray areas require make-up air, and since the air exhausted from spray application operations is normally contaminated and can be recirculated only 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 often can be provided by natural infiltration of air through building walls, windows, doors, and so forth. In general, if the volume of the room or building where the exhaust system is located is not equal to at least 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 shutoff 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, and so forth, should not exceed 60 m/min (200 ft/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 generally is advisable to engage the services of a qualified ventilating engineer to obtain a safe and efficient installation.

The features that should be considered include the following:

(1) Location of sources of heat to comply with Chapter 6
(2) Locating air intakes to prevent recalculation of contaminated air, and equipping air intakes with appropriate screens or filters
(3) Automatic temperature and proportioning controls, including an independent excess temperature limit control
(4) 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
(5) An interlock between the spray booth exhaust system and the make-up air system to ensure that both systems are operable and provide a proper balance of supply and replacement air
(6) In the case of direct-fired units, operating controls that ensure that concentrations of unburned fuel or products of combustion are kept to levels that are safe for operating personnel if inhaled

A.7.5.1 If air exhausted from the spray area is permitted to be recirculated, as provided for in 7.5.1, 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.7.5.2 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 are 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. One such standard is ANSI Z9.7, *Recirculation of Air from Industrial Process Exhaust Systems.*

A.7.6 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 exhaust air before it enters an incinerator, are subject to fires from the spontaneous ignition of residue that collects on heat exchanger surfaces.

A.7.7 For ducts for powder coating systems, the strength of the materials of construction should be considered, since the duct might have to contain the pressure of a deflagration. *(See NFPA 68, Guide for Venting of Deflagrations.)*

A.7.8 The designer of the exhaust ducts and fasteners should refer to appropriate design guides, such as the SMACNA *Round Industrial Duct Construction Standards* and the SMACNA *Rectangular Industrial Duct Construction Standards*, published by the Sheet Metal and Air Conditioning Contractors National Association, Inc.

A.7.11 If there are other operations that give off ignitible vapors in the vicinity of a spray application operation, they should be provided with independent mechanical ventilation.

A.8.1 For large spray operations, coatings, thinners, and solvents can be stored in one of the following locations:

(1) Underground storage tanks
(2) Aboveground storage tanks
(3) Separate buildings
(4) 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:

(1) Flammable liquid storage cabinets
(2) A protected enclosed metal structure
(3) Use of metal containers with limitations on the quantity of liquid located near the spray area

A.8.4.1 NFPA 77, *Recommended Practice on Static Electricity*, provides information on bonding and grounding.

A.8.4.2 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.8.4.3 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.

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

A.8.4.5 The severity and extent of the many fires in spray application operations have been substantially increased when rubber or plastic supply hose were burned off, resulting in the entire contents of the supply system being added 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.8.5.2 NFPA 77, *Recommended Practice on Static Electricity*, provides information on static protection.

A.9.1 As indicated in Chapter 8, it is not advisable to keep large quantities of flammable or combustible liquids in areas that expose personnel or important property to injury or loss. The primary reason 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, handheld fire extinguishers suitable for fire in ordinary combustibles or hose streams are effective.

Regardless of the level of filtration, residues will accumulate in the exhaust ductwork. Because the ductwork is part of the spray area, it must be protected in accordance with Chapter 7. This includes the ductwork from a water-wash booth.

Because the particulate filters will accumulate paint residue, they must be protected. The solvent concentrator units, by their design, contain high concentrations of solvent, so they also must be protected. Also, the most commonly used solvent concentrators use activated carbon as the adsorption media. This media is highly combustible, especially with high levels of solvents absorbed. Ketone solvents pose an even greater risk.

Because suppression media other than water might damage the carbon bed, water-based suppression systems (wet pipe sprinklers, preaction sprinklers, dry pipe sprinklers, and open-head deluge systems) are recommended for this application.

The recirculated air supply unit must be protected because of the filter media it contains. Also, many large air supply units have gas-fired heaters to heat outside make-up air.

Air supply ducts from the particulate filter to the air supply unit and from the air supply unit to the spray booth are not normally protected, since all particulates have been filtered.

The choice of the automatic fire protection system should always be based on good engineering practice. Generally, for most spray areas, automatic sprinklers are considered most appropriate *(see A.9.4)*. However, consideration must be given to how much water is likely to flow and to how much water is to be contained.

Dry chemical extinguishing systems are most appropriate for small spray application operations (e.g., automotive refinishing, furniture refinishing, and similar processes) that utilize dry filters to capture overspray. These systems provide economical adequate protection. They are a viable alternative for any facility without sufficient water supply to support an automatic sprinkler system.

Carbon dioxide or clean agent extinguishing systems should be used for open area protection only after careful consideration. Holding the required concentration of agent for the period of time needed for extinguishment in a spray booth environment can be difficult. In addition, total flooding with carbon dioxide in normally or potentially occupied areas presents serious health concerns. The time delay required prior to discharge can allow a fire time to grow and spread. Carbon dioxide and clean agent systems, however, are an appropriate choice for protecting electrostatic equipment enclosures inside or immediately outside the spray area.

A.9.4 Spray application operations should be located only in buildings that are completely protected by an approved system of automatic sprinklers. If the operations are 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. Proper drainage of the large volume of water frequently necessary to extinguish spray finishing room fires often presents considerable difficulty.

Automatic sprinklers in spray areas, including the interior of spray booths and exhaust ducts, should be wet pipe, preaction, or deluge system so 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. 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 extensive resulting damage.

The location of the sprinkler heads inside spray booths should be selected with care to avoid heads being placed in the direct path of spray and yet afford protection for the entire booth interior. When sprinkler heads are in the direct path of spray, even one day's operation can result in deposits on the sprinkler heads 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 1220 mm (4 ft) 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 8.4 m^2 (90 ft^2).

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

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 in the selection of 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.9.4.1 Subsection 9.4.1 lists four types of automatic sprinkler systems and requires that the one "most appropriate for the portion of the spray area being protected" be used. Generally, an open-head deluge system provides the highest level of protection, given that all sprinklers in the protected area flow simultaneously. This type of system is most appropriate for large, down-draft, water-wash spray booths when protecting automatic electrostatic spray application zones.

Wet pipe automatic sprinkler systems are appropriate for protecting spray booths that utilize nonelectrostatic application processes or operations using listed electrostatic application processes. Wet pipe systems are also generally used to protect exhaust plenums (eliminator or scrubber sections), exhaust ducts, and air recirculation filter houses.

Dry pipe systems have been included because some exhaust duct designs include sections that are subject to freezing.

Preaction systems have been included because some spray application processes and equipment can be damaged by unwanted water discharge. This damage can be disruptive and costly. Powder spray booths and solvent concentrator (air pollution abatement) systems are examples of systems where it is appropriate to use a preaction system.

A.9.4.6 Water supply requirements for most industrial paint spray operations should be adequate to supply all automatic sprinklers in the spray area. Loss experience has shown that fires starting in the exhaust duct have spread to the spray booth and that fires starting in the booth have spread to the exhaust duct.

Sprinklers or sprinkler systems protecting stacks or ducts should be of a type not subject to freezing. Automatic systems are preferred, but manual systems are also acceptable. Dry pendent sprinklers are often used inside buildings near exhaust duct penetrations to the outside. Nonfreeze or dry-type sprinkler systems are often used in ducts outside buildings. For some industries, such as the automotive industry, manually operated open-head systems have proven effective protection for ducts and stacks.

A.9.5 This discharge is typically accomplished by means of a piping network from the fire protection system into all parts of the spray area. To avoid potential flashback of an unextinguished fire, modular fire protection 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 fall within the limits of the listing.

A.9.7 During the first few seconds in the development of a fire in a dry powder spray booth, the following observations can be made:

(1) *Conventional structure equipment (spray booth connected to enclosed collector by ductwork*

(a) 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 600 mm to 1800 mm (about 2 ft to 6 ft) 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.

(b) 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.

(c) 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:

i. Heat exposure effects of the fire, acting on 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.

ii. 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 9.7 are directed toward this result.

(2) *Integrated spray booth/"open" collector*

(a) Fire in the spray plumes of the guns is identical to that found in A.9.7(1). Because 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.

(b) Attempts to extinguish "deep-seated" fires with carbon dioxide and dry chemical extinguishers have yielded disappointing results. Although flame is promptly knocked down, continued production of smoke and ultimate reflash should be expected. The most satisfactory results have been yielded by thoroughly soaking the filter cartridges and residues with water.

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A.9.8 Unlike powder application systems, the make-up air and exhaust systems for a liquid application system have to continue to function, unless there is a compelling reason to shut them down.

A.10.1 The materials used in spray application processes can create serious fire hazards. For example, the vapors and mists created by the atomization of flammable and combustible liquids can form explosive mixtures in air. In addition, deposits of residues can ignite spontaneously or be easily ignited. Finally, fires involving flammable and combustible liquids or combustible residues can spread rapidly and can produce intense heat and smoke. Properly designed equipment can do much to lessen these hazards but cannot eliminate them. These inherent characteristics should make it obvious that supervision of operations, maintenance of equipment, and daily cleaning are essential to a safe operation.

It is important that some type of periodic inspection be conducted and recorded as part of the maintenance procedures. It is also important that any inspections of spray application equipment be conducted by competent and reliable personnel who have knowledge of the equipment and the inherent characteristics of the materials used.

The frequency of the inspections depends on the individual components of the spray application process. For example, it might be acceptable to check sprinkler control valves or other control mechanisms for approved fire protection systems on a weekly or even monthly basis. However, this frequency would not be acceptable for ensuring adequate airflow through collector filters of a spray booth. At a minimum, that should be done at the beginning of each operating shift. Similarly, the build-up of residues would also need to be checked on a per-shift basis. Individual plant operations might dictate that either of these items (airflow and residue build-up) be checked every few hours.

A.10.1.1 The use of the term *predetermined* is intended to convey the idea that one cannot arbitrarily locate or conduct spray application operations without thought to the hazards and special requirements that such operations demand. Requirements regarding electrical equipment and ventilation are of primary concern. This standard also specifies requirements that can vary based on the type of equipment used, the type of material being spray applied, and even the type of operation. Any spray application operation should also consider the storage, handling, and distribution of the coating materials used in the process. Certainly there are other factors, but these examples should adequately explain the need for predetermining the spray area and why operations should be confined to those areas.

A.10.2 In the spray finishing of any workpiece, there is frequently a portion of the spray that does not deposit directly on the object or material being coated but does deposit on adjacent surfaces as residue material. This is referred to as *overspray*. Many of these residues are highly combustible, igniting at very low temperatures or spontaneously, resulting in fast-spreading fires. To limit the duration and intensity of fires, the accumulation of deposits has to be minimized and controlled as much as practical. The accumulation of residues represents one of the most significant challenges to fire control.

Cleaning. The interior of spray booths, exhaust fan blades, and exhaust ducts should be cleaned regularly to avoid the accumulation of residues. Either spray operators should be allowed ample time for this cleaning, or a special maintenance crew should be provided for cleaning at the close of each day's operation. If equipment is so designed that during cleanup hose streams or fixed water nozzles can be used in ducts and spray booths without water damage to building and contents, cleaning operations are greatly facilitated. Many plants have found that by coating the interior of spray booths with a suitable soap-like or water-soluble material immediately after cleaning, adhesive spray deposits can be removed the following day with the use of water streams. Other materials, such as plastics that can be readily peeled off the interior of the spray booth, can also be used to facilitate cleaning of the overspray residue.

Properly maintained water-wash booths offer lower fire loading than dry booths. To maintain this advantage, it is necessary to perform regular and scheduled maintenance. This maintenance schedule should be recorded and the records filed. When the nozzles, jets or orifices, eliminator packs, and strainer screens become fouled with accumulated sludge or overspray, combustible residues will be deposited on the interior of the exhaust duct and fan blades. The nozzles, jets, orifices, and eliminator packs should be inspected each work shift. Strainer screens should be removed and cleaned each work shift.

The booth interior, exhaust stack, and fan blades should be checked periodically, and accumulations of overspray and dirt should be removed as required. Exhaust ducts or stacks should not be entered for cleaning or repairs unless they are free from flammable vapors and have been thoroughly wet down.

A.10.5 Many fires have originated from the spontaneous ignition of fabric and waste impregnated with coating materials. When sprayed articles are rubbed with rags or waste, all unclean rags and waste should be immediately placed in approved waste cans and removed from the premises at least daily at the close of each shift. When employees change clothes on plant premises, soiled clothing should be kept in metal lockers provided in a segregated dressing room.

A.10.5.3 See NFPA 77, *Recommended Practice on Static Electricity*, for information on bonding and grounding.

A.10.7.4 See NFPA 77, *Recommended Practice on Static Electricity*, for information on bonding and grounding.

A.10.9 Bleaching compounds, such as hydrogen peroxide, hypochlorites, perchlorates, or other oxidizing compounds, can cause fires when in contact with organic finishing materials. Hence, if bleaching compounds are to be used in spray booths, the booths should be thoroughly cleaned and used only for that purpose. The alternate use of spray booths for bleaching compounds and other finishing materials or the alternate use of lacquers containing nitrocellulose and other types of finishing materials containing drying oils, such as varnishes, oil-based stains, air-drying enamels, primers, and so forth, without first thoroughly removing all traces of deposits can result in a spontaneous ignition fire.

A.10.10 Stricter environmental regulation has given rise to the increased use of chlorinated solvents, such as 1,1,1-trichloroethane and methylene chloride. These solvents are not photochemically reactive and, therefore, can be useful in helping to meet standards regarding volatile organic compound emissions. However, these solvents have a well-documented characteristic of being chemically reactive with aluminum. The reaction that occurs is unpredictable both in terms of when it will occur and to what degree it will proceed. In most situations there is no apparent reaction. Other situations have noted effects ranging from simple corrosion to

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catastrophic explosion-like failure accompanied by considerable shrapnel and a fireball. Understanding and controlling the subsequent hazard is hindered by this unpredictability. Although there is some understanding of the actual reaction, the following factors acting as independent variables have been found to have an effect on the initiation and rate of reaction:

(1) Heat
(2) Pressure
(3) Ratio of aluminum surface area to volume of solvent, presence of moisture (condensation), aluminum alloy content, metal content of the coating, and the introduction of other solvents or materials

Therefore, the only assuredly safe condition is to keep these materials separate.

It is important to realize that aluminum has been used as a primary material for spray equipment construction over many years. Incorporating these solvents into existing spray systems cannot be done safely without first determining the construction material of the equipment and then replacing those components where contact with aluminum and chlorinated solvent will occur within a pressurizable device (e.g., pumps, heaters, piping, fluid valves, and spray gun cups).

A.10.12 If repairs or changes are to be made to equipment, care should be taken to see that all residue deposits are removed and the area wet down with water beforehand in order to avoid a fire. During such repairs, no spraying should be conducted, all flammable and combustible liquids and portable combustible material should be removed from the vicinity, and suitable fire extinguishers should be kept readily available.

The use of welding or cutting torches should be prohibited except under the supervision of a competent person familiar with the fire hazards involved. *(See NFPA 51B, Standard for Fire Prevention During Welding, Cutting, and Other Hot Work.)*

A.11.3.4 Ground circuit resistance should be measured using a test instrument that applies at least 500 volts to the objects being evaluated. A megohmmeter should be used for this test, rather than a volt-ohm meter.

A.12.5.1 This requirement can be met with the use of suitable gloves.

A.13.3 When a spray booth or spray room is used for drying or curing at elevated temperatures in accordance with Section 13.3, it is considered a Class A oven or furnace as defined by NFPA 86, *Standard for Ovens and Furnaces*. The requirements specified by NFPA 86 must be given careful consideration in the design and operation of this equipment because of the potential for increased fuel load in the booth or room, the exhaust plenum, and associated exhaust ductwork.

A.13.5 In powder coating processes, the powder is heated during or after its application to fuse the powder into a complete integral film. During the fusion cycle, some powders will release hazardous vapors.

A.14.3.1(4) For dry chemical fire protection systems, it might be prudent to double the quantity of agent and its flowrate, compared to a similar size fully enclosed spray booth to achieve the desired degree of protection. This is due to the relatively unenclosed nature of a limited finishing workstation compared to a traditional spray booth.

This recommendation is based on a white paper provided by the Fire Equipment Manufacturers' Association titled "Recommendations for Protection of Curtained Limited Finishing Workstations."

A.14.3.7.2 A means of showing that the limited finishing workstation is in the drying or curing mode of operation can be, but is not limited to, having the lighting of the workstation go out, use of a flashing light or strobe, or an audible device.

A.15.1 The hazards associated with combustible dusts are present in such processes to a degree depending on the chemical composition of the material and its particle size, shape, and distribution. Generally, coating powders are applied by the following means:

(1) Fluidized bed
(2) Electrostatic fluidized bed
(3) Powder spray guns
(4) Electrostatic powder spray guns

A.15.8.1 Where a listed explosion suppression system is used, refer to NFPA 69, *Standard on Explosion Prevention Systems*.

A.15.8.3 A "tight" enclosure is one in which a deflagration is likely to produce a sustained overpressure of 0.7 kPa (0.1 psi). See NFPA 68, *Guide for Venting of Deflagrations*, for information on the design of deflagration vents.

A.16.1 Organic peroxides are a group of chemicals that are used as catalysts (chain reaction initiators) in the polymerization of plastics monomers and resins. Commercially, they are available as numerous formulations that differ not only in chemical species but also in concentration, type, and amount of diluent.

The rapidly expanding reinforced styrene–polyester composites industry is one of the larger users of organic peroxide formulations. The formulations are used to catalyze (harden) the styrene–polyester resin. Frequently, the resin mixture and the catalyst are spray-applied to the reinforcing matrix using an automatic proportioning spray applicator. The most widely used catalyst systems are formulations of methyl ethyl ketone peroxide (MEKP), in varying concentration with different diluents, usually dibutyl phthalate. For transportation purposes, the U.S. Department of Transportation classifies these formulations as "organic peroxides" or "flammable liquids."

For purposes of storage and warehousing, NFPA 432, *Code for the Storage of Organic Peroxide Formulations*, classifies these materials using a five-tiered system, depending on their relative hazard as packaged for shipment. Thus, NFPA 432 recognizes that the different formulations available differ widely in fire hazard. In many cases, the "active oxygen," a measure of the material's catalytic activity and one measure of its reactivity hazard, has been reduced, thus reducing any explosion hazard.

The following precautions are recommended:

(1) Organic peroxide formulations should be stored in a cool, dry location that is separated from the work area. The formulations should not be stored with materials with which it might not be compatible. Storage quantity limitations and fire protection requirements are contained in NFPA 432, *Code for the Storage of Organic Peroxide Formulations*.
(2) The amount of organic peroxide formulation kept in the work area should be limited to that needed for a single day's use. Any formulation remaining at the end of a workday should be returned to the storage area.
(3) All necessary precautions, as recommended by the supplier, should be taken when organic peroxide formulations are used. Good housekeeping should be strictly observed, and spills should be immediately cleaned. Spilled

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material or material (such as resin) that has been contaminated with organic peroxide formulations has to be properly disposed of immediately. Trained personnel and safe operating procedures are essential for safe operation. The user should refer to the Material Safety Data Sheet (MSDS) or its equivalent for safety and handling information for the specific formulation being used.

A.16.3.2 Such mixing can result in a spontaneous fire or explosion.

A.16.6 The chemical and thermal stability of organic peroxide formulations is markedly reduced by contact or contamination with strong acids or bases, sulfur compounds, amines, and reducing agents of any type. Decomposition gases or vapors produced by some organic peroxide formulations can present a fire or explosion hazard. For example, the decomposition of benzoyl peroxide produces highly flammable vapors.

Heat, including heat from fire exposure, is an important factor in the decomposition of organic peroxide formulations. Some formulations decompose quietly when exposed to a slow, gradual increase in temperature. However, these same formulations can decompose violently or even explode when subjected to a rapid, excessive increase in temperature, such as from fire exposure.

In general, an organic peroxide that is formulated with a diluent into a dilute solution or paste burns more slowly than the concentrated or pure material and is less sensitive to shock or impact.

A.17.1 The reinforced styrene–polyester composites industry uses a variety of fabrication techniques to manufacture a wide range of useful products. Most of these products are fabricated with polyester- or vinyl ester–based resins and a fiber reinforcement, most commonly glass fiber. The resins contain a monomer, usually styrene, and are mixed with a catalyst to initiate curing. Other volatile organic chemicals used include the organic peroxide formulations, such as methyl ethyl ketone peroxide (MEKP), used to cure the resin, and various dyes and admixtures.

Open molding is the predominant molding method, with mold sizes ranging from less than 0.1 m^2 (1 ft^2) to very large structures, such as boat hulls over 30 m (100 ft) in length. The two most widely used application methods are hand lay-up and spray-up. In the hand lay-up fabrication method, a glass fiber mat is saturated with the resin by direct spray application or by manual application of the liquid resin. The spray-up fabrication method employs a "chopper gun" that simultaneously applies catalyzed resin and chopped glass fiber to a mold. In addition, many operations use a spray-applied polyester resin gelcoat, as for in-mold coating. Products produced by this industry include boats, bathtubs and shower enclosures, sinks and lavatories, underground storage tanks, auto and truck bodies, recreational vehicles, pollution control equipment, piping, and other specialized parts.

A.17.3 The determination by the Technical Committee on Finishing Processes that Ordinary Hazard (Group 2) sprinkler design density is sufficient for protecting spray application of styrene cross-linked thermoset resins (commonly known as glass fiber–reinforced plastics) is based on several factors:

(1) Although the styrene monomer that is a component in unsaturated polyester resin is a Class I flammable liquid by definition, actual burn tests reveal that the resin does not readily ignite and burns slowly when it does ignite.

(2) Tests of resin application areas have shown that the processes do not produce vapors that exceed 25 percent of the lower flammable limit (LFL). Resin application tests have also indicated that the maximum levels of vapor concentrations are about 690 parts per million (ppm) for spray application. The tests were conducted in an enclosed area with no ventilation. This concentration is much less than 25 percent of the LFL, which is 11,000 ppm for styrene.

A.17.5.3 NFPA 77, *Recommended Practice on Static Electricity*, contains information on static electricity.

A.18.1 The safety of a spray application process depends on the employees who operate it and the knowledge and understanding they have of the process and equipment involved. Therefore, it is important to maintain an effective and ongoing training program for all employees involved in such work. New employees should be effectively trained before being assigned to a job. After the initial training, employees should receive periodic retraining to ensure their knowledge and understanding of normal process procedures as well as with emergency procedures or changes in procedures. Safe work habits are developed; they do not occur naturally.

All training should be provided by qualified personnel knowledgeable in the processes and operations involved. Appropriate training should be provided for all employees involved in or affected by spray application processes. This includes, but is not limited to, operating, supervisory, housekeeping, and maintenance personnel.

A.18.1.2 Any work requiring entry of employees into confined spaces should be conducted in accordance with a written procedure that is rigidly followed. This procedure should include, but not be limited to, the following:

(1) Analysis of confined space atmosphere for flammable, combustible, toxic, or oxygen-deficient conditions
(2) Rescue, fire, and emergency procedures
(3) Locking and tagging procedures for all power and process hazard sources
(4) Ventilation
(5) Personal protective equipment
(6) Proper tools and electrical equipment
(7) Written entry authorization by a qualified responsible individual

Annex B Determining Lower Flammable Limits

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

B.1 General. 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 ignitible 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, 3.8 L (1 gal) of the average

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solvent will occupy approximately 0.7 m^3 (23 ft^3) when evaporated into vapor at average room temperature. Therefore, if 3.8 L (1 gal) of liquid solvent is completely evaporated and thoroughly mixed with the surrounding air of an enclosure, the enclosure has to have a volume of more than 70 m^3 (2500 ft^3) to avoid an ignitible mixture, assuming the lower limit of the flammable range of the solvent is 1 percent in air. This is a conservative number; almost all 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 ignitible 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 75 m^3/L (10,000 ft^3/gal) evaporated at the maximum flow rate of the spray apparatus.

Adequate mechanical ventilation throughout all areas where ignitible vapors or mists might be present is essential to prevent the formation of flammable mixtures. The volume of air movement necessary obviously will 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.

B.2 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 moving through the booth 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 handheld 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 toward the filters and the exhaust duct, they are 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 also should be increased for operations in which large objects are moved into and out of the booth on conveyors at relatively high speeds and for operations in which 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.

B.3 Spray Rooms. Spray rooms should be designed to provide air movement that is as uniform as possible, so that all vapors and mists move to the exhaust system. Although 75 m^3 of air per liter of solvent evaporated (10,000 ft^3/gal) 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.

B.4 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.

Annex C Determining Ventilation Airflow for Powder Application Systems

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

C.1 General. The probability that a fire that has ignited in a spray booth will propagate through the exhaust system to the powder collector can be minimized if the concentration of airborne fuel (powder) in the exhaust ductwork is maintained below the minimum explosive concentration (MEC). Several years of industrial experience have shown that the practice of limiting powder concentration to a maximum of 50 percent MEC provides an adequate margin of safety. Measurement of airborne dust concentration in the field does, however, present some problems. Several air-sampling techniques incorporating the collection of dust with impactors, filters, or impingers do produce valid results but involve substantial delay (for laboratory processing) between the time of sampling and the time a result is available. No instrument that will provide an on-the-spot determination is in widespread use.

Limitation of powder concentration in exhaust ductwork is, therefore, most commonly accomplished through engineering control of the individual capacity of each system component to ensure that, under worst-case conditions (maximum rated delivery of all guns going into the exhaust with no allowance for collection of powder on workpieces), a powder-in-air concentration of more than 50 percent MEC cannot be reached.

C.2 Calculation of Worst-Case Powder-in-Air Concentration as Percentage of MEC. Before proceeding with this calculation, it is essential as a first step to establish the value of each term to be used in the calculation.

C.2.1 Minimum Explosive Concentration (MEC). Specifications usually available from the manufacturers of coating powders can be used to establish the MEC. If that specification is not available (or if the system is projected for use with a variety of coating powders), a figure of 30 g/m^3 (30 oz/1000 ft^3) can be used. This is considered representative of the lowest MEC to be found among common coating powders. *(See Table C.2.1.)*

C.2.2 Procedure for Determination of Maximum Powder Concentration in Exhaust Airstream of Apparatus Having Separate Collectors Connected to a Spray Booth by Ductwork.

C.2.2.1 Step 1. Check that the units are expressed consistently as shown in Table C.2.2.1. Be sure not to mix units from one system with units from the other.

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Table C.2.1 Representative Test Data on Specific Powders

Type	Sample No.	MEC		Autoignition Temperature	
		g/m^3	$oz/1000\ ft^3$	°C	°F
Epoxy	1				
	2	45	45		
	3	65	65		
	4	39	39		
	5	52	52		
	6	46	46	496	925
	7	70	70	521	970
	8	97	97	537	998
	9	91	91	539	1002
	10	78	78	534	993
	11	78	78	551	1024
Polyester	1	65	65	424	795
	2*	71	71	421	790
Polyolefin	1	32	32		
	2	32	32	516	960

*Same as Sample 1 but with metallic component in pigment.
Note: Data determined using FM Global 3.7-Liter Dust Explosion Test Apparatus, a modified Hartmann Test Apparatus.

Table C.2.2.1 Equivalent Units of Measurement

Property Being Measured	SI Units	U.S. Customary Units
MEC	g/m^3	$oz/1000\ ft^3$
Airflow	m^3/hr	ft^3/min
Maximum delivery	g/hr	oz/min

C.2.2.2 Step 2. Divide the maximum delivery rate by the airflow to determine the concentration of powder in the airstream.

$$\frac{\text{Maximum delivery}}{\text{Airflow}} = \text{Maximum concentration}$$

C.2.2.3 Step 3. Divide this maximum concentration by the minimum explosive concentration and then multiply by 100 to express the maximum concentration as a percentage of the MEC.

$$\frac{\text{Maximum concentration}}{\text{MEC}} \times 100 = \%\ \text{MEC}$$

Note that this limitation of concentration is not intended for application to apparatus segments other than ductwork, such as the interior of the spray booth, or to the flow through pneumatic transfer hose and tubes.

If the final result of this calculation indicates that a worst-case concentration of less than 50 percent MEC is to be expected, then the system can be considered to have adequate ventilation.

C.2.3 Maximum Powder Delivery. Specifications by the manufacturer of the spray application equipment can be used to establish maximum delivery rate of the equipment installed. Alternatively, the maximum delivery rate can be determined experimentally by adjusting each gun to its maximum output condition and operating it for a stated period of time (e.g., 5 minutes). During that time, the amount of powder passing through the gun can be determined by collecting the powder actually flowing through the gun in a large filter bag and weighing the bag. Delivery rate measured should be expressed in grams per hour or in ounces per minute.

C.2.4 Exhaust Airflow. Airflow through the exhaust system can be established from equipment specifications. Alternatively, it can be established by measurement of average air velocity through all spray booth openings (using valid traverse techniques) and subsequent multiplication of that velocity by the total booth opening area. Total airflow should be expressed in terms of cubic meters per hour or cubic feet per minute.

Measurement of airflow through ductwork is usually not recommended because the ductwork geometry does not lend itself to application of simple procedures. Reliable determinations of flow through the ducts can be made only through application of complicated, precise procedures by highly trained technicians.

Annex D Fire Record

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

D.1 General. Many fires can be prevented by following the provisions outlined in this standard. Other provisions of this standard are intended to minimize losses to property and interruption to production.

D.1.1 Liquid-Based Coatings. The following information is based on a study of 250 fires involving spray application of liquid-based coating materials. Where provisions of this standard were followed, a typical spray booth fire was confined to the booth, plenum, and exhaust system. A typical fire starting in the work area of the booth spreads across overspray deposits to the plenum and exhaust duct. A fire starting in the exhaust duct spreads across overspray deposits to the plenum and booth work area. All sprinklers in the booth, plenum, and exhaust duct usually operate to control the fire. One or more sprinklers outside the booth might operate, depending on quantity of overspray residue. Final extinguishment generally is by small hose or portable extinguishers.

The leading causes of fire in conventional systems included the following:

(1) Use of spark-producing equipment such as cutting, welding, and grinding near the spray area
(2) Friction, caused in most cases by overheated bearings on the exhaust fan shaft or by rubbing of exhaust fan blades against overspray deposits on walls of the exhaust duct
(3) Arcing electrical equipment
(4) Spontaneous ignition
(5) Discharge of static electricity

The leading causes of fire in electrostatic paint spray operations included the following:

(1) Ungrounded or improperly grounded objects in the spray area
(2) Failure to fully de-energize equipment before cleaning
(3) Pinhole leaks in the paint hose to the spray gun
(4) Other causes similar to nonelectrostatic systems, such as smoking and cutting and welding

D.1.2 Contributing Factors. Thirty-five of the 250 losses exceeded $100,000 combined property damage and business interruption. It was determined that failure to follow one or

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more of the basic provisions of this standard was the reason for the large losses in all cases. The most frequent deficiencies were the following:

(1) Lack of complete automatic sprinkler protection. Either no protection was provided or protection was lacking or ineffective in part of the spray area. Normally this was due to lack of protection or sprinkler heads coated with overspray in exhaust ducts or plenum.
(2) Inadequate cutoff between spraying operations and the rest of the plant.
(3) Poor maintenance with excessive buildup of overspray. Failure to keep areas outside booths free of overspray residue has resulted in fire spread between booths. Overspray residue can accumulate on the floor between booths (if ventilation is inadequate or if spraying is done outside booths), the underside of roofs near where the exhaust ducts penetrate (through loose-fitting duct sections), and on the roof around the discharge openings of several booth exhausts. Fire in one booth traveled up the exhaust, ignited overspray deposits on the roof, and, in turn, ignited deposits in exhaust ducts of other booths.
(4) Use of nitrocellulose-based lacquers. In these losses, personnel discovered the fire immediately and used portable extinguishers during the early stages of the fire but were unable to control the fire. The fire either flashed across overspray residue outside booths, immediately involving a large area, or burned in a concealed area where it could not be reached. Smoke quickly drove personnel out of the area. Automatic sprinklers can protect the room and the structure of the booth and duct system. However, if there is a continuous surface of residue between booths, the sprinklers might not prevent spread of fire from one booth to another. Good housekeeping and use of water-wash booths are basic to spraying operations involving nitrocellulose-based lacquers.

D.1.3 Powder Coatings. Loss experience indicates that where provisions of this standard were followed a typical fire in a powder system was confined to the powder spray pattern of the guns. When powder supply is shut off, burning stops. Residues within the spray booth are extremely difficult to ignite and virtually never participate in the fire when the fast-acting flame detectors referred to in Section 9.7 function normally. Total heat release is so restricted that no damage at all results.

Losses resulting in greater damage have occurred when the powder supply was not immediately cut off.

D.1.3.1 When equipment is configured to use conventional cyclone, baghouse, or enclosed cartridge collectors connected to the spray booth by ductwork, this results in ignition of the collector by the mechanism described in A.9.7. Damage can be limited if the collectors are properly vented and the vents ducted to the outside [maximum explosion vent duct length approximately 3 m (10 ft)]. When the collector is vented inside, burning powder is discharged into the room in substantial quantities. The burning powder can result in a rapid pressurization of the room, causing structural damage, or it might ignite combustibles in the area and open automatic sprinklers at ceiling level, or both. In virtually all cases investigated, the pressure pulse generated by ignition of an enclosed collector has resulted in backstreaming of the ductwork to the spray booth and ejection of a fireball through the spray booth back into the room, with high probability of attendant injuries and secondary damage, even if the collector is properly vented.

D.1.3.2 Since the integrated spray booth/"open" powder collector was introduced in the United States in 1978, the rate of fire occurrence has not changed significantly, but the ultimate results are substantially different. Although hundreds of fires have been reported, no explosions have occurred with this type of collector. Only two cases are known in which the fire extended beyond the confines of the spray booth. In both cases, as well as in all the cases where any significant damage occurred within the spray booth, a common set of conditions prevailed: The fast-acting flame detector and sprinkler protection called for by this standard were either absent or not in operation.

Annex E Informational References

E.1 Referenced Publications. The documents or portions thereof listed in this annex are referenced within the informational sections of this standard and are not part of the requirements of this document unless also listed in Chapter 2 for other reasons.

E.1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 30, *Flammable and Combustible Liquids Code*, 2003 edition.

NFPA 51B, *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work*, 2003 edition.

NFPA 68, *Guide for Venting of Deflagrations*, 2002 edition.

NFPA 69, *Standard on Explosion Prevention Systems*, 2002 edition.

NFPA 70, *National Electrical Code®*, 2005 edition.

NFPA 72®, *National Fire Alarm Code®*, 2007 edition.

NFPA 77, *Recommended Practice on Static Electricity*, 2007 edition.

NFPA 86, *Standard for Ovens and Furnaces*, 2007 edition.

NFPA 432, *Code for the Storage of Organic Peroxide Formulations*, 2002 edition.

E.1.2 Other Publications.

E.1.2.1 AIHA Publications. American Industrial Hygiene Association, 2700 Prosperity Avenue, Suite 250, Fairfax, VA 22031.

ANSI/AIHA Z9.7, *Recirculation of Air from Industrial Process Exhaust Systems,* 1998.

E.1.2.2 FEMA Publications. Fire Equipment Manufacturers Association, 1300 Sumner Avenue, Cleveland, OH 44115-2851.

"Recommendations for Protection of Curtained Limited Finishing Workstations."

E.1.2.3 ISA Publications. Instrumentation, Systems, and Automation Society, 67 Alexander Drive, Research Triangle Park, NC 27709.

ANSI/ISA-61241–10 (12.10.05), *Electrical Apparatus for Use in Zone 20, Zone 21, and Zone 22 Hazardous (Classified) Locations — Classification of Zone 20, Zone 21 and Zone 22 Hazardous (Classified) Locations,* 2004.

E.1.2.4 SMACNA Publications. Sheet Metal and Air Conditioning Contractors National Association, Inc., 4201 Lafayette Center Drive, Chantilly, VA 22021.

Rectangular Industrial Duct Construction Standards, 1st ed., 2004.

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E.2 Informational References. (Reserved)

E.3 References for Extracts in Informational Sections.

NFPA 70, *National Electrical Code®*, 2005 edition.

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- Committee votes by written ballot on Proposals. If two-thirds approve, Report goes forward. Lacking two-thirds approval, Report returns to Committee.
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3.3.78 Effective Ground-Fault Current Path. An intentionally constructed, permanent, low impedance electrically conductive path designed and intended to carry ~~underground~~ electric fault current ~~conditions~~ from the point of a ground fault on a wiring system to the electrical supply source.

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