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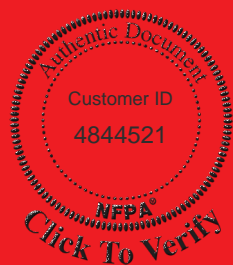
# 33

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## Standard for Spray Application Using Flammable or Combustible Materials

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## 2018



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## NFPA® 33

### Standard for

## Spray Application Using Flammable or Combustible Materials

### 2018 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 November 10, 2017, with an effective date of November 30, 2017, and supersedes all previous editions.

This edition of NFPA 33 was approved as an American National Standard on November 30, 2017.

### Origin and Development of NFPA 33

NFPA 33, *Standard for Spray Application Using Flammable or Combustible Materials*, originally titled *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, *Standard for Dipping, Coating, and Printing 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, 2006, and 2010.

The following major changes were incorporated into the 2003 edition:

- (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.
- (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 were adopted in the 2007 edition:

- (1) In Chapter 3, the definition of *spray area* was 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 were 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 was amended with text extracted from *NFPA 70®*, *National Electrical Code®*, to reflect changes in *NFPA 70* to hazardous locations.

- (4) Definitions were 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 was revised to allow fire retardant combustible materials for ducts connected to powder coating booths.
- (6) In Chapter 8, the maximum quantities of flammable and combustible liquids were 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 were revised, expanded, and clarified.
- (8) In Chapters 11, 12, and 15, 11.3.6, 12.5.4, and 15.13.4 were 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 were added for spray booths and spray rooms that are also used for drying and curing operations.
- (10) In Chapter 14, more definitive requirements were added for drying, curing, and fusion apparatus used in limited finishing workstations.

The following major changes were adopted in the 2011 edition:

- (1) In Section 1.1, the scope was amended to exempt certain small quantity operations, and a decision tree was added to Annex A (A.1.1.1) to assist the user in determining whether NFPA 33 is applicable to a particular spray application process.
- (2) The definition of *spray area* in 3.3.1.3 was amended to more clearly identify which parts of the spray system are not considered to be part of the spray area.
- (3) Chapter 6 was revised to recognize the Zone 21 and Zone 22 hazardous (classified) area classifications for combustible dusts. This correlated with *NFPA 70, National Electrical Code*, with respect to the latter's recognition of Zones 21 and 22 for electrical systems.
- (4) Section 7.7 was amended to allow concrete as a material of construction for spray area exhaust plenums and ducts, thus allowing a formed concrete exhaust plenum in the floor beneath a spray booth or room.
- (5) Section 8.2 was completely revised to recognize the concept of maximum allowable quantities (MAQs) of flammable and combustible liquids and to establish quantity limits based on MAQs. This correlated with *NFPA 30, Flammable and Combustible Liquids Code*.
- (6) Section 13.2 was revised to clarify that, if a spray area is used for drying or curing at a temperature above that at which the spray application takes place, the provisions of Section 13.3 must be followed. In addition, *ambient* was defined in Chapter 3 as the temperature range in the spray booth or room at which the spray application process takes place.
- (7) A new paragraph, 13.3.1.9, was added to exempt spray booths and spray rooms that are also used for drying and curing from the requirement for explosion relief venting, if certain conditions are met.
- (8) Subsection 13.3.2 was replaced with a new Section 13.5, which addressed installations where the spray booth or spray room is directly connected to the drying/curing oven by an enclosed vestibule.
- (9) Subsection 15.8.1 was amended to require that the concentration of combustible powder in the exhaust from a powder coating booth be based on the actual minimum explosive concentration of the powder being used.
- (10) Section 17.3 was amended by replacing the requirement for an automatic sprinkler system with a requirement that resin application areas be protected in accordance with Chapter 9, thus allowing other types of fire protection systems.
- (11) Subsection 17.5.2 was amended to replace the requirement for Division 1/Zone 1 electrical equipment with Division 2/Zone 2.

In the 2016 edition, terms and definitions were modified to be consistent with other NFPA documents and to mirror terms and definitions used in NFPA 34. Exceptions and vague and unenforceable language were removed from the document to comply with *Manual of Style for NFPA Technical Committee Documents*. The 2016 edition also contained the following changes:

- (1) Chapter 1 was revised to indicate that the standard now applies to spray application processes and operations that are conducted indoors or outdoors within temporary membrane enclosures.
- (2) Definitions of various types of spray booths and membrane enclosures were added to coordinate with changes made in other chapters of the document.
- (3) Chapter 4 was revised to address egress and accessibility concerns for spray operations that occur in basement.
- (4) The figures in Chapter 6 were revised to improve consistency and to clarify electrical classification requirements in the document.
- (5) Clarifications to mixing room requirements were made in Chapter 8.
- (6) Chapter 9 was revised to allow the use of water mist systems and to clarify the sprinkler design area requirement. Annex material was added to provide guidance in determining the water supply requirements for sprinklers likely to open in a fire incident. Duct protection requirements were revised to indicate that a sprinkler head should be located at the top of a vertical duct.

- (7) Chapter 9 also was revised to include fire protection for newer technology spray booths and scrubbers.
- (8) The figure in Chapter 14 was revised to improve consistency and to clarify the electrical classification requirements in the document.
- (9) Chapter 15 was completely revised to incorporate requirements for combustible dusts that are present in operations such as bag dump stations, pneumatic conveying systems, and other operations that generate dust.
- (10) The Committee added a new Chapter 18 on the use of temporary membrane enclosures for spraying workpieces that cannot be sprayed in traditional spray booths or rooms.
- (11) Table C.2.1 in Annex C was updated with current test data.

The following changes have been made for the 2018 edition:

- (1) Chapter 1, Administration, added clarification to document application. For example, Chapter 14 shall apply only to miscellaneous spray operations, and Chapter 18 shall apply only to spray application processes or operations that are conducted in temporary membrane enclosures both inside and outside buildings and structures.
- (2) Chapter 3, Definitions, was modified to include application definitions as well as to be consistent with other NFPA documents. New or revised definitions for applications including *automated spray application operations*, *basement*, *control area*, *dry particulate scrubber spray booth*, and *workstation* are provided. In addition, definition changes made to liquids and materials are consistent with other NFPA documents placing noncombustible material, limited-combustible material, and classification of liquids and determination of flash points in a General Requirements section. Changes to definitions are consistent with NFPA 1, NFPA 30, and *NFPA 5000*.
- (3) Chapter 4, General Requirements, is applicable to all spray operations. It has been revised to clarify definitions and spraying location, making them consistent with Chapter 5 requirements.
- (4) Chapter 5, Construction and Design of Spray Areas, Spray Rooms, and Spray Booths, has been revised to address the confusion between spray rooms and spray booths. It provides requirements for each type of spray location.
- (5) Chapter 6, Electrical and Other Sources of Ignition, has been revised. In addition, the figures in Chapter 6 were revised to improve consistency and to clarify electrical classification requirements in the document. The movement power vehicles in spray areas has also been clarified.
- (6) Chapter 7, Ventilation, has been revised to provide clarification of the heating of recirculated air and the manifolding of exhaust ducts.



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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 and printing processes, except for certain dipping processes that are within the scope of the Committee on Ovens and Furnaces.



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## NFPA 33

### Standard for

# Spray Application Using Flammable or Combustible Materials

2018 Edition

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

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. Extracted text may be edited for consistency and style and may include the revision of internal paragraph references and other references as appropriate. 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 operations that use less than 1 L (33.8 fl oz) of flammable or combustible liquid in any 8-hour period.

**1.1.5** This standard shall apply to spray application processes or operations that are conducted both indoors and outdoors within temporary membrane enclosures.

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

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

**1.1.8** This standard shall not apply to the use of aerosol products in containers up to and including 1 L (33.8 oz) capacity that are not used repeatedly in the same location. (See A.1.1.7.)

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

**1.1.10** This standard shall not apply to the hazards of toxicity or to 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 19 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 **only** 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. Chapter 18 shall apply only to spray application processes or operations that are conducted in temporary membrane enclosures **both inside and** outside buildings and structures.

**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 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*, 2018 edition.

NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems*, 2018 edition.

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 2016 edition.

NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*, 2016 edition.

NFPA 16, *Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems*, 2015 edition.

NFPA 17, *Standard for Dry Chemical Extinguishing Systems*, 2017 edition.

NFPA 30, *Flammable and Combustible Liquids Code*, 2018 edition.

NFPA 68, *Standard on Explosion Protection by Deflagration Venting*, 2018 edition.

NFPA 69, *Standard on Explosion Prevention Systems*, 2014 edition.

NFPA 70®, *National Electrical Code®*, 2017 edition.

NFPA 72®, *National Fire Alarm and Signaling Code*, 2016 edition.

NFPA 86, *Standard for Ovens and Furnaces*, 2015 edition.

NFPA 91, *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Particulate Solids*, 2015 edition.

NFPA 101®, *Life Safety Code®*, 2018 edition.

NFPA 259, *Standard Test Method for Potential Heat of Building Materials*, 2018 edition.

NFPA 400, *Hazardous Materials Code*, 2016 edition.

NFPA 496, *Standard for Purged and Pressurized Enclosures for Electrical Equipment*, 2017 edition.

NFPA 701, *Standard Methods of Fire Tests for Flame Propagation of Textiles and Films*, 2015 edition.

NFPA 750, *Standard on Water Mist Fire Protection Systems*, 2015 edition.

NFPA 2001, *Standard on Clean Agent Fire Extinguishing Systems*, 2018 edition.

NFPA 5000®, *Building Construction and Safety Code®*, 2018 edition.

### 2.3 Other Publications.

**2.3.1 ASME Publications.** American Society of Mechanical Engineers, Two Park Avenue, New York, NY 10016-5990.

*Boiler and Pressure Vessel Code*, Section VIII, 2015.

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

ASTM D5/D5M, *Standard Test Method for Penetration of Bituminous Materials*, 2013.

ASTM D56, *Standard Test Method for Flash Point by Tag Closed Cup Tester*, 2010.

ASTM D93, *Standard Test Methods for Flash Point by Pensky-Martens Closed Cup Tester*, 2015a.

ASTM D323, *Standard Test Method for Vapor Pressure of Petroleum Products (Reid Method)*, 2015a.

ASTM D3278, *Standard Test Methods for Flash Point of Liquids by Small Scale Closed-Cup Apparatus*, 2011.

ASTM D3828, *Standard Test Methods for Flash Point by Small Scale Closed Cup Tester*, 2012a.

ASTM D4359, *Standard Test Method for Determining Whether a Material is a Liquid or a Solid*, 2012.

ASTM E84, *Standard Test Method for Surface Burning Characteristics of Building Materials*, 2015b.

ASTM E136, *Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C*, 2016.

ASTM E2652, *Standard Test Method for Behavior of Materials in a Tube Furnace with a Cone-shaped Airflow Stabilizer, at 750°C*, 2015.

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

ANSI/UL 340, *Standard for Tests for Comparative Flammability of Liquids*, 2009, revised 2014.



ANSI/UL 723, *Standard for Test for Surface Burning Characteristics of Building Materials*, 2008.

ANSI/UL 900, *Standard for Air Filter Units*, 2004, revised 2015.

ANSI/UL 2208, *Standard for Solvent Distillation Units*, 2010, revised 2015.

### 2.3.4 Additional 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*, 2018 edition.

NFPA 56, *Standard for Fire and Explosion Prevention During Cleaning and Purging of Flammable Gas Piping Systems*, 2017 edition.

NFPA 69, *Standard on Explosion Prevention Systems*, 2014 edition.

NFPA 70®, *National Electrical Code®*, 2017 edition.

NFPA 5000®, *Building Construction and Safety Code®*, 2018 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.

**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.** An NFPA Standard, the main text of which contains only mandatory provisions using the word “shall” to indicate requirements and that is in a form generally suitable

for mandatory reference by another standard or code or for adoption into law. Nonmandatory provisions are not to be considered a part of the requirements of a standard and shall be located in an appendix, annex, footnote, informational note, or other means as permitted in the NFPA Manuals of Style. When used in a generic sense, such as in the phrase “standards development process” or “standards development activities,” the term “standards” includes all NFPA Standards, including Codes, Standards, Recommended Practices, and Guides.

### 3.3 General Definitions.

**3.3.1\* Ambient.** For the purposes of this standard, the temperature range of the air in the spray area at which a spray application process takes place.

#### 3.3.2 Area.

**3.3.2.1 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.

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

**3.3.2.3\* Spray Area.** Any fully enclosed, partly enclosed, or unenclosed area in which flammable or combustible vapors, mists, residues, dusts, or deposits are present due to the operation of spray processes, including (1) any area in the direct path of a spray application process; (2) the interior of a spray booth, spray room, or limited finishing workstation, as herein defined; (3) the interior of any exhaust plenum, eliminator section, or scrubber section; (4) the interior of any exhaust duct or exhaust stack leading from a spray application process; (5) the interior of any air recirculation path up to and including recirculation particulate filters; (6) any solvent concentrator (pollution abatement) unit or solvent recovery (distillation) unit; and (7) the inside of a membrane enclosure. The following are not 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 recirculation particulate filters; and (4) exhaust ducts from solvent concentrator (pollution abatement) units.

**3.3.2.3.1 Outdoor Spray Area.** A spray area that is outside the confines of a building or that has a canopy or roof that does not limit the dissipation of the heat of a fire or dispersion of flammable vapors and does not restrict fire-fighting access and control. For the purpose of this standard, an outdoor spray area can be treated as an unenclosed spray area, as defined in 3.3.3.3.2.

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

**3.3.3 Automated Spray Application Operations.** Operations where the spray application operation is performed by mechanical or electronic devices that take the place of human labor.

**3.3.4 Basement.** For the purposes of this standard, a story of a building or structure having one-half or more of its height below ground level and to which access for fire-fighting purposes is restricted. [30, 2018]

**3.3.5 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.

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

**3.3.7 Competent Person.** One who is capable of identifying existing and predictable hazards in the surroundings or working conditions that are unsanitary, hazardous, or dangerous to employees, and who has authorization to take prompt corrective measures to eliminate them. [56, 2017]

**N 3.3.8\* Control Area.** A building or portion of a building within which hazardous materials are allowed to be stored, dispensed, used, or handled in quantities not exceeding the maximum allowable quantities (MAQ). [5000, 2018]

**3.3.9 [Electrical] Utilization Equipment.** Equipment that utilizes electric energy for electronic, electromechanical, chemical, heating, lighting, or similar purposes. [70, 2017]

**3.3.10 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.

**3.3.10.1 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.

**3.3.11 Inerting.** A technique by which a combustible mixture is rendered nonignitable by adding an inert gas or a noncombustible dust. [69, 2014]

**Δ 3.3.12 Limited Combustible.** See Section 4.5.

**3.3.13 Liquid.** Any material that (1) has a fluidity greater than that of 300 penetration asphalt when tested in accordance with ASTM D5/D5M, *Standard Method of Test for Penetration of Bituminous Materials*, or (2) is a viscous substance for which a specific melting point cannot be determined but that is determined to be a liquid in accordance with ASTM D4359, *Standard Test Method for Determining Whether a Material is a Liquid or a Solid*. [30, 2018]

**Δ 3.3.13.1 Combustible Liquid.** Any liquid that has a closed-cup flash point at or above 37.8°C (100°F), as determined by the test procedures and apparatus set forth in Section 4.7. Combustible liquids are classified according to Section 4.6. [30, 2018]

**3.3.13.2 Flammable Liquid.** Any liquid that has a closed-cup flash point below 37.8°C (100°F), as determined by the test procedures and apparatus set forth in Section 4.7, and a Reid vapor pressure that does not exceed an absolute pressure of 276 kPa (40 psi) at 37.8°C (100°F), as determined by ASTM D323, *Standard Test Method for Vapor Pressure of Petroleum Products (Reid Method)*. Flammable liquids are classified according to Section 4.6. [30, 2018]

**3.3.14 Material.**

**3.3.14.1 Flammable or Combustible Material.** Any material, including its residue, that is used in the spray application process and also meets the definition of a combustible liquid (see 3.3.13.1), a flammable liquid (see 3.3.13.2), or a combustible powder (see 3.3.6).

**N 3.3.14.2 Limited-Combustible Material.** See Section 4.5.

**Δ 3.3.14.3 Noncombustible Material.** See Section 4.4.

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

**3.3.16 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.

**3.3.17\* Recirculation Particulate Filter.** A filter, or series of filters, capable of removing more than 95 percent of particles 0.3 to 10 μ in size from the airstream.

**3.3.18\* 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.

**3.3.18.1 Dry Particulate Scrubber Spray Booth.** A spray booth that is equipped with a dry filtration system that uses a dry, noncombustible particulate medium to remove paint overspray particulate from the spray booth exhaust airstream.

**3.3.18.2 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.

**3.3.18.3 Electrostatic Precipitator Spray Booth.** A spray booth that removes the paint particles from the exhaust air by directing the exhaust air through an electrostatic field and capturing the paint particles on grounded elements.

**3.3.18.4 High-Capacity Dry Paint Arrestor Booth.** A spray booth equipped with a dry media paint particulate overspray filtration system that utilizes discrete filtration elements having a paint holding capacity of greater than or equal to 22.7 kg (50 lb)/ filter element.

**3.3.18.5 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.

**3.3.19\* Spray Room.** A power-ventilated fully enclosed room with a specified fire resistance rating used for spraying of flammable or combustible materials.

**3.3.20 Ventilation.** The changing of air within a compartment by natural or mechanical means.

**3.3.21 Workstation.**

**Δ 3.3.21.1\* Limited Finishing Workstation.** A power-ventilated apparatus that is capable of confining the vapors, mists, residues, dusts, or deposits that are generated by a limited spray application process. A limited finishing workstation is not a spray booth or spray room, as herein defined.

**3.3.21.2 Preparation Workstation.** A power-ventilated apparatus that is used to control the dusts and residues generated by surface preparation operations. A preparation workstation is not a limited finishing workstation, spray booth, or spray room, as herein defined.

## Chapter 4 General Requirements

**4.1\* Location of Spray Application Operations.** Spray application operations and processes shall be located in industrial occupancies as defined by *NFPA 5000* and shall be confined to spray booths, spray rooms, spray areas, or in temporary membrane enclosures as defined in this standard.

**4.1.1\* Locations in Other Occupancies.** Spray application operations and processes shall not be conducted in any building that is classified as an assembly, an educational, a day care, a health care, an ambulatory health care, a detention/correctional, a residential, a mercantile, a business, or a storage occupancy, unless the following requirements are met:

- (1) The spraying is 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 or in a spray room (see Section 5.2).
- (2) The room is protected by an approved automatic sprinkler system designed and installed in accordance with NFPA 13.

**4.2\* Separation.** Spray application operations shall be separated from other operations, materials, or occupancies by location, fire barrier walls, and horizontal assemblies in accordance with *NFPA 5000*, or other means acceptable to the authority having jurisdiction.

**4.3\* Basements.** Spray booths, rooms, and areas shall not be located in a basement unless all the following requirements are met:

- (1) A means of egress is provided that meets the requirements of 5.1.4.
- (2) An access means is provided for emergency response personnel.

### 4.4 Noncombustible Material.

**4.4.1** A material that complies with any one of the following shall be considered a noncombustible material:

- (1)\* The material, 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.
- (2) The material is reported as passing ASTM E136, *Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C*.
- (3) The material is reported as complying with the pass/fail criteria of ASTM E136 when tested in accordance with the test method and procedure in ASTM E2652, *Standard Test Method for Behavior of Materials in a Tube Furnace with a Cone-shaped Airflow Stabilizer, at 750°C*.

[5000:7.1.4.1.1]

**4.4.2** Where the term *limited-combustible* is used in this standard, it shall also include the term noncombustible. [5000:7.1.4.1.2]

**4.5 Limited-Combustible Material.** A material shall be considered a limited-combustible material where both of the follow-

ing conditions of 4.5.1 and 4.5.2, and the conditions of either 4.5.3 or 4.5.4, are met. [5000:7.1.4.2]

**4.5.1** The material does not comply with the requirements for a noncombustible material in accordance with Section 4.4. [5000:7.1.4.2(1)]

**4.5.2** The material, in the form in which it is used, exhibits a potential heat value not exceeding 8141 kJ/kg (3500 Btu/lb) where tested in accordance with NFPA 259. [5000:7.1.4.2(2)]

**4.5.3** The material has a structural base of a noncombustible material with a surfacing not exceeding a thickness of 3.2 mm ( 1/8 in.) where the surfacing exhibits a flame spread index not greater than 50 when tested in accordance with ASTM E84, *Standard Test Method for Surface Burning Characteristics of Building Materials*, or UL 723, *Standard for Test for Surface Burning Characteristics of Building Materials*. [5000:7.1.4.2.1]

**4.5.4** The material is composed of materials which, in the form and thickness used, neither exhibit a flame spread index greater than 25 nor evidence of continued progressive combustion when tested in accordance with ASTM E84, *Standard Test Method for Surface Burning Characteristics of Building Materials*, or UL 723, *Standard for Test for Surface Burning Characteristics of Building Materials*, and are of such composition that all surfaces that would be exposed by cutting through the material on any plane would neither exhibit a flame spread index greater than 25 nor evidence of continued progressive combustion when tested in accordance with ASTM E84 or UL 723. [5000:7.1.4.2.2]

**4.5.5** Where the term limited-combustible is used in this standard, it shall also include the term *noncombustible*. [5000:7.1.4.2.3]

**4.6 Classification of Liquids.** Any liquid within the scope of this standard and subject to the requirements of this standard shall be classified in accordance with this section. [30:4.3]

**4.6.1** Flammable liquids, as defined in 3.3.13.2, shall be classified as Class I liquids and shall be further subclassified in accordance with the following:

- (1) Class IA Liquid — Any liquid that has a flash point below 22.8°C (73°F) and a boiling point below 37.8°C (100°F)
- (2) Class IB Liquid — Any liquid that has a flash point below 22.8°C (73°F) and a boiling point at or above 37.8°C (100°F)
- (3) Class IC Liquid — Any liquid that has a flash point at or above 22.8°C (73°F), but below 37.8°C (100°F) [30:4.3.1]

**4.6.2** Combustible liquids, as defined in 3.3.13.1, shall be classified in accordance with the following:

- (1) Class II Liquid — Any liquid that has a flash point at or above 37.8°C (100°F) and below 60°C (140°F)
- (2) Class III Liquid — Any liquid that has a flash point at or above 60°C (140°F)
  - (a) Class IIIA Liquid — Any liquid that has a flash point at or above 60°C (140°F), but below 93°C (200°F)
  - (b) Class IIIB Liquid — Any liquid that has a flash point at or above 93°C (200°F)

[30:4.3.2]



**N 4.7 Determination of Flash Point.** The flash point of a liquid shall be determined according to the methods specified in 4.7.1 through 4.7.4. [30:4.4]

**N 4.7.1** Except as specified in 4.7.1.1, the flash point of a liquid having a viscosity below 5.5 centiStokes at 40°C (104°F) or below 9.5 centiStokes at 25°C (77°F) shall be determined in accordance with ASTM D56, *Standard Test Method for Flash Point by Tag Closed Cup Tester*. [30:4.4.1]

**N 4.7.1.1** Cut-back asphalts, liquids that tend to form a surface film, and liquids that contain suspended solids shall not be tested in accordance with ASTM D56, *Standard Test Method for Flash Point by Tag Closed Cup Tester*, even if they otherwise meet the viscosity criteria. Such liquids shall be tested in accordance with 4.7.2. [30:4.4.1.1]

**N 4.7.2** The flash point of a liquid having a viscosity of 5.5 centiStokes or more at 104°F (40°C) or 9.5 centiStokes or more at 25°C (77°F) or a flash point of 93.4°C (200°F) or higher shall be determined in accordance with ASTM D93, *Standard Test Methods for Flash Point by Pensky-Martens Closed Cup Tester*. [30:4.4.2]

**N 4.7.3** As an alternative, ASTM D3278, *Standard Test Methods for Flash Point of Liquids by Small Scale Closed-Cup Apparatus*, shall be permitted to be used for paints, enamels, lacquers, varnishes, and related products and their components that have flash points between 0°C (32°F) and 110°C (230°F) and viscosities below 150 Stokes at 25°C (77°F). [30:4.4.3]

**N 4.7.4** As an alternative, ASTM D3828, *Standard Test Methods for Flash Point by Small Scale Closed Cup Tester*, shall be permitted to be used for materials other than those for which ASTM D3278, *Standard Test Methods for Flash Point of Liquids by Small Scale Closed-Cup Apparatus*, is specifically required. [30:4.4.4]

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

### 5.1\* Spray Areas.

**5.1.1** 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.

**N 5.1.1.1** 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.

**N 5.1.1.2** Air intake filters that are a part of a wall or ceiling assembly shall be listed 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, walls, or ceilings that enclose a spray area or for ventilation ductwork to or from an enclosed spray area unless otherwise permitted by 5.1.3.1.

**N 5.1.3.1** Aluminum shall be permitted to be used for interior components, such as platforms, spray apparatus components, and other ancillary devices.

**Δ 5.1.4** Enclosed spray areas shall be provided with means of egress that meet the applicable requirements of Chapter 40 of NFPA 101.

**N 5.2 Spray Rooms.** In addition to the requirements of Section 5.1, spray rooms shall be constructed of and separated vertically and horizontally from all surrounding areas by construction assemblies that have a fire resistance rating of not less than 2 hours.

### N 5.3 Spray Booths.

**N 5.3.1** Spray booths shall meet the requirements of Sections 5.1 and 5.3.

**N 5.3.2** 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.).

**N 5.3.3** Structural sections of spray booths shall be permitted to be sealed with a caulk or sealant to minimize air leakage.

**N 5.3.4** Spray booths that are used exclusively for powder coating shall meet the requirements of Chapter 15 and shall be permitted to be constructed of fire-retardant combustible materials where approved by the authority having jurisdiction.

**N 5.3.4.1** Listed spray booth assemblies that are constructed of other materials shall be permitted.

**N 5.3.5** Spray application operations and processes that involve the use of finishing materials containing nitrocellulose shall be confined to water-wash spray booths as defined in this standard unless otherwise specified in 5.3.5.1.

**N 5.3.5.1** Spray application of finishing materials containing nitrocellulose shall be permitted in a dry-type spray booth provided that residue is removed from all baffle plates at least daily and all filters are changed at least daily.

**5.4 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.

**5.5\* 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 connected spray booths shall not be considered as “other operations” except as provided for in Section 13.3.

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

**5.5.2** A clear space of not less than 915 mm (3 ft) shall be maintained on all sides and above the spray booth, and shall be kept free of any storage or combustible construction.

**5.5.2.1** The requirement in 5.5.2 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.

**5.5.2.2** The requirement in 5.5.2 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.

### 5.6 Illumination and Observation Panels.

**5.6.1** Panels for luminaires or 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.

**5.6.1.1** Listed spray booth assemblies that have observation panels constructed of other materials shall be permitted.

**5.6.2** Panels for luminaires shall be separated from the fixture to prevent the surface temperature of the panel from exceeding 93°C (200°F).

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

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

▲ **5.7 Ventilation.** Spray areas that are equipped with ventilation distribution, baffle plates, or dry overspray collection filters shall meet the requirements of 5.7.1 through 5.7.5.

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

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

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

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

**5.7.5** 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* and all applicable requirements of this chapter.

■ **6.2.1.1** Powered vehicles shall meet the requirements of Section 6.10.

■ **6.2.1.2** 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.
- (4) A Class II, Division 1 location shall be permitted to be alternatively classified as a Zone 21 location.
- (5) A Class II, Division 2 location shall be permitted to be alternatively classified as a Zone 22 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, Zone 2, or Zone 22.

**6.2.5.1** 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, Zone 2, or Zone 22 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 ignitable mixture.

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

- (1) An ignitable concentration of flammable gas or vapor can exist under normal operating conditions.
- (2) An ignitable 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 ignitable 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*, 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 ignitable 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 ignitable 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*, a Class I, Zone 0 location shall be any location where an ignitable 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*, a Class I, Zone 1 location shall be any location where one of the following conditions exists:

- (1) An ignitable concentration of flammable gas or vapor is likely to exist under normal operating conditions.
- (2) An ignitable 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 ignitable 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 ignitable 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*, a Class I, Zone 2 location shall be any location where one of the following conditions exists:

- (1) An ignitable concentration of a flammable gas or vapor is not likely to exist under normal operating conditions, and if an ignitable 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 ignitable 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 ignitable 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*, 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 ignitable mixtures under normal operating conditions.
- (2) Mechanical failure or abnormal operation of machinery or equipment might cause an explosive or ignitable 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*, 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 ignitable 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 ignitable by abnormal operation or failure of electrical equipment.

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

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

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

- (1) An ignitable concentration of combustible dust is likely to exist occasionally under normal operating conditions.
- (2) An ignitable 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 ignitable 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 ignitable concentration of combustible dust could be communicated from an adjacent 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\* Zone 22.** As defined in 506.5(B)(3) of *NFPA 70*, a Zone 22 location shall be any location where one of the following conditions exists:

- (1) An ignitable 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 ignitable concentration of combustible dust could be communicated from an adjacent 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** The spray area as defined in 3.3.3.3 shall be Class I, Division 1; Class I, Zone 1; Class II, Division 1; or Zone 21, whichever is applicable.

**6.4.2** 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; Class II, Division 1; or Zone 21 locations, whichever is applicable.

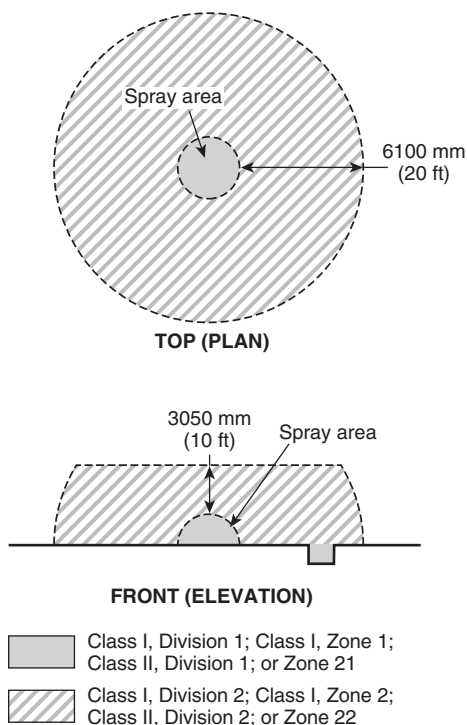
**6.4.3\*** Electrical wiring and utilization equipment that is located in the spray area and is subject to deposits of combustible residues shall be listed for such exposure and shall be suitable for Class I, Division 1; Class I, Zone 1; Class II, Division 1; or Zone 21 locations, whichever is applicable.

**6.5 Electrical Devices in Areas Adjacent to or Connected to Spray Areas.** Electrical wiring and utilization equipment located in areas adjacent to or connected to the spray area, including but not limited to vestibules and tunnels, shall be classified in accordance with 6.5.1 through 6.5.5.

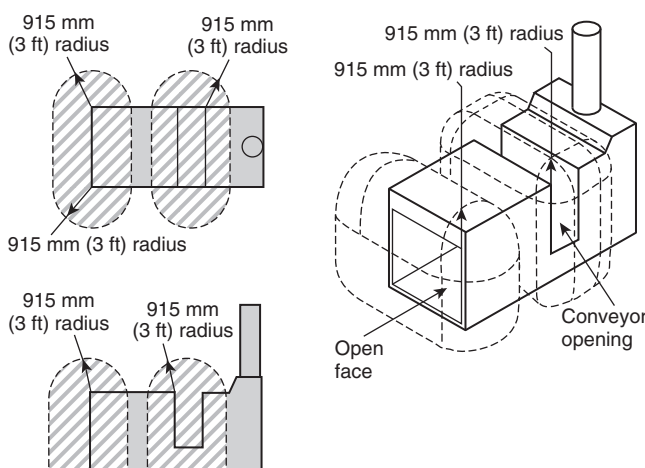
**6.5.1** Electrical wiring and utilization equipment located outside, but within 6100 mm (20 ft) horizontally and 3050 mm (10 ft) vertically, of an unenclosed spray area and not separated from the spray area by partitions extending to the boundaries of the area designated as Division 2, Zone 2; or Zone 22 in Figure 6.5.1 shall be suitable for Class I, Division 2; Class I, Zone 2; Class II, Division 2; or Zone 22 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, as shown in Figure 6.5.2(a) or Figure 6.5.2(b), any electrical wiring or utilization equipment located outside the booth or room but within 915 mm (3 ft) of any opening shall be suitable for Class I, Division 2; Class I, Zone 2; Class II, Division 2; or Zone 22 locations, whichever is applicable.

**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; Class II, Division 2; or Zone 22 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



**FIGURE 6.5.1 Electrical Area Classification for Unenclosed Spray Areas.**

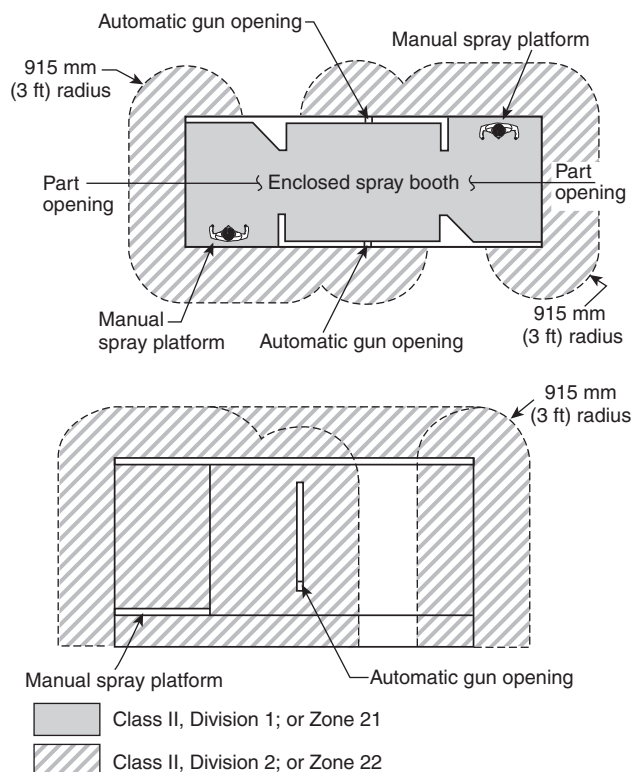


**FIGURE 6.5.2(a) Class I, Division 2; Class I, Zone 2; Class II, Division 2; or Zone 22 Locations Adjacent to an Open-Face or Open-Front Spray Booth or Spray Room.**

Class I, Division 2; Class I, Zone 2; Class II, Division 2; or Zone 22 locations, whichever is applicable.

**6.5.4** If spray application operations are confined to an enclosed spray booth or room, electrical area classification shall be as follows:

- (1) The area within 915 mm (3 ft) of any opening shall be classified as Class I, Division 2; Class I, Zone 2; Class II, Division 2; or Zone 22 locations, whichever is applicable, as shown in Figure 6.5.4.



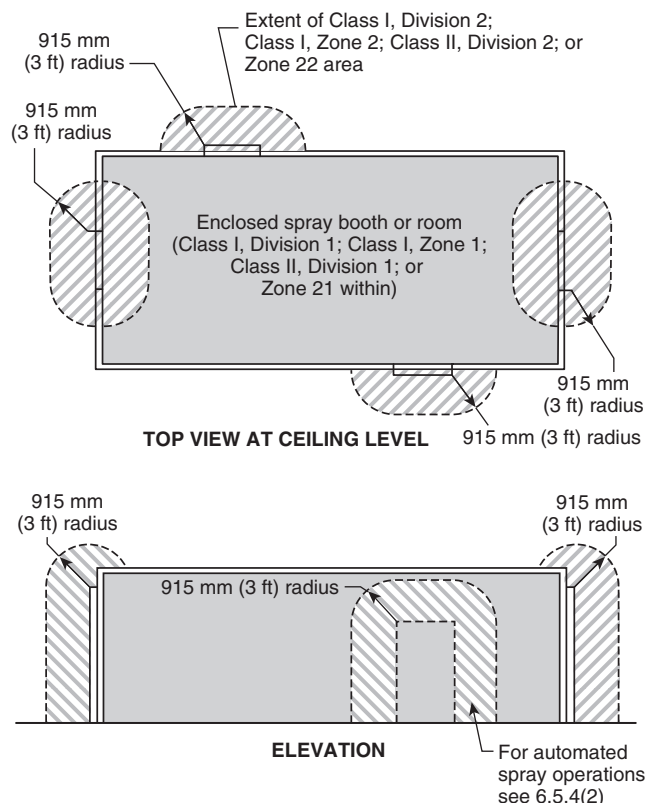
**▲ FIGURE 6.5.2(b) Class II, Division 1; or Zone 21 Locations Inside Powder Coating Booth and On the Manual Spray Platforms. Class II, Division 2; or Zone 22 Locations Adjacent to Automatic Gun Openings and Outer Edge of the Manual Spray Platform for Powder Coating Booth.**

- (2)\* Where automated spray application equipment is used, the area outside the access doors shall be unclassified provided the door interlock prevents the spray application operations when the door is open.
- (3) Where exhaust air is recirculated and all requirements of Section 7.5 are met, both of the following shall apply:
  - (a) The interior of any recirculation path downstream of the recirculation particulate filter up to and including the air supply plenum shall be classified as Class I, Division 2; Class I, Zone 2; Class II, Division 2; or Zone 22 locations, whichever is applicable.
  - (b) The interior of fresh air supply ducts shall be unclassified.
- (4) Where exhaust air is not recirculated, the interior of fresh air supply ducts and fresh air supply plenums shall be unclassified.

**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



**▲ FIGURE 6.5.4 Class I, Division 2; Class I, Zone 2; Class II, Division 2; or Zone 22 Locations Adjacent to an Enclosed Spray Booth or Room.**

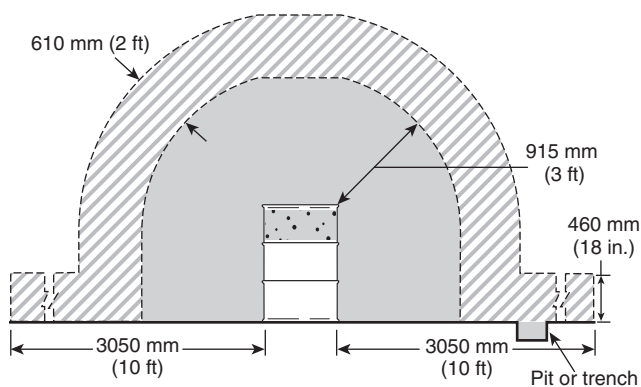
or grade level shall be classified as Class I, Division 1 or Class I, Zone 1, whichever is applicable.

- (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.

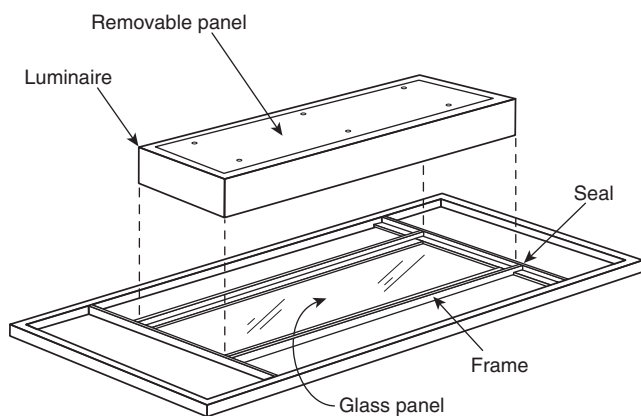
**6.5.5.2** Electrical wiring and utilization equipment installed in these areas shall be suitable for the location, as shown in Figure 6.5.5.2.

## 6.6 Illumination.

**6.6.1** Luminaires, 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 5.6 shall be suitable for use in unclassified locations. Such fixtures shall be serviced from outside the spray area.



**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.**

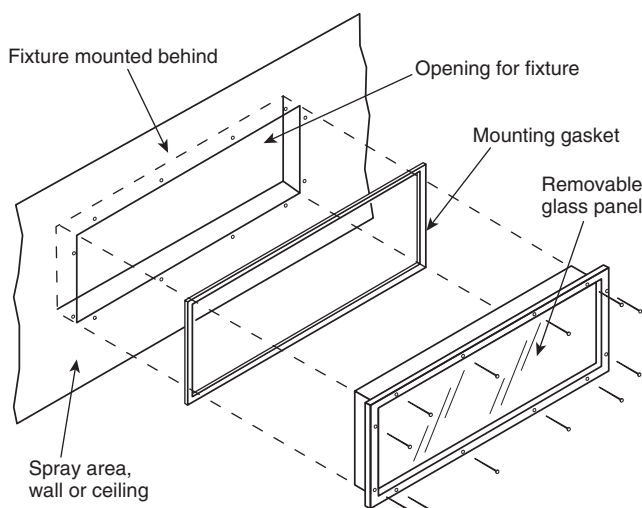
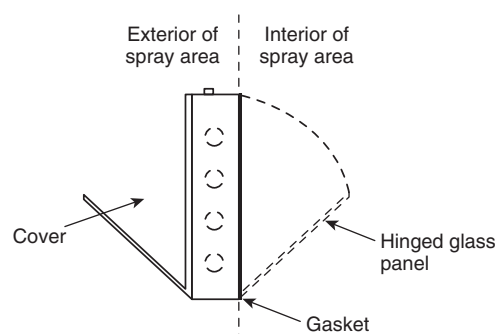


**FIGURE 6.6.1 Example of a Luminaire Mounted Outside the Spray Area and Serviced from Outside the Spray Area.**

**6.6.2** Luminaires, 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 5.6; and that are located within a Class I, Division 2; a Class I, Zone 2; a Class II, Division 2; or a Zone 22 location shall be suitable for such location. Such fixtures shall be serviced from outside the spray area.

**6.6.3** Luminaires, 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; Class II, Division 2; or Zone 22 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** Luminaires that are located inside the spray area shall meet the requirements of Section 6.4 and Section 6.7.



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

**6.7\* Static Electricity.** 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). 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.

**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*.
- (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 for liquid applications or dusttight seals for powder applications where the cord enters junction boxes, fittings, or enclosures.
- (6) They are listed for deposits of combustible residues.

▲ **6.9 Portable Electric Luminaires.** Portable electric luminaires used in spray areas shall meet the requirements of 6.4.3.

**6.10 Movement of Powered Vehicles.** Powered vehicles shall be listed for the electrical area classification in which they are used, and unlisted 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.

## Chapter 7 Ventilation

**7.1 General.** Ventilating and exhaust systems shall be designed and installed in accordance with the applicable requirements of NFPA 91 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.)*

**7.2.1\*** Spray areas equipped with overspray collection filters shall have an effective means to ensure that the performance requirements of Section 7.2 are met.

**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.

**7.2.4** In confined spaces, where ventilation is not capable of meeting the requirements of Section 7.2, an inerting procedure shall be permitted to be used. Such procedures shall meet the applicable requirements of NFPA 69 and shall be acceptable to the authority having jurisdiction.

**7.3\* Make-Up Air.** 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 from liquid spray operations shall be conducted by ducts directly to the outside of the building. Exhaust ducts shall follow the shortest route to the point of discharge and shall meet the following conditions:

- (1) Exhaust ducts shall not penetrate a fire wall or fire barrier wall.

- (2) Exhaust discharge shall be directed away from any air intakes.
- (3) Exhaust discharge point shall be at least 1830 mm (6 ft) from any exterior wall or roof.
- (4) Exhaust discharge point shall be at least 3048 mm (10 ft) from openings into the building.
- (5) Exhaust discharge point shall be at least 3048 mm (10 ft) above adjoining grade.
- (6) 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.
- (7) Exhaust duct shall not 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.
- (8) Exhaust duct shall not discharge in the direction of any exit discharge or public way that is within 7625 mm (25 ft) of the exhaust duct discharge point.

▲ **7.5\* Recirculation of Exhaust.** Air exhausted from spray areas shall not be recirculated unless all of the following requirements are met:

- (1) Recirculation particulate filters as defined in this standard shall be used to remove particulates from the recirculated air.
- (2) The concentration of vapors in the exhaust airstream shall not exceed 25 percent of the lower flammable limit.
- (3) Listed equipment shall be used to monitor the concentration of vapors in all exhaust airstreams.
- (4) The equipment specified in 7.5(3) shall initiate a local 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.
- (5) All equipment installed to process and remove contaminants from the air exhausted from spray operations shall be approved by the authority having jurisdiction.
- (6)\* For occupied spray areas where a portion of the exhaust air is recirculated within the spray area, toxicity and worker exposures shall be addressed.

■ **7.6 Heating of Recirculated Air.** Where recirculated air is heated, the following requirements shall be met:

- (1) The air heater shall be located downstream of the recirculation particulate filter and vapor concentration monitor.
- (2) The surface temperature of the air heater shall not exceed 93°C (200°F).

**7.7\* Manifolding of Exhaust Ducts.** Individual spray booths shall be separately ducted to the building exterior except as indicated in 7.7.1 or 7.7.2.

■ **7.7.1** Multiple cabinet spray booths whose combined frontal area does not exceed 1.7 m<sup>2</sup> (18 ft<sup>2</sup>) shall be permitted to be manifolded if the sprayed materials used will not react and cause ignition of the residue in the ducts.

■ **7.7.2** 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 finishing materials containing nitrocellulose are 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.

**7.8\* Materials of Construction.** Exhaust plenums and exhaust ducts and fasteners shall be constructed of steel, except as allowed in 7.8.1, 7.8.2, and 7.8.3.

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

**7.8.2** Concrete shall be permitted to be used. The interior surfaces of the concrete exhaust plenum or exhaust duct shall be smooth and sealed to facilitate cleaning.

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

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

**7.9.1** 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.

**7.9.2** Hangers and supports shall be fastened to the building or to the structure to minimize vibration and stress on the duct system.

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

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

**7.9.5** The provisions of 7.9.4 shall not disallow the use of concrete exhaust plenums or exhaust ducts where some or all of the plenum or duct is part of the concrete floor.

**7.10 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.

#### 7.11 Exhaust Fans and Drives.

**7.11.1** 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. Necessary allowances shall be 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 shall maintain alignment even when the blades of the fan are heavily loaded. All bearings shall be of the self-lubricating type or shall be provided with accessible lubricating ports.

**7.11.2** Electric motors that drive exhaust fans shall not be placed inside any spray area unless they meet the provisions of 6.4.3.

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

**7.12\* 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 and of this chapter.

**8.2 Storage in Process Areas.** The maximum allowable quantities (MAQs) of flammable and combustible liquids in each control area shall not exceed the amounts specified in Table 8.2, with additional quantities allowed in accordance with the requirements established in Section 8.3.

### 8.3 Mixing.

**8.3.1** Dispensing or transfer of liquids from containers and filling of containers, including portable mixing tanks and “pressure pots,” shall be done only in a spray area with the ventilation in operation or in a mixing room.

**8.3.2** Where the quantities of liquids required or the floor area necessary to provide a suitable mixing room exceeds the limits specified in 8.3.3 through 8.3.6, the mixing room shall meet all applicable requirements of NFPA 30.

**Table 8.2 MAQ of Flammable and Combustible Liquids per Control Area**

	Liquid Classes	Quantity		Notes
		L	gal	
Flammable liquids	IA	115	30	1, 2
	IB and IC	460	120	1, 2
	IA, IB, IC combined	460	120	1, 2, 3
Combustible liquids	II	460	120	1, 2
	IIIA	1265	330	1, 2
	IIIB	50,600	13,200	1, 2

Notes:

(1) Quantities are permitted to be increased 100 percent where all liquids are stored in approved flammable liquids storage cabinets or in safety cans. Where Note 2 also applies, the increase for both notes is permitted to be applied accumulatively.

(2) Quantities are permitted to be increased 100 percent in buildings equipped throughout with an automatic sprinkler system installed in accordance with NFPA 13. Where Note 1 also applies, the increase for both notes is permitted to be applied accumulatively.

(3) Containing not more than the maximum allowable quantity per control area of Class IA, Class IB, or Class IC flammable liquids, individually.

Source: Table 9.6.1 of NFPA 30.

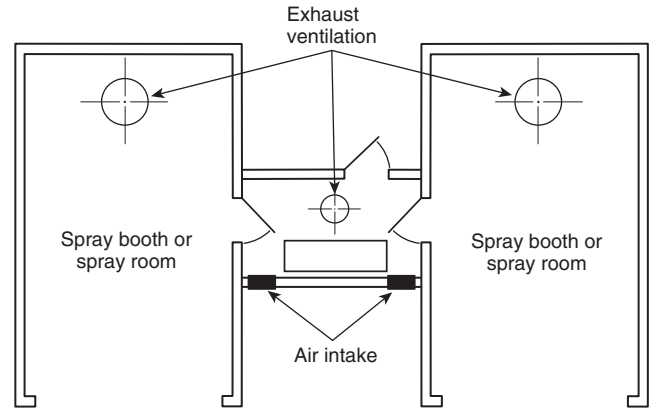
**8.3.3** Mixing rooms shall meet all of the following requirements:

- (1) Mixing rooms shall meet the construction requirements of Section 5.1.
- (2) The area of a mixing room shall not exceed 14 m<sup>2</sup> (150 ft<sup>2</sup>).
- (3) If more than one mixing room is installed, the total quantity of liquids shall not exceed the limits in 8.3.5 or 8.3.6.
- (4) Mixing rooms shall be designed to contain a spill of the contents in the room.
- (5) Mixing rooms where dispensing, handling, or transferring of Class I, Class II, or Class III liquids at temperatures at or above their flash point occurs shall be provided with mechanical ventilation capable of providing air movement not less than 0.3 m<sup>3</sup>/min/m<sup>2</sup> (1 ft<sup>3</sup>/min/ft<sup>2</sup>) of floor area or 4 m<sup>3</sup>/min (150 ft<sup>3</sup>/min), whichever is greater.
- (6) Ventilation systems provided in accordance with 8.3.3(5) shall be in operation during operating hours or whenever vapors are present.
- (7) Mixing rooms shall be classified for purposes of electrical area classification in accordance with Chapter 7 of NFPA 30.
- (8) Mixing rooms shall be provided with an approved automatic fire protection system that meets all applicable requirements of Chapter 9.
- (9) Mixing rooms shall be provided with portable fire extinguishers located in accordance with NFPA 10.

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

**8.3.5** 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 8.3.5(a) and Figure 8.3.5(b), the combined quantities of liquids located in the spray areas and the mixing room shall not exceed 454 L (120 gal).

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



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

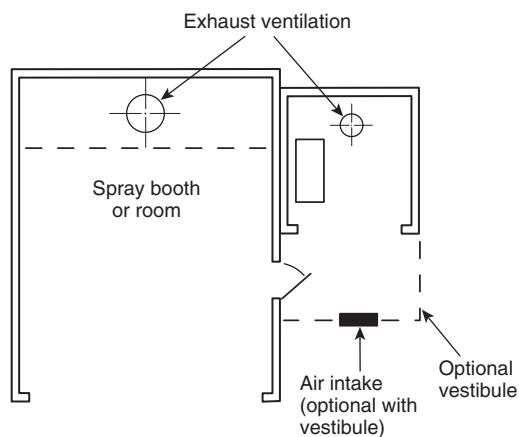
**FIGURE 8.3.5(b) Mixing Room Within 1830 mm (6 ft) of Spray Area and with Direct Entry to Spray Area, Including Maximum Volume of Liquid Allowed.**

the mixing room shall not exceed 80 L/m<sup>2</sup> (2 gal/ft<sup>2</sup>), up to a maximum of 1135 L (300 gal), as shown in Figure 8.3.6. The amount of liquid in the spray area shall not exceed 227 L (60 gal).

**8.4 Distribution Systems — Piping.**

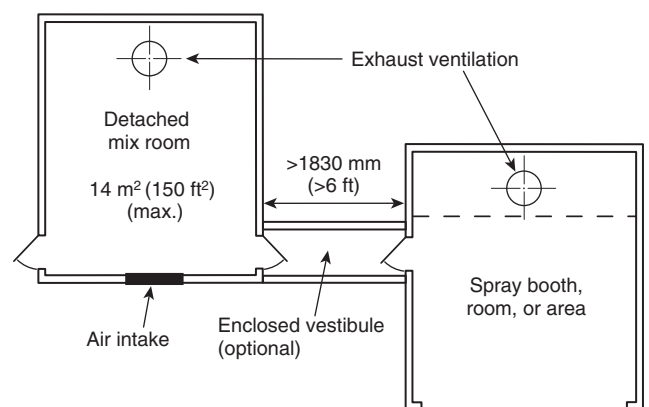
**8.4.1\*** Piping systems that convey flammable or combustible liquids between storage tanks, mixing rooms (paint kitchens), and spray areas shall be of steel or other material having comparable properties of resistance to heat and physical damage. Piping systems shall be properly bonded and grounded.

**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.



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

**FIGURE 8.3.5(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, 1362 L (360 gal)

**FIGURE 8.3.6 Mixing Room More Than 1830 mm (6 ft) from Spray Area, Including Maximum Volume of Liquid Allowed.**

**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** 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.

**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.

**8.5.5.1** Containers that meet the following requirements need not meet the requirements of the ASME *Boiler and Pressure Vessel Code*, Section VIII, for construction, tests, and maintenance:

- (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.

**8.5.6.1** If electric heaters are used to heat the liquid being sprayed, the electric heater shall be approved and listed for the specific location in which it is used. (See Chapter 6.)

**8.5.6.2** Heaters shall not be located in spray booths or other locations subject to the accumulation of deposits of combustible residue.

**8.5.7** Agitators, if used, shall be driven by compressed air, water, low-pressure steam, or electricity.

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

**8.5.8** Methods for cleaning paint circulation systems shall meet the requirements of Chapter 18 of NFPA 30.

**8.5.9** Compressed air shall be permitted to be used for cleaning paint delivery hose 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.**

**N 9.1.1** Spray areas, as defined in this standard, used for liquid spray operations and mixing rooms shall be protected with an approved automatic fire protection system. This shall apply to both manual and automated spray application processes.

**N 9.1.2** Spray areas used for powder application operations shall be in accordance with Section 15.5.

**9.1.3** 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
- (2) An automatic foam water sprinkler system that meets all applicable requirements of NFPA 16
- (3) A carbon dioxide extinguishing system that meets all applicable requirements of NFPA 12
- (4) A dry chemical extinguishing system that meets all applicable requirements of NFPA 17
- (5) A gaseous agent extinguishing system that meets all applicable requirements of NFPA 2001
- (6) A water mist fire protection system that meets the applicable requirements of NFPA 750

**9.1.4** The fire alarm and fire protection system shall be supervised in accordance with NFPA 72.

**Δ 9.2 Ventilation Systems.** Air make-up systems and spray area exhaust systems shall remain functioning during any fire condition.

**9.2.1\*** Where air exhausted from spray areas is recirculated, an interlock shall shut down the recirculation of air during any fire condition unless it can be demonstrated that shutdown creates a greater hazard.

**N 9.2.2** Air make-up systems, spray area recirculation systems, and spray area exhaust systems shall be permitted to be shut down and dampers shall be permitted to close where the automatic fire protection system type requires that ventilation be discontinued.

### **N 9.3\* Coating Material Delivery Systems.**

**N 9.3.1** 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 the event of fire.

**N 9.3.2** 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.

**N 9.4 Conveyors.** For operations where the workpiece is automatically conveyed through the spray area, activation of the

automatic fire protection system shall automatically stop any conveyors into and out of the spray area.

#### 9.5\* Automated Spray Application Operations.

**9.5.1 Interlock.** For automated 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 all spray application operations

**N 9.5.1.1** The requirements of 9.5.1 shall not apply to operations where the supply of flammable or combustible liquids is located within the spray area and does not exceed 18.9 L (5 gal).

**Δ 9.5.1.2** For automated spray application operations, the additional requirements of Section 9.9 for automated liquid electrostatic spray application equipment shall also apply.

**Δ 9.5.2 Emergency Shutdown.** For automated spray application operations, one or more manual emergency system shutdown stations shall be installed to serve each spray area in accordance with the following requirements:

- (1) When activated, the stations shall accomplish at least the functions listed in Section 9.3, Section 9.4, and 9.5.1.
- (2) At least one such station shall be within ready access of operating personnel.
- (3) If access to the station required in 9.5.2(2) is likely to involve exposure to danger, an additional station shall be located adjacent to an exit from the area.

#### 9.6\* Automatic Sprinkler Systems.

**9.6.1\*** 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.

**9.6.2** The automatic sprinkler system shall be designed as follows:

- (1) For spray application of styrene cross-link thermoset resin application areas, sprinklers shall be designed for Ordinary Hazard (Group 2) as defined in NFPA 13.
- (2) For powder coating operations, sprinklers shall be designed for Ordinary Hazard (Group 2) as defined in NFPA 13.
- (3) For all other spray areas, sprinklers shall be designed for Extra Hazard (Group 2) as defined in NFPA 13.

**9.6.2.1** The sprinkler design area shall not be required to exceed the area of the booth or room in which spraying or resin application is conducted.

**9.6.3\*** 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.

**N 9.6.3.1** Hose streams in accordance with NFPA 13 for the occupancy shall be included in the water suppression systems demands.

**9.6.4** 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 9.6.2.

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

**9.6.6\* Duct Protection.** Sprinkler systems protecting stacks or ducts with widths or diameters equal to or greater than 0.25 m (10 in.) but less than 3.7 m (12 ft) shall meet all of the following requirements:

- (1) One sprinkler shall be located at the top of each vertical riser and at the midpoint of each offset. Additional sprinklers shall be spaced on 7.3 m (24 ft) centers if the rise is greater than 7.3 m (24 ft).
- (2) Horizontal exhaust ducts shall have sprinklers located on 3.7 m (12 ft) centers beginning no more than 1.7 m (6 ft) from the duct entrance.
- (3) If exhaust ducts are manifolded, a sprinkler shall be located in the manifold at the junction of each exhaust duct with the manifold.
- (4) Sprinklers shall provide a minimum flow of 114 L/min (30 gpm) per sprinkler at a minimum of 1 bar (15 psi) pressure.
- (5) 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.
- (6)\* The system demand shall include the discharge from the hydraulically most remote adjacent sprinklers in a common 30.5 m (100 linear ft) area of duct (horizontal and/or vertical).
- (7)\* The supply line to the duct sprinklers, if taken from the ceiling sprinkler system, shall be equipped with an accessible listed control valve.

**9.6.6.1** Stacks and exhaust ducts shall be provided with access openings for inspection and maintenance of sprinklers.

**9.6.6.2** 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.

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

**9.6.7.1** 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.

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

**9.7\* 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.

**9.8 Portable Fire Extinguishers.** Portable fire extinguishers shall be provided and located in accordance with NFPA 10.

#### 9.9\* Protection for Automated Liquid Electrostatic Spray Application Equipment.

**9.9.1** 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*. 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 9.5.1
- (2) Disconnect power to the high-voltage elements in the spray area and de-energize the system

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

- (1) In addition to meeting the requirements in 9.9.1, 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<sup>2</sup>)
  - (b) A carbon dioxide extinguishing system
  - (c) A dry chemical extinguishing system
  - (d) A gaseous agent extinguishing system
  - (e) A water mist fire protection 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 9.9.2(1) and accomplish the requirements of 9.5.1 and 9.9.1(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 9.5.1 and 9.9.1(2).

#### **9.10 Protection for Dry Particulate Scrubber.**

**9.10.1** The use of dry particulate scrubbers shall be permitted provided that both of the following conditions are met:

- (1) The virgin powder used for paint particulate scrubbing is noncombustible.
- (2) The concentration of paint solids collected and mixed in the powder scrubbing material is maintained such that the mixture remains noncombustible.

**9.10.2** The dry particulate scrubber chambers shall be protected by an approved automatic fire protection system.

**9.10.2.1** The automatic fire protection system shall be **in-stalled** in accordance with any of the protection systems described in 9.1.3.

**9.10.3** Access for inspection and cleaning of sprinklers shall be provided.

**9.10.4\*** Areas subject to buildup of overspray residues where protection is permanently obstructed shall be protected by approved fire protection systems.

**9.10.4.1** Areas subject to buildup of overspray residues shall be cleaned to minimize the fuel loading.

**9.10.5** The scrubber shall be designed to direct the flow from the fire extinguishing system to an approved location or shall be designed to contain a minimum of 20 minutes of flow.

**9.10.6** In addition to the requirements of 9.5.1, activation of the automatic fire protection system shall automatically accomplish all of the following:

- (1) Shut down the operation of the dry particulate scrubbing system.
- (2)\* Automatically stop the air recirculation.

#### **9.11 Protection for Electrostatic Precipitator Scrubber.**

**9.11.1** The use of high-voltage electrostatic precipitator type scrubbers shall be permitted provided they meet the applicable requirements on Chapter 11.

**9.11.2** High voltage electrostatic precipitators shall be protected by an approved automatic fire protection system.

**9.11.2.1\*** Activation of the fire protection system shall be by an approved automatic detection system.

**9.11.3\*** Areas subject to buildup of overspray residues where protection is permanently obstructed shall be protected by approved fire protection systems.

**9.11.3.1** Areas subject to buildup of overspray residues shall be cleaned to minimize the fuel loading.

**9.11.4** The scrubber shall be designed to direct the flow from the fire-extinguishing system to an approved location or shall be designed to contain 20 minutes of flow.

**9.11.5** In addition to the requirements of 9.5.1, activation of the automatic fire protection system shall automatically accomplish all of the following:

- (1) Meet the requirement of 11.3.8(3)
- (2) Meet the requirement of 11.3.8(4)
- (3)\* Automatically stop the air recirculation

**9.11.6** The high-voltage power supplies shall be capable of monitoring current draw and shutting down or reducing voltage to prevent the generation of an electrostatic discharge.

#### **9.12 Protection for High-Capacity Dry Paint Arrestor.**

**9.12.1** The filtration media shall be protected by an approved automatic fire protection system in accordance with 9.1.3.

**9.12.2** If the filter itself is made from combustible material, the filter shall be housed in a noncombustible enclosure.

**9.12.2.1** The enclosure housing the filters shall be closed during spraying operations.

**9.12.2.2** The enclosure shall be protected by an approved automatic fire protection system in accordance with 9.1.3.

**9.12.2.3** The filters and enclosure shall be designed so as to prevent overspray residues from accumulating on the inside of the enclosure.

**9.12.3\*** Areas subject to buildup of overspray residues where protection is permanently obstructed shall be protected by approved fire protection systems.

**9.12.4\*** In addition to the requirements of 9.5.1, activation of the automatic fire protection system shall automatically stop air recirculation.

## 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.

**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** Where 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 daily 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** Overspray collectors shall be inspected daily and clogged filters shall be discarded and replaced. Maintenance procedures shall be established to ensure that overspray collector filters are replaced before restriction to airflow is reduced below the minimum established by Section 7.2.

**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 227 L (60 gal) nominal capacity and are used to recycle Class I, Class II, or Class IIIA liquids. [30:19.6.1.1]

**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. [30:19.6.1.2]

**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*. [30:19.6.2]

**10.8.3 Solvents.** Solvent distillation units shall only be used to distill liquids for which they have been investigated and that are listed on the unit's marking or contained within the manufacturer's literature. [30:19.6.3]

**10.8.3.1** Unstable or reactive liquids or materials shall not be processed unless they have been specifically listed on the system's markings or contained within the manufacturer's literature. [30:19.6.3.1]

#### 10.8.4 Location. [30:19.6.4]

**10.8.4.1** Solvent distillation units shall be located and operated in locations in accordance with their approval or listing.

**10.8.4.2** Solvent distillation units shall not be used in basements.

**10.8.4.3** Solvent distillation units shall be located away from potential sources of ignition, as indicated on the unit's marking.

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

**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.

**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 3.3.3.3, except as provided in 11.3.1.1 or 11.3.1.2.

**11.3.1.1** Equipment that meets the requirements given in Chapter 6 shall be permitted to be located in the spray area.

**11.3.1.2** High-voltage grids, electrodes, electrostatic atomizing heads, integral power supplies, and their connections shall be permitted to be located in the spray area.

**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 cables shall be insulated and protected from mechanical damage and exposure to destructive chemicals.

**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 ( $10^6$  ohms). 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 ( $10^6$  ohms). 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 de-energize 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 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 or shall meet the requirements of 11.5.1 or 11.5.2.

**11.5.1** Spray equipment that was installed prior to December 31, 1997, shall be listed or approved.

**11.5.2** This requirement shall not apply to automatic electrostatic spray equipment protected in accordance with Sections 9.7 or 9.9.

## 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  $10^6$  ohms (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 ( $10^6$  ohms). 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  $10^6$  ohms (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.** Drying, curing, or fusing apparatus used in connection with spray application of flammable and combustible materials shall meet all applicable requirements of NFPA 86.

**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. If the temperature in the spray area is elevated for the

purpose of accelerating the drying or curing process, then the requirements of Section 13.3 shall apply.

### **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 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.

**13.3.1.3** Where 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\*** Where 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, curing, or fusing operation and 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, 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.
- (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 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 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. Track-mounted systems also shall 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.

**13.3.1.9\*** Explosion relief shall not be required for a spray booth or spray room that is alternately used for drying, curing, or fusing, if all of the following conditions exist:

- (1) The spray booth or spray room is used for batch-type spray application operations only.
- (2) The air heater is not within the recirculated air path.
- (3) The ventilation system complies with the applicable requirements of NFPA 86.

### **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. If the flash-off area is adjacent to or connected to a spray booth or spray room then the requirements of Section 13.5 shall apply.

**13.4.3** Open or enclosed, unheated flash-off areas shall be ventilated in accordance with Section 7.12.

**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 Spray Booths or Spray Rooms Adjacent to or Connected to Rooms or Equipment Used for Drying, Curing, or Fusing.**

**13.5.1** Interconnecting doors and related interlocks shall meet the requirements of NFPA 86. An interlock shall be provided to prevent spray application operations when the interconnecting doors are open.

**13.5.2\*** Where an interconnecting door is not used, a 915 mm (3 ft) minimum pressurized vestibule shall be provided for separation. This vestibule shall be ventilated in accordance with Section 7.12. Airflow into the vestibule shall be proven and interlocked so that loss of ventilation or airflow shuts down the

spray application equipment or the heating equipment. Airflow into the connected spray booth or spray room shall be capable of confining vapors and mists to the spray booth or spray room.

**13.5.3** 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).

**13.6\* Ventilation.** Fusion apparatus shall be ventilated at a rate that maintains the concentration of ignitable vapors in the area at or below 25 percent of the lower flammable limit.

**13.7 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 ANSI/UL 340, *Standard for Tests for Comparative Flammability of Liquids*
- (2) Not contain any solvent or component that has a flash point below 37.8°C (100°F)
- (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.

**14.2.1** 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.

■ **14.3.1** A limited finishing workstation shall be designed and operated in accordance with the requirements of 14.3.2 through 14.3.10.

▲ **14.3.2** A limited finishing workstation shall be designed and constructed to have all of 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 Sections 4.4 and 4.5 or that can successfully pass Test Method 2 in NFPA 701
- (3) A dedicated mechanical exhaust and filtration system
- (4)\* An approved automatic extinguishing system that meets the requirements of Chapter 9

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

**14.3.4** The limited finishing workstation shall meet all applicable requirements of Chapter 4 through Chapter 10 and Chapter 19 of this standard.

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

**14.3.6** The area inside the curtains or partitions shall be considered a Class I, Division 1; Class I, Zone 1; Class II, Division 1; or Zone 21 hazardous (classified) location, as defined by Article 500 of NFPA 70.

**14.3.6.1** A Class I, Division 2; Class I, Zone 2; Class II, Division 2; or Zone 22 hazardous (classified) location, as applicable, shall extend 915 mm (3 ft) both horizontally and vertically beyond the volume enclosed by the outside surface of the curtains or partitions as shown in Figure 14.3.6.1.

**14.3.6.2** 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.

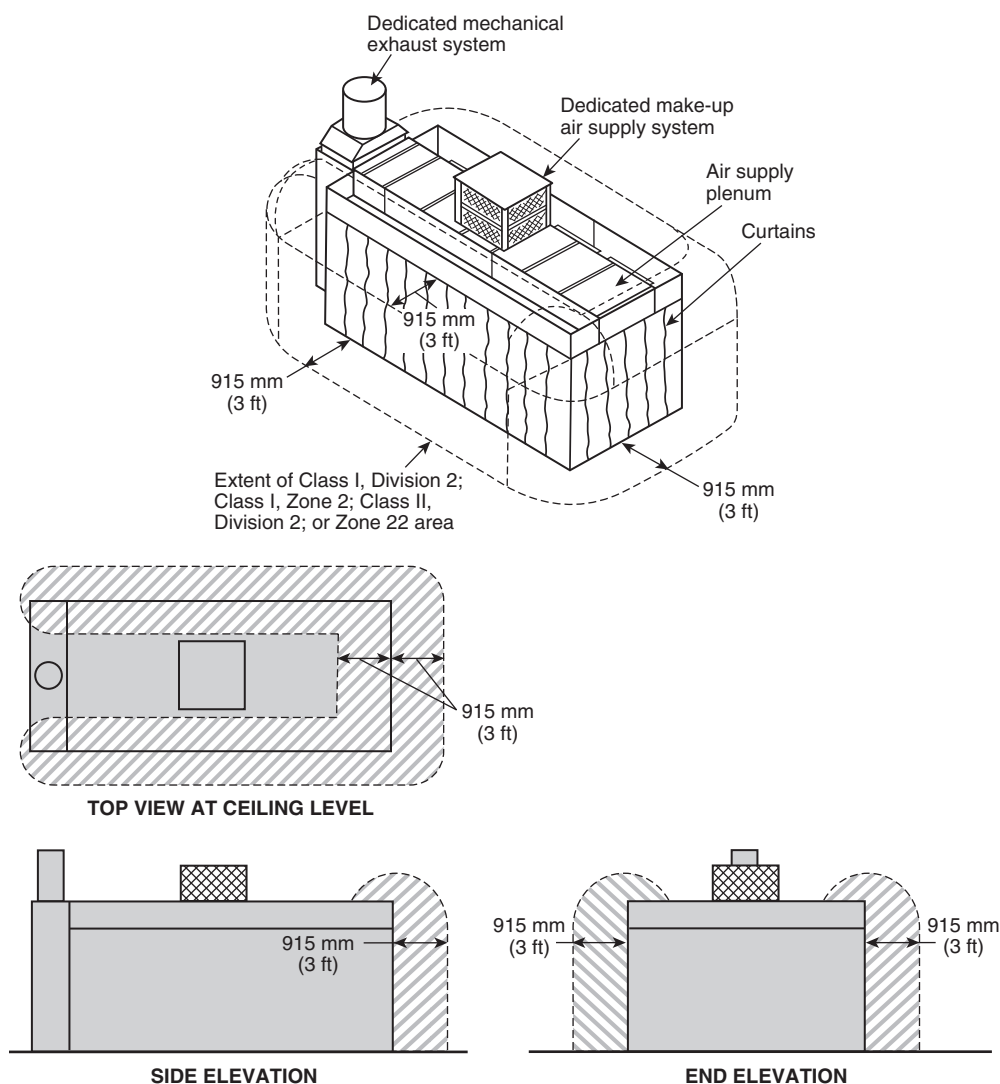
**14.3.7** Any limited finishing workstation used for spray application operations shall not be used for any operation that is capable of producing sparks or particles of hot metal or for operations that involve open flames or electrical utilization equipment capable of producing sparks or particles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

**14.3.8** 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 14.3.8.1 through 14.3.8.3.

**14.3.8.1** Where 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.

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

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



**FIGURE 14.3.6.1 Class I, Division 2; Class I, Zone 2; Class II, Division 2; or Zone 22 Locations Adjacent to a Limited Finishing Workstation.**

**14.3.9** 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.

**14.3.10** 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 15.18 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.

#### 15.5.1 General.

**15.5.1.1** Spray areas, as defined in this standard, shall be protected with an approved automatic fire protection system.

**15.5.1.2** The requirement in 15.5.1.1 shall apply to both manual and automated spray application processes.



**N 15.5.2 Protection Systems.**

**N 15.5.2.1** 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
- (2) An automatic foam water sprinkler system that meets all applicable requirements of NFPA 16
- (3) A carbon dioxide extinguishing system that meets all applicable requirements of NFPA 12
- (4) A dry chemical extinguishing system that meets all applicable requirements of NFPA 17
- (5) A gaseous agent extinguishing system that meets all applicable requirements of NFPA 2001
- (6) A water mist fire protection system that meets the applicable requirements of NFPA 750

**N 15.5.2.2** The fire alarm and fire protection system shall be supervised in accordance with *NFPA 72*.

**N 15.5.3 Automated Spray Application Operations.** For automated 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

**N 15.5.3.1 Emergency Shutdown.** For automated spray application operations, one or more manual emergency system shutdown stations shall be installed to serve each spray area in accordance with the following requirements:

- (1) When activated, the stations shall accomplish at least the functions listed in 15.5.3 and 15.5.8.1.
- (2) At least one such station shall be within ready access of operating personnel.
- (3) If access to the station required in 15.5.3.1(2) is likely to involve exposure to danger, an additional station shall be located adjacent to an exit from the area.

**N 15.5.4 Ventilation Systems.** Ventilation systems shall be shut down during any fire alarm condition.

**N 15.5.5 Automatic Sprinkler Systems.**

**N 15.5.5.1\*** 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.

**N 15.5.5.2** The automatic sprinkler system for powder coating operations shall be in accordance with the following requirements:

- (1) Sprinklers shall be designed for Ordinary Hazard (Group 2) as defined in NFPA 13.
- (2) The sprinkler design area shall not be required to exceed the area of the booth or room in which spraying is conducted.

**N 15.5.5.3** 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.

**N 15.5.5.4** Where sprinklers are installed to protect spray areas, water shall be permitted to be supplied from domestic water systems, provided the domestic supply can meet the demand for the design criteria of 15.5.5.2.

**N 15.5.5.5** The sprinkler system shall be controlled by a separate listed indicating valve(s), operable from floor level.

**N 15.5.5.6** Sprinklers shall be protected against overspray residue by either location or covering in order to operate quickly in event of fire.

**N 15.5.5.6.1** Sprinklers shall be permitted to be covered by either cellophane bags that are equal to or less than 0.08 mm (0.003 in.) thick or by thin paper bags.

**N 15.5.5.6.2** The coverings permitted in 15.5.5.6.1 shall be replaced frequently so that heavy deposits of residue do not accumulate.

**N 15.5.5.7** Sprinklers that have been painted or coated by overspray or residues shall be replaced with new sprinklers.

**N 15.5.6\* 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.

**N 15.5.7 Portable Fire Extinguishers.** Portable fire extinguishers shall be provided and located in accordance with NFPA 10.

**N 15.5.8\* Protection for Automated Powder Application Equipment.**

**N 15.5.8.1** 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*.

**N 15.5.8.1.1** The optical flame detection shall, in the 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
- (5) Disconnect power to the high-voltage elements in the spray area and de-energize the system

**N 15.5.8.2** Automated powder application equipment that is unlisted shall be further protected by the following:

- (1) In addition to meeting the requirements in 15.5.3 and 15.5.8.1, 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, and activation of this system shall automatically accomplish the requirements of 15.5.3 and 15.5.8.1.
- (3) Manual activation stations shall be installed in accordance with the following:
  - (a) At least one such station shall be within ready access of operating personnel.
  - (b) If access to the station required in 15.5.8.2(3)(a) is likely to involve exposure to danger, an additional

station shall be located adjacent to an exit from the area.

- (c) These devices shall activate the fire protection system as specified in 15.5.2 for the affected automated zone, if applicable, and accomplish the requirements in 15.5.8.1.

**N** 15.5.8.2.1 The requirements of 15.5.8.2 shall not apply to a closed-head wet pipe automatic sprinkler system.

**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 5.7, 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*, as applicable.

**15.7.2** Where the object or material being coated is preheated, 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<sup>6</sup> ohms (1 megohm). This requirement shall also apply to any personnel who enter the area.

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

#### 15.8.1 Ductwork.

**15.8.1.1\*** Where nondeposited, air-suspended powder (powder overspray) is conveyed by ductwork to a recovery system, sufficient airflow shall be provided in the ductwork to maintain the powder concentration in the ductwork at not more than 50 percent 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<sup>3</sup> (0.015 oz/ft<sup>3</sup>).

**15.8.1.2** Exhaust equipment shall bear an identification plate stating the ventilation rate for which it was designed.

**15.8.1.3** If 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 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 shall either 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 that meets the requirements of NFPA 68
- (2) A deflagration suppression system that meets the requirements of NFPA 69

**15.8.4** Ventilation for powder coating being applied via fluidized beds and electrostatic fluidized beds shall be designed to 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.

### 15.10 Operation and Maintenance.

**15.10.1\*** The area surrounding the spray area, including horizontal surfaces such as ledges, beams, pipes, hoods, and floors, shall be maintained to prevent the accumulation of powder.

**15.10.2** Surfaces outside of the spray area shall be cleaned in a manner that does not scatter powder or create dust clouds. Vacuum sweeping equipment, where used, shall be of a type approved for use in hazardous locations.

**15.10.3** The booth exhaust shall remain on during spray area cleaning operations to confine airborne combustible dust.

**15.10.4** Means shall be provided to prevent tramp metal or spark-producing material from being introduced into the powder being deposited.

**15.10.5** 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 provisions 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 Fluid 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.

**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 15.7.1.

**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 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.

**15.13.5.1** 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.

**15.14 Hot Flocking.** 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.

**15.15 Fluid Bed Coating.** 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.

#### **15.16\* Powder Coating Delivery and Circulation.**

**15.16.1\*** All bins, hoppers, and fluid beds that are actively in use in the powder application process shall be grounded and shall comply with 15.7.3 and 15.13.4.

**15.16.2\*** Bins, hoppers, and fluid beds shall be vented to prevent the accumulation of powder outside of the application process in accordance with 15.8.4.

**15.16.3** The compressed air supply shall be interlocked with the ventilation system so that the equipment cannot be operated unless ventilation is in operation.

#### **15.17\* Powder Unloading, Bag Dumping Stations, and Pneumatic Conveying Systems.**

**15.17.1** Powder unloading, bag dumping stations, and pneumatic conveying systems located in, connected to, or adjacent to the spray area shall be Class II, Division 2 as defined in 6.3.2.2 or Zone 22 as defined in 6.3.2.5.

**15.17.2** All powder unloading, bag dumping stations, and pneumatic conveying systems shall comply with Section 6.5.

**15.17.3** Housekeeping shall be maintained in accordance with 15.10.1 through 15.10.4.

#### **15.18 Screening or Sieving Operations.**

**15.18.1** When a screening or sieving operation is an in-line, integral part of the powder application equipment, it shall meet the requirements of 15.13.3.

**15.18.2** Ventilation for screening or sieving operations shall be designed to contain and prevent the accumulation of powder outside of the operation.

#### **15.19 Storage and Handling.**

**15.19.1** Containers, such as but not limited to, bags, jars, boxes, totes, bins, super-sacks, hoppers, collectors, and so on, containing powder coating material shall be permitted to be stored directly adjacent to spray areas provided that the container meets all of the following requirements:

- (1) Is not actively used in the spray process
- (2) Is covered or sealed
- (3) Is labeled with the contents
- (4) Does not interfere with equipment operation

#### **15.19.2\* Housekeeping.**

**15.19.2.1** Areas around the spray area, including horizontal surfaces such as ledges, beams, pipes, hoods, and floors, shall be cleaned to prevent accumulation of powder.

**15.19.2.2** Surfaces shall be cleaned in a manner that does not scatter powder or create dust clouds.

**15.19.2.3** Vacuum sweeping equipment, where used, shall be approved for Class II, Division 2 or Zone 22 locations.

#### **15.19.3\* Spill Clean-up.**

**15.19.3.1** All sources of ignition shall be removed from the area of a spill or accidental release of powder.

**15.19.3.2** Tools used for the clean-up shall be of a type that cannot produce a spark.

**15.19.3.3** Vacuum sweeping equipment shall be approved for Class II, Division 2 or Zone 22 locations.

**15.19.3.4\*** The use of brooms for sweeping up the powder shall be done in a way that does not scatter powder or create dust clouds.

**15.19.3.5** Disposal of the spill material shall be in accordance with local, state, and federal regulations.

**15.19.3.6\*** Compressed air, unless in a booth or vented coating area, shall not be permitted during clean-up.

**15.19.3.6.1** Compressed air lines shall be conductive and grounded.

## **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, not including styrene cross-linked composites manufacturing 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 400 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.

## 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 in accordance with Chapter 9.

**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* 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 2 or Class I, Zone 2 locations, if applicable as defined in 6.3.1.2.

**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.

**17.6.1.1** 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 buildup of overchop to be removed.

**17.7.3.1** Accumulated overchop shall be disposed of when it has reached an average thickness of 50 mm (2 in.).

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

## Chapter 18 Spray Application Operations in Membrane Enclosures

### 18.1 Scope.

**18.1.1\*** This chapter shall apply to spray application operations and processes for coating the exterior of a workpiece conducted in membrane enclosures.

**18.1.2** Spray application operations and processes within the enclosure shall only be permitted for the workpiece for which the enclosure was erected.

**18.1.2.1** Spray application operations for parts removed from the workpiece shall be conducted in accordance with applicable requirements of this standard.

**18.2 General.** Membrane enclosures shall be erected for 180 days or less.

**18.2.1\*** Enclosures erected under this chapter shall only be used for the duration of a spray operation at a fixed location which can involve multiple coats for a single workpiece.

**18.2.2** Material used for membrane enclosures shall have been tested in accordance with and passed the Test 2 requirements of NFPA 701, and testing shall have been performed by an independent test laboratory.

**18.2.3** Membrane material shall not be reused for any other spray application operations.

**18.2.4\*** Operations conducted within the enclosure other than spray applications shall meet the fire and safety requirements for those operations.

**18.2.4.1** Other operations shall not take place while the spray application operation is in progress.

**18.2.4.2** Hot work shall be in compliance with Chapter 10.

### 18.3 Location.

**18.3.1 Outside of Buildings.** The spray area shall be separated from permanent structures by a minimum of 4.6 m (15 ft) and shall not block emergency vehicle access to adjacent buildings.

**18.3.2 Inside Buildings.** Membrane enclosures for spray painting shall be permitted to be installed in buildings provided all of the requirements 18.3.2.1 of through 18.3.2.2.3 are met in addition to the applicable requirements of Chapter 18.

#### 18.3.2.1 Membrane Material.

**18.3.2.1.1\*** Other than material in a vertical plane, the membrane material shall be listed for installation beneath sprinklers and installed to meet the requirements of 8.15.15 in NFPA 13 for drop out ceilings and ceiling materials.

**18.3.2.1.2** Where a listed membrane material is used, it shall be considered a drop-out ceiling in NFPA 13 and follow the applicable requirements for those assemblies.

**18.3.2.2 Building Protection.** Buildings in which membrane enclosures are installed shall be provided with automatic sprinkler systems in accordance with Section 9.5.

**18.3.2.2.1\*** The automatic sprinkler system shall be designed for extra hazard (Group 2) occupancies as defined in NFPA 13.

**18.3.2.2.2\*** Sprinkler installations in areas using membrane materials shall comply with all design and installations rules outlined in NFPA 13.

**18.3.2.2.3\*** Buildings in which membrane enclosures are installed shall be provided with a Class III standpipe system in accordance with NFPA 14.

### 18.4 Membrane Enclosure Occupancy.

**18.4.1** During the spray process, only personnel required for the process shall be allowed inside the membrane enclosure, vessel, or workpiece.

**18.4.2** Travel distance to an exit from within a membrane enclosure shall comply with Table 40.2.6 in NFPA 101 for General Industrial Occupancies.

### 18.5 Operations and Maintenance within Membrane Enclosures.

**18.5.1** The spray area shall consist of the interior of the membrane enclosure.

**18.5.1.1** No hot work, welding, grinding, or cutting shall take place in the spray area while it is permitted for spray painting per Section 18.10.

**18.5.1.2** No vehicles, ordinary combustibles, portable buildings, or container storage shall be located in the 1.5 m (5 ft) Class I, Division 2; Class I, Zone 2 area during spray operations.

**18.5.1.3** No smoking or open flames shall be allowed in the paint spray area, including the membrane enclosure, while it is permitted for spray painting per Section 18.10.

**18.5.1.4** Hot work adjacent to designated spray painting operations in membrane enclosures shall be performed only when authorized by the competent person designated for spray painting.

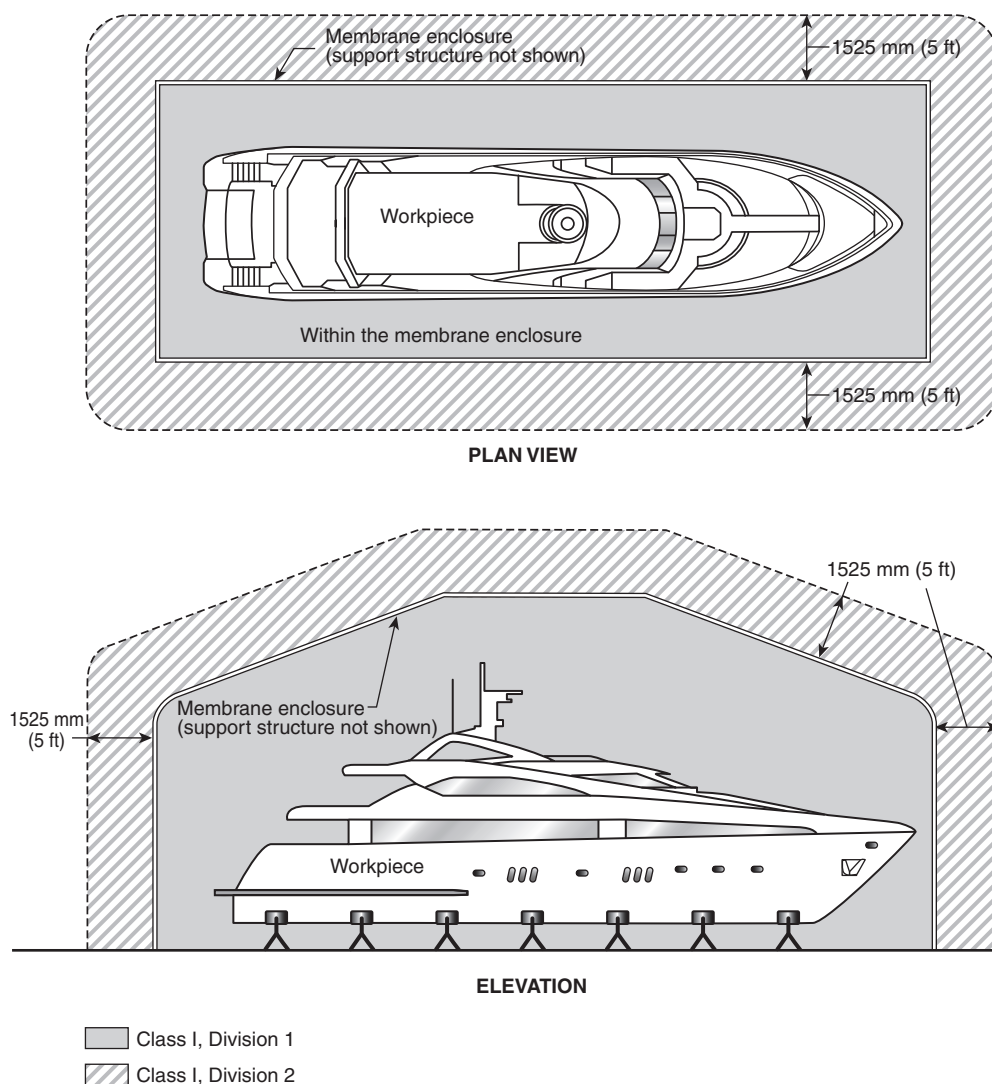
### 18.6 Electrical and Other Sources of Ignition.

**18.6.1** Electrical wiring and utilization equipment used in membrane enclosures during spray painting shall comply with Chapter 6 except as amended below.

**18.6.1.1** The spray area consists of the area within the membrane enclosure and shall be considered a Class I, Division 1 area, as shown in Figure 18.6.1.1.

**18.6.1.2** A 1.5 m (5 ft) zone outside of the membrane enclosure shall be considered Class I, Division 2, as shown in Figure 18.6.1.1.

**18.6.2** All lighting, electrical power cords, and any related equipment within the membrane enclosure shall be in accordance with 6.4.3.



▲ FIGURE 18.6.1.1 Electrical Classifications for Outdoor Membrane Enclosures.

**18.6.2.1** All lighting, electrical power cords, and any related equipment within the 1.5 m (5 ft) distance horizontally from the exterior of the membrane enclosure shall be listed for Class I Division 2 as defined by *NFPA 70* when used during spray paint operations.

**18.6.3** All power to the workpiece shall be disconnected during spray painting.

**18.6.4\*** Workpieces shall be grounded.

**18.6.5** Scaffolding shall be bonded to the workpiece and grounded to an appropriate grounding rod or other approved method consistent with 6.2.1-referenced requirements.

**18.6.6** Spray paint equipment shall be grounded.

**18.6.7** Equipment used to monitor the concentration of solvent vapors shall be calibrated for the solvents used. The calibration frequency shall be per the manufacturer's recommendations.

## 18.7 Ventilation.

**18.7.1** Each membrane enclosure shall be provided with mechanical ventilation consistent with requirements in Section 5.7 and Chapter 7, except as amended by the requirements of this chapter.

**18.7.1.1\*** The ventilation system shall be designed and installed to ensure that the enclosure is maintained at a pressure that is negative relative to the surrounding environs.

**18.7.2\*** The concentration of the vapors and mists in the exhaust stream of the ventilation system during spray operations and ambient air drying operations shall not exceed 10 percent of the lower flammable limit.

■ **18.7.2.1** Equipment used to monitor the concentration of solvent vapors shall be calibrated for the solvents used.

■ **18.7.2.2** The calibration frequency required by 18.7.2.1 shall be per the manufacturer's recommendations.

**18.7.2.3** All spray operations within the membrane enclosure shall cease operations when the concentration of the vapors and mists in the exhaust stream of the ventilation system reaches or exceeds 10 percent of the lower flammable limit.

**18.7.2.4** An interlock shall be provided so that the spray apparatus is automatically stopped if the ventilation system fails to maintain the concentration of the vapors and mists in the exhaust stream below 10 percent of the lower flammable limit.

**18.7.2.4.1** Where interlocks cannot be effectively provided for ventilation equipment that uses plant air, large air storage tanks, or equipment that cannot be instantly shut off, an audible alarm upon loss of ventilation that will alert all spray paint operators shall be permitted with authority having jurisdiction approval.

**18.7.3** Exhaust air shall be taken from one or more points within 300 mm (12 in.) of the floor of the enclosure.

**18.7.4** An adequate supply of clean make-up air shall be provided per the requirements of Section 7.3.

**18.7.5\*** The location of both the exhaust and make-up air openings shall be arranged to provide air movement throughout the enclosure and across all portions of the floor to prevent accumulation of flammable vapors.

**18.7.6** Ventilation equipment containing overspray collection filters shall follow the requirements of 7.2.1.

**18.7.7** Air exhausted from the membrane enclosure shall not be recirculated.

**18.7.8** Routing of exhaust shall comply with **Section 7.4**.

#### **18.7.9 Drying.**

**18.7.9.1** Membrane enclosures used for spray application of flammable or combustible materials shall not be used for drying, curing, or fusing operations at elevated temperature.

**18.7.9.2** Freshly sprayed workpieces shall be dried only in spaces that are ventilated to prevent the concentration of vapors from exceeding 10 percent of the lower flammable limit.

#### **18.8 Recordkeeping.**

**18.8.1** Any contractor supplying exhaust equipment for painting and coating work within membrane enclosures shall provide documentation that the equipment complies with Chapter 7 requirements.

**18.8.2** All equipment shall bear a permanent unique number or other designation to identify equipment in use.

**18.8.3** Records of approved equipment shall be kept on file for 12 months. Such records shall be in the form of a memorandum stating the equipment number, the owner of the equipment, and the leaser of the equipment, if any, and state that the owner has accepted the equipment for use at the facility.

**18.8.4** Installers shall provide NFPA 701, Test 2 documentation of the membrane material to the owner before installation.

**18.8.5** Records shall be made available to the AHJ or any inspecting authority upon request.

#### **18.9 Storage and Handling of Flammable and Combustible Liquids.**

**18.9.1 Coating Material Handling.** Flammable and combustible paints, coatings, and cleaning agents for equipment within the membrane enclosure and its 1.5 m (5 ft) Class I Division 2; Class I Zone 2 area shall not exceed 37.9 L (10 gal) total at any time.

**18.9.1.1** All mixing and storage shall be done outside the membrane enclosure area.

**18.9.1.2** When mixing and storage operations are located inside buildings, they shall be protected in accordance with Chapter 8.

#### **18.10 Facilities Compliance Permitting.**

**18.10.1\*** Permits for spray painting shall be issued for each spray paint activity on a daily basis. Paint spray permit records shall be kept for 12 months for review by the AHJ.

**18.10.2** Competent persons shall perform all spray paint permitting for membrane enclosures.

**Δ 18.10.3** Spray painting shall not be performed in any membrane enclosure until a **paint spray permit** is signed by a competent person and posted at the entrance to the enclosure *(See example in Figure A.18.10.1.)*

**18.10.4** The competent person shall have the authority to stop the spray painting operation if any equipment malfunctions, if combustible gas detection readings exceed 10 percent of LFL readings, or if any spray operations are deemed unsafe by the competent person.

**18.10.5** No spray paint operations shall take place without permitting by a competent person present at all times that spray painting is in progress.

**18.10.6** Combustible gas testing shall be performed by the competent person prior to the start of spray painting, during spray painting operations, and 10 minutes after the ventilation has been shut down.

**18.10.6.1** Equipment used to monitor the concentration of solvent vapors shall be calibrated for the solvents used. The calibration frequency shall be per the manufacturer's recommendations.

**18.10.7** The competent person shall inspect all electrical connections within the membrane enclosure as a part of permitting.

**18.10.8** The competent person shall ensure that energized electrical equipment is in compliance with the requirements in Section 18.6.

**18.10.9** The competent person shall ensure that ventilation exhaust equipment and paint spray compressors are interlocked. For spray painting within membrane enclosures, *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.

#### **18.11 Protection.**

**18.11.1** Portable fire extinguishers shall be installed, inspected, and maintained in accordance with NFPA 10.



**18.11.2** The minimum size of all extinguishers shall be 4A:80B:C.

**18.11.3** Pre-engineered extinguishing systems shall not be utilized for fire protection unless specifically listed for use in membrane enclosures.

## Chapter 19 Training

**19.1\* 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

**19.1.1** 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.

**19.1.2\*** 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.

**19.1.3** 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.

**19.1.4** 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 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.

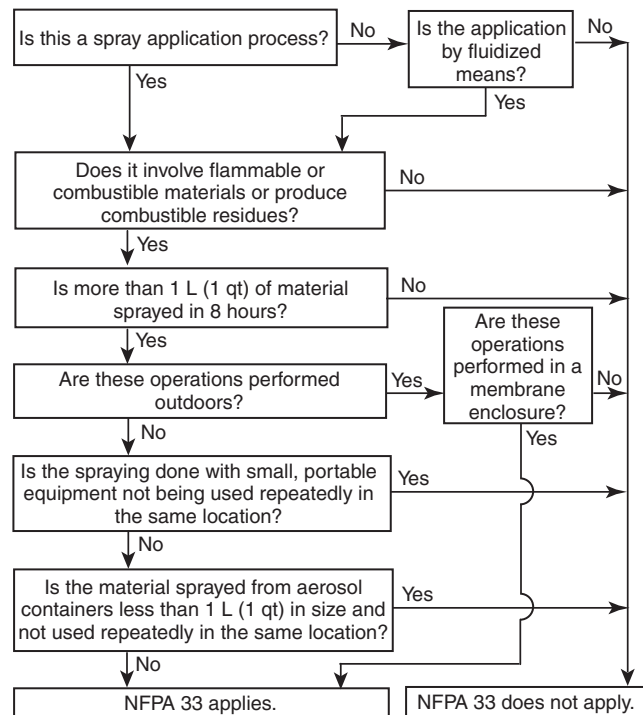
**A.1.1.1** Refer to Figure A.1.1.1 for assistance in determining whether NFPA 33 applies to a particular spray application process.

**A.1.1.4** There are many industrial applications that involve routine use of small quantities of flammable or combustible liquids (e.g., coatings, lubricants, adhesives) on a regular or periodic basis. An example would be touch-up of manufactured articles using aerosol containers or small, portable spray application equipment. The intent of this provision is to allow such use without having to comply with the requirements of NFPA 33.

**A.1.1.6** This standard does not cover spray application operations that are conducted outdoors on buildings, bridges, tanks, or similar structures. These situations occur only occasionally for any given structure and overspray deposits are not likely to present a hazardous condition. Also, the space where there might be an ignitable vapor air or dust air mixture is very limited due to atmospheric dilution.

**A.1.1.7** The occasional use of 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.



**FIGURE A.1.1.1 Decision Tree—Does NFPA 33 Apply?**

- (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 Ambient.** Most lower explosive limit (LEL) (also known as "lower flammable limit" or "LFL") values are reported at 25°C (77°F), although several are given at 100°C (212°F). The LEL value decreases at higher temperatures, so it is necessary that the LEL value for the particular solvent be corrected for the operating temperature of the spray booth or spray room when operating above 25°C (77°F). See 12.6.8.3 of NFPA 86 for calculation of the correction factor. Note that NFPA 86 uses the term *lower flammable limit (LFL)*.

**Δ A.3.3.2.3 Spray Area.** This definition identifies the areas in which vapors, residue, and combustible powders might exist, either in suspension or on surfaces, as a result of the normal operation of the equipment. The presence of these materials requires various protection measures as identified later in this standard, such as the installation of fire suppression systems.

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 areas are typically 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 recirculation particulate filters
- (4) Exhaust ducts from solvent concentrator (i.e., pollution abatement) units

Spray booth recirculation systems contain a recirculation particulate filter, or series of filters, that have a minimum removal efficiency intended to minimize the potential for particulate accumulation in downstream areas. The reduction of particulates downstream of these filters reduces the hazards that are found in spray areas.

**N A.3.3.8 Control Area.** For a typical spray paint operation, this could include a process area within which spraying, mixing, and other ancillary activities might occur.

**A.3.3.17 Recirculation Particulate Filter.** Recirculation particulate filters are intended to minimize the potential for particulate accumulation in downstream areas. The removal efficiency is based upon EPA Method 319 in 40 CFR 63, "Test Methods, Pollutant Measurement Methods from Various Waste Media, Method 319 — Determination of Filtration Efficiency for Paint Overspray Arrestors." This test method is the basis for the filters typically found in current recirculation spray booths.

**A.3.3.18 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.3.3.19 Spray Room.** The entire spray room is considered part of the spray area. A spray booth is not a spray room.

**N A.3.3.21.1 Limited Finishing Workstation.** A limited finishing workstation is a power-ventilated apparatus that meets all the requirements found in Section 14.3 of this standard but does not meet the requirements of a spray booth or spray room as herein defined.

**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. 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.

**A.4.1.1** The use of proper cutoff between hazards and exposures depends on many factors. Where the exposure hazard is high or severe, the authority having jurisdiction might require protection beyond the indicated 2-hour fire resistance rating.

**A.4.2** Spray application operations that incorporate assembly lines or conveyor systems present special problems. If conveyor systems extend between separate buildings, a sprinklered, noncombustible, connecting passageway is advisable. 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 should be provided with automatic high-velocity spray nozzles arranged to create a counterdraft. If conveyor systems pass through fire walls or fire barrier walls, it is most desirable to provide a short gap in the conveyor to allow automatic fire doors to close. Interlocks might be necessary to stop conveyors moving toward the fire walls and clear the conveyors moving away from the fire walls in order to prevent fire doors from dropping on conveyed materials and thereby preventing complete closure. Another option is to provide a noncombustible or limited-combustible, sprinkler-protected tunnel on both sides of the opening.

Rooms that house spray application operations should be separated from other occupancies or operations by construction that meets the requirements of Chapter 5 of this standard.

In sprinklered buildings where spray application operations occupy one portion of an open area, the spray application operations should be surrounded by noncombustible or limited-combustible draft curtains extending downward at least 460 mm (18 in.) from the ceiling, but deeper if practical. The draft curtains aid in preventing the activation of sprinklers outside the area enclosed by the curtains and tend to confine the discharge of water to the immediate area of the fire. Additional consideration might be given to the use of heat and smoke vents to aid in fire control.

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

**N A.4.3** Processes involving flammable or combustible liquids should not be located in any basement area for the following reasons:

- (1) Lack of egress
- (2) Lack of access by emergency response personnel
- (3) The possibility for extensive structural damage should an explosion occur because of accumulations of vapors

Note that other requirements, such as NFPA 30's prohibition of Class I liquids in basements, are still applicable. The require-

ments of Section 4.3 are not intended to override or reduce any stricter code requirements as adopted by the authorities having jurisdiction.

The walls and doors of the booth or spray area can impact the existing egress paths in any building area, particularly a basement level or upper story where egress pathways are limited. Subsection 5.1.4 references the egress requirements in Chapter 40 of NFPA 101. Because spray operations present a higher hazard than is typical in most nonindustrial areas, this is a minimal standard approach.

A means of access for emergency response personnel is required for search and rescue efforts. It is also required for manual fire-fighting efforts to control and extinguish a fire. The large variety of equipment and types of coating operations in existence increase the likelihood of fires in concealed spaces or flash fires involving a large area within the occupied floor. These can be especially difficult to address in belowgrade areas.

In some cases, emergency response access can be provided by grade level access to areas that are partly below grade (*see 3.3.4, Basement*).

**N A.4.4.1(1)** Examples of such materials include steel, concrete, masonry, and glass.

**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 3.3.2.3, 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.5.5** 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 ignitable gases or vapors are always present or likely to be present (Division 1) or whether ignitable 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 ignitable 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 in 1996.

**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 luminaires, and power tools. In powder coating applications, the temperature of the object or material being coated should be maintained at least 28°C (50°F) below the autoignition temperature of the powder.



**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 luminaires, 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*.

**A.6.3.1.1** This classification usually includes the following locations:

- (1) Where volatile flammable liquids or liquified flammable gases 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 ignitable concentrations of flammable vapors or gases are likely to occur in the course of normal operations

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

- (1) The inside of inadequately vented enclosures containing instruments normally venting flammable gases or vapors to the interior of the enclosure
- (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 ignitable concentrations of vapors

**A.6.3.1.2** This classification usually includes locations where volatile flammable liquids or flammable gases or 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) Informational Note No. 1]

Piping without valves, checks, meters, and similar devices would not ordinarily introduce a hazardous condition even though used for flammable liquids or gases. Depending on factors such as the quantity and size of the containers and ventilation, locations used for the storage of flammable liquids or liquefied or compressed gases in sealed containers may be considered either hazardous (classified) or unclassified locations. See *NFPA 30*. [70:500.5(B)(2) Informational Note 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 ignitable 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) Informational Note 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.

**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 shut-down (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) Informational Note 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 ignitable concentrations of flammable vapors or gases are likely to occur in the course of normal operation but not classified Zone 0.

**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) Informational Note]

**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) Informational Note No. 1]

Where products such as seed 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) Informational Note No. 2]

**A.6.3.2.3** As a guide to classification of Zone 20 locations, refer to ISA 60079-10-2, *Explosive Atmospheres — Part 10-2: Classification of areas — Combustible dust atmospheres*. [70:506.5(B)(1) Informational Note No. 1]

Zone 20 classification includes locations inside dust containment systems; hoppers, silos, etc., cyclones and filters, dust transport systems, except some parts of belt and chain conveyors, etc.; blenders, mills, dryers, bagging equipment, etc. [70:506.5(B)(1) Informational Note 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 contain-



ment 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. [70:506.5(B)(2) Informational Note No. 2]

See also A.6.3.2.3.

- ▲ **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 **unclassified**. [70:506.5(B)(3) Informational Note 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. [70:506.5(B)(3) Informational Note No. 3]

See also A.6.3.2.3.

- ▲ **A.6.4.3** Equipment that is both listed for accumulation of deposits of combustible residues and listed for Class I, Division 1; Class I, Zone 1; Class II, Division 1; or Zone 21 locations can be installed in the spray area. (See NFPA 70.)

**A.6.5.4(2)** Access doors into a spray area that must be closed to allow normal automated spray application operations to occur should not be considered an opening. The door should be considered a maintenance access and never open while a hazardous condition exists in the booth. Therefore, the area outside the door/maintenance access should be considered **unclassified**.

- **A.6.5.5** Supply containers include paint pressure pots, paint pressure tanks, and any container with attached pumping equipment.

**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 for additional information.

**A.7.2.1** Acceptable means to comply with 7.2.1 include, but are not limited to, visible gauges, audible alarms, approved interlocks, or an effective inspection program.

**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, if inhaled, are kept to levels that are safe for operating personnel

**A.7.5** If air exhausted from the spray area is permitted to be recirculated, as provided for in Section 7.5, it is critical for effective monitoring that sensors be protected from obstruction and contamination. See *NFPA 72* for recommended maintenance and calibration procedures.

**A.7.5(6)** 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 *AIHA/ASSE Z9.7, Recirculation of Air from Industrial Process Exhaust Systems*.

**A.7.7** 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.7.8** 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*.)

**A.7.9** 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 *ANSI/SMACNA 002, Rectangular Industrial Duct Construction Standards*, published by the Sheet Metal and Air Conditioning Contractors National Association.

**A.7.12** If there are other operations that give off ignitable 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 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.

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.8.5.2** NFPA 77 provides information on static protection.

**Δ 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.

Depending on the level of filtration, residues could accumulate in the exhaust ductwork. Because the ductwork is part of the spray area, it must be protected in accordance with Chapter 9. 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. Additionally, the most commonly used solvent concentrators use activated carbon as the adsorption medium. This medium 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.9.6). However, consideration must be given to how much water is likely to flow and 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.

**NA.9.2.1** During a fire condition, an interlock should shut down the recirculation air so as not to return smoke to the spray booth or spray room. The air make-up system and exhaust system should remain in operation.

**NA.9.3** The severity and extent of fires in spray application operations have substantially increased when rubber or plastic supply hose were burned off, resulting in the addition of the entire contents of the supply system to the fire. By limiting the amount of fuel available, the magnitude of the fire can be held to more manageable limits. The shutoff should be accomplished by means of an interlock with a fire detection system or the automatic fire extinguishing system for the spray area. This shutoff is normally accomplished by shutting the distribution pumps. In some cases, it is also advisable to limit the flow from the solvent piping system. This can be accomplished with properly specified check valves in the pipe “drops.”

**NA.9.5** This section applies to unmanned operations such as application equipment attached to a mechanical support or manipulator, including robotic devices. This section does not apply to devices that are held or manipulated by a person.

**A.9.6** 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 sprinklers 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 drain-

age 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 sprinklers 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 sprinklers are in the direct path of spray, even one day's operation can result in deposits on the sprinklers 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 9.3 m<sup>2</sup> (100 ft<sup>2</sup>).

All sprinkler systems in spray areas should be controlled by an accessible indicating control 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.9.6.1** Subsection 9.6.1 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, downdraft, 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.

Precision 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 precision system.



**A.9.6.3** Determining the water supply requirements for a paint spray application system requires identification of the credible fire scenario that results in the greatest water demand. In small booths, this is typically a combination of the sprinklers within the booth and those in the exhaust plenum and stack.

Large or complex paint spray systems can include some of the following features that require careful evaluation in determining the total system water demand in the event of a fire:

- (1) *Multiple (primary and secondary) fire protection systems.* A common example is a wet pipe system combined with a deluge or water mist system. These systems can operate simultaneously, and this possibility should be evaluated to ensure that the water supply is adequate.
- (2) *Large booths with multiple protection zones.* The fire scenario determining the required water supply needs to take into account the likelihood of involving more than one water-based fire protection system. This is especially true where optical flame detection is used to activate deluge systems. Consider the following:
  - (a) If optical flame detection can “view” a fire in adjacent zone
  - (b) Proximity of two zones
  - (c) Airflow between zones transporting hot gases to adjacent zone
- (3) *Recirculating or interconnected exhaust systems.* In simple exhaust systems, a developing fire tends to follow the airflow from the source to the exhaust point. However, in recirculating or interconnected systems, the possibility exists that airflow will also draw the fire into adjacent systems.
- (4) *Multiple exhaust plenum areas.* Supply plenums are usually devoid of paint or coating residue and cannot be expected to be part of a single fire scenario involving a spray booth or area. Exhaust plenums, including water wash/eliminator sections in downdraft booths, can contain a build-up of combustible residue and the airflow naturally draws a fire from the booth into the plenum and then on to the exhaust system. As in the multiple spray zone example, it is possible that more than one exhaust plenum could become involved.
- (5) *Concealed spaces.* In some booths, external or internal enclosures are provided for the purposes of paint and solvent supply, mixing, and recirculation. These enclosures are often protected by wet pipe sprinkler systems independent of the primary booth protection systems. Their operation might or might not be likely during a booth fire depending on the fire separation of these systems from the spray area.

Building areas outside of the spray area or paint booth are not included in the demand calculation, as the fire suppression systems and booth/spray area construction are intended to contain a fire until manual fire-fighting efforts can achieve final fire extinguishment.

Figure A.9.6.3(a) and Figure A.9.6.3(b) show two examples of demand calculation worksheets to demonstrate how both simple and complex systems can be evaluated. Note that the accuracy of the decisions made in determining the water supply demand depends on the expertise of the evaluator.

Spray Area/Spray Booth Water Demand Calculation Worksheet	
	Flow
<b>Total Demand:</b>	695 gpm
1. Spray area demand*	
a. 1st Zone:	
b. 2nd Zone:	
c. Sprinkler system:	130 gpm
2. Exhaust system demand	65 gpm
3. Eliminator/scrubber	
4. Hose stream	500 gpm

Assumptions:

- (1) Small booth with straight airflow path into the booth through filter to plenum and then through stack (direct to atmosphere).
- (2) Demands for booth and exhaust (stack) sprinklers are totaled (assumes all sprinklers operate).

**▲ FIGURE A.9.6.3(a) Spray Area/Spray Booth Water Demand Calculation Worksheet for a Simple Booth.**

Spray Area/Spray Booth Water Demand Calculation Worksheet			
		Flow	PSI
<b>Total Demand:</b>		1,974 gpm	103 psi
1. Spray area demand			
a. 1st Zone:		488 gpm	96 psi
b. 2nd Zone:		605 gpm	103 psi
c. Sprinkler system:			
2. Exhaust system demand			
a. Path 1		360 gpm	75 psi
b. Path 2			
c. Path 3			
3. Eliminator/scrubber		521 gpm	88 psi

Assumptions:

- (1) Deluge systems in two zones operate because optical flame detectors are not sufficiently isolated from adjacent zones.
- (2) Ceiling closed-head (wet) system does not operate because deluge systems are effective in controlling the fire and cooling the spray area.
- (3) Exhaust demand is based upon all heads operating along the airflow path from the fire origin to the termination of the exhaust stack.

**▲ FIGURE A.9.6.3(b) Spray Area/Spray Booth Water Demand Calculation Worksheet for a Complex System.**



**A.9.6.6** 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 can spread to the spray booth and that fires starting in the booth can 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. Nonfreeze or dry-type sprinkler systems can be used in ducts subject to freezing. For some industries, such as the automotive industry, manually operated open-head systems have proved to be effective protection for ducts and stacks.

Ductwork in powder coating applications does not require fire protection. Based on design duct velocity, there is no accumulation of residual powder.

- N A.9.6.6(6)** Consideration should be given to duct areas resulting in the highest sprinkler discharge demand. This might actually include multiple paths of ducts, provided the total length of the ducts considered does not exceed 30.5 m (100 linear ft) and all subsections of ducts are interconnected.

While a developing fire might follow the direction of airflow and vertical rise in the ducts, it should not be assumed that a fire will only occur while the system is operating. Operations such as cutting and welding can result in ignition of residues inside the duct while equipment is idle.

It is not anticipated that both the building ceiling and spray area systems will operate simultaneously if installed in accordance with both this standard and NFPA 13, so a total demand including both building ceiling and spray area systems is not required by this section.

- N A.9.6.6(7)** Minimal hose streams might be needed to effect final extinguishment if the fire is limited to inside the stack alone. To determine water supply requirements, see 9.6.3 and A.9.6.3 for guidance.

**A.9.7** 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 or 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.9.9** 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.9.10.4** Exposed areas downstream of a work piece and upstream of a dry filtration system are susceptible to build-up of paint overspray. These areas include, but are not limited to sheet metal shrouding around filter elements, guide plates that direct air flow into the dry filtration system, and maintenance walkways. Commonly, removable coatings such as plastic sheeting, foils, or greases are applied over these exposed areas to facilitate cleaning of the overspray build-up. As these coatings are intended to be removed at discrete intervals, a finite amount of overspray build-up will be present in these exposed areas during normal booth operation, requiring the need for fire protection over these areas. Depending upon the design of the dry filtration system, some or all portions of these exposed

areas can be adequately protected by the main spray booth fire suppression system. In some cases, permanent design features of the dry filtration system, such as sheet metal air guide plates, baffles, or filter shrouds, obstruct the main spray booth fire suppression system from adequately protecting all exposed areas. In these cases, additional fire protection is needed to ensure all exposed areas are adequately protected.

**A.9.10.6(2)** When recirculation is stopped, ventilation might need to be diverted to atmosphere to maintain ventilation in accordance with Section 9.2.

**A.9.11.2.1** A fire detection system might be but does not have to be of the smoke, air aspirating, heat, or flame detection type or a combination of them. Special consideration should be given for the location of the detection units as residue built up can block the sensing elements or reduce their sensitivity. Periodic cleaning should be performed.

**A.9.11.3** See A.9.10.4.

**A.9.11.5(3)** When recirculation is stopped, ventilation might need to be diverted to atmosphere to maintain ventilation in accordance with Section 9.2.

**A.9.12.3** See A.9.10.4.

**A.9.12.4** When recirculation is stopped, ventilation might need to be diverted to atmosphere to maintain ventilation in accordance with Section 9.2.

**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 buildup 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 buildup) 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 for information on bonding and grounding.

**A.10.7.4** See NFPA 77 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 finishing materials 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 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.*)

**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.

**Δ A.11.3.8** A 2-second time requirement is listed in Section 6.2.2 of FM 7260, *Electrostatic Finishing Equipment*, and in BS EN 50050-1, *Electrostatic hand-held spraying equipment — Safety requirements — Part 1: Hand-held spraying equipment for ignitable liquid coating materials*; BS EN 50050-2, *Electrostatic hand-held spraying equipment — Safety requirements — Part 2: Hand-held spraying equipment for ignitable coating powder*; and BS EN 50050-3, *Electrostatic hand-held spraying equipment — Safety requirements — Part 3: Hand-held spraying equipment for ignitable flock*.

**A.11.4.2** Safe painting distance and the speed of de-energizing can be verified by Section 6.3 of FM 7260, *Electrostatic Finishing Equipment*.

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

**A.13.3** Where 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. 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.13.3.1.3.2** In some applications, the heating equipment used to maintain the air temperature for spraying operations is the same equipment used to elevate the air temperature for curing. In these situations, it might not be practical to completely turn off the heating equipment. In the event entry is made, the heating equipment should revert to the operating parameters used for spraying operations. The system should require a manual reset to return to the drying, curing, or fusing cycle.

**A.13.3.1.9** Where using the spray booth or spray room for drying, curing, or fusing at temperatures above 25°C (77°F), the ventilation specified in Chapter 7 of this standard must be corrected for temperature to ensure that the concentration of vapor in the exhaust air stream is maintained below 25 percent of the lower flammable limit (LFL). See Annex D of NFPA 86 for an explanation of the effects of temperature on the lower limit of flammability.

**A.13.5.2** It is often not possible to install doors in systems which utilize conveyors to move the workpiece. Vestibule length is based upon 6.5.2 and would be equal to the separation that would be required between the two pieces of equipment if there was no connecting vestibule.

**A.13.6** 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.14.3.2(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 "Recom-

mendations for Protection of Curtained Limited Finishing Workstations."

**A.14.3.8.2** 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 use of 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
- (5) Hot flocking

**N A.15.5** Liquid and powder coating operations have different needs when it comes to fire protection. Therefore, for better understanding, fire protection requirements for powder coating operations have been removed from Chapter 9 and incorporated into Chapter 15.

**N A.15.5.5.1** Building areas outside of the spray area or paint booth are not included in the demand calculation, as the fire suppression systems and booth/spray area construction are intended to contain a fire until manual fire-fighting efforts can achieve complete fire extinguishment.

**N A.15.5.6** 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 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.

**N A.15.5.8** 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 (i.e., 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 (e.g., flickering of flames), 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 9.9 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.15.5.8(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.

**A.15.7.3** 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.

All electrically conductive parts and machinery in the spray area are to be grounded. The resistance to ground must not be more than 1 megohm ( $10^6$  ohms). It is recommended that the resistance be tested regularly. All object hangers and load bars are to be kept clean in order to ensure good grounding of the object or material being coated. In addition, all electrically conductive devices such as the powder coating spray booth, powder coating apparatus, powder applicator mounting and moving devices, powder containers, feed hoppers, powder feed

pumps, powder reclaim devices, and so forth are to be properly grounded. The floor in the coating area should be electrically conductive, and operating personnel should wear static dissipative footwear. The operating personnel should hold handheld electrostatic powder spraying equipment in the bare hand. If gloves are worn, the glove should be electrically conductive. There is the potential of shock for ungrounded operating personnel due to static charge buildup from the electrostatic charging process. When static-charged operating personnel comes in contact with a ground source, the discharge (shock) can be quite uncomfortable for the personnel. See NFPA 77 for information on bonding and grounding.

**■ A.15.8** Ductwork in powder coating applications does not require fire protection. Based on design duct velocity, there is no accumulation of residual powder.

**A.15.8.1.1** Where an explosion suppression system is used, refer to NFPA 69.

**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 for information on the design of the deflagration vents.

**A.15.9.2** See NFPA 654 for nonmetallic powders (less than 10 percent metal powder contents) and NFPA 484 for metallic powders.

**A.15.10.1** If the surrounding area of a powder process has dust accumulations on surface areas outside of the process, action should be taken to properly clean up these accumulations. Action should also be taken to find out why these accumulations are happening and eliminate the accumulation on surfaces outside of the process. An example of a problem that would cause dust accumulations outside the spray booth would be pin holes in powder feed hoses or hoses with loose clamps.

**▲ A.15.16** Powder is supplied to the spray applicator in various ways. Powder can be supplied to a system from such containers as fluidized hoppers, booth collector fluidized beds, and vibratory box feeders. Hoppers are fluidized to enable the powder to be pumped out more efficiently. They can be various shapes and sizes. Some systems feed powder to the applicators by pumping powder from a fluidized bed in the bottom of the collector. Powder can be fed from the boxes it is shipped in. When this is done the box is normally on a vibrating base which aids in making the powder loose to help in pumping powder from the box. These boxes are normally 11.3 kg (25 lb) or 22.7 kg (50 lb).

**A.15.16.1** Containers, lids, pumps, and access doors made of conductive material should be grounded. Fluidized beds and hoppers are normally made of steel. These are to be grounded to remove ignition sources. These ground connections should be inspected on a regular basis.

**A.15.16.2** Equipment supplying powder to the spray applicators should be maintained and operated in a manner that minimizes the escape of dust particles. Lids and access doors used in fluidized beds, hoppers, and drum containers are designed to prevent dust leaks. Because of the fluidizing process, hoppers are operated under a very small positive pressure. This pressure should be vented to a dust collection system to minimize the escape of dust particles. Hoppers are normally vented to the dust collector of the spray system booth, a dedicated booth, or a shared common after filter. This removes the dust cloud formed above the fluidized powder in the container,



which if not removed could be an ignitable mixture. However, as long as the hoppers and pumps are grounded there should be no source of ignition.

**▲ A.15.17** Powder unloading, bag dumping stations, and pneumatic conveying systems are used to transport fresh powder to the powder delivery container in the powder application process. Powder can be transported from the boxes it is shipped in, which are normally 11.3 kg (25 lb), 22.7 kg (50 lb), or (682 kg (1500 lb)). The box is normally on a vibrating base, which aides in making the powder loose to help in pumping powder from the box. Drum unloaders are normally used for high volume pumping. These drums are normally made of fiber and contain 100 lb to 300 lb of powder that is in a plastic bag, or the drums are lined with polyethylene. These drums are held in a support frame, normally mobile, and vibrated when powder is pumped from them. Large sacks can be used to feed powder in bulk to systems using high volumes of one type of powder. These can be gravity fed or have vibrators near the bottom to aid in pumping of the powder. Vibratory motors used in box, drum, or sack fed systems can be pneumatic or electrically operated. If electrically conductive, all components are to be grounded. If electrically operated, motors should be rated for a Class II, Division 2 or Zone 22 location.

FIBCs used in areas containing combustible powders with a MIE greater than 3 mJ should be Type B, C, or D. If the MIE of the handled powder is 3 mJ or less, or if the powder is conductive ( $p_v < 1$  megohm-m), Type C or D FIBCs should be used. See NFPA 77.

**A.15.19.2** Housekeeping of the powder coating area is important to maintain a clean, safe work environment. Regular cleaning of walls, floors, and horizontal surfaces such as ducts, pipes, ledges, beams, and equipment should be put in place to minimize powder and dust accumulations. Reducing additional dust accumulations is a major factor in reducing the hazard in areas where a dust hazard exists. See NFPA 654, Annex D for information on dust layer characterizations and precautions.

**A.15.19.3** Avoid spills by using proper powder handling equipment and techniques where spills might occur. Powder hoppers and containers should be properly sized with adequate opening sizes for powder transfer and inspection. Powder hoses should be inspected periodically to insure integrity, and they are securely connected and are not plugged to avoid pressure buildup in the hose. When a spill occurs, it is important to clean it up immediately using the proper cleaning tools. Refer to the coating manufacturers' MSDS.

**A.15.19.3.4** The use of "sweeping compounds" to minimize dust clouds is recommended. Sweeping compound is a dust control absorbent and deodorizer for collecting and keeping dust and dirt down while sweeping.

**A.15.19.3.6** Compressed air hoses are equipped with pressure relief nozzles limiting the discharge gauge pressure to 30 psi (270 kPa) in accordance with the OSHA requirements in 29 CFR 1910.242(b), "Hand and Portable Power Tools and Equipment, General." Refer to 8.2.2.4 of NFPA 654.

**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 concentrations 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 400 classifies these materials using a five-tiered system, depending on their relative hazard as packaged for shipment. Thus, NFPA 400 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 they might not be compatible. Storage quantity limitations and fire protection requirements are contained in NFPA 400.
- (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 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 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<sup>2</sup> (1 ft<sup>2</sup>) 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 the following 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. The LFL concentration for styrene is 11,000 ppm. Twenty-five percent of the LFL is 2,750 ppm.

**A.17.5.3** NFPA 77 contains information on static electricity.

**A.18.1.1** The intent of establishing requirements for membrane enclosures is to reduce the potential of fire associated with spray operations. Membrane enclosures are intended for use with large workpieces that cannot be moved into a spray booth and where open spraying is not practical due to proximity to other operations, finish quality, or concerns regarding the collection of overspray.

Enclosing spray operations, even outdoors, creates potential fire hazards not found with open spraying of large or stationary objects such as buildings, bridges, tanks, marine vessels, or similar structures. Once the spray operation is enclosed, issues such as ventilation rate, solvent concentration, electrical area classification, materials of construction of the temporary enclosure, and fire protection should be considered.

Membrane enclosure operations are limited to the exterior of the workpiece. Spray application operations and processes conducted within the interior of a workpiece can involve confined space operations. An example would be painting the interior of a marine vessel, which would not be covered by this standard. Guidance for other types of operations involving confined spaces can be found in the applicable OSHA standards or guidelines.

**A.18.2.1** The repeated use of a temporary membrane enclosure where the item being painted is removed and another is placed in the enclosure is not allowed by this chapter's requirements. This is to say that the equipment or vessel being painted within a membrane enclosure can be painted in stages to include prime and finish painting as well as painting of areas or sections of the equipment or vessel.

**A.18.2.4** Membrane enclosures, once erected, might enclose other tasks such as sanding, masking, or other work done in preparation for painting. These tasks occur when spray application operations are not in progress.

- ▲ **A.18.3.2.1.1** There are membrane materials that have been investigated as a ceiling material in accordance with UL 723S, *Outline of Investigation for Drop-Out Ceilings Installed Beneath Automatic Sprinklers*, or as FM 4651, *Plastic Suspended Ceiling Panels*. Such membrane materials are designed such that the activation of the sprinkler and the ability of the sprinkler discharge to reach the hazard being protected are not adversely impacted.

While the drop-out ceiling provisions in NFPA 13 do not reference membrane materials, the listing requirement in 18.3.2.1.1 is the same criteria that is used to list drop-out ceilings. As such, the same restrictions and applications that apply to drop-out ceilings should apply to membrane materials.

- **A.18.3.2.2.1** This design criteria has been selected for spray operations. If the workpiece has other operations performed, then the protection selected should also be based upon the applicable NFPA standard.

**A.18.3.2.2.2** While Section 9.6 requires compliance with NFPA 13, this paragraph reinforces the need to meet the design and installation requirements of NFPA 13. For example, if the scaffolding creates an obstruction as defined by NFPA 13, the obstruction rules of NFPA 13 apply.

**A.18.3.2.2.3** When approved by the authority having jurisdiction, yard hydrants can be considered an alternative to the hose connection for fire department use, and a Class II system can be provided.

**A.18.6.4** Grounding by vessel shore power cords neutral ground, independently outside by attachment of a rod driven into the ground or any other appropriate method consistent with 6.2.1 referenced requirements.

**A.18.7.1.1** Any leaks in the exterior surface of the membrane enclosure should not be capable of discharging flammable vapors into areas not designed or intended for hazardous atmospheres. A system operating at positive pressure is not allowed because it could result in unanticipated releases of flammable vapors in the event that the membrane is torn or cut.

**A.18.7.2** Ten percent of the lower flammable limit (LFL) is required as the upper allowable limit in the exhaust stream for the following reasons:

- (1) Due to the unique nature of membrane enclosures, the total volume could be much greater than the volume in which spray operations take place (unlike a typical spray booth). This can result in much lower concentrations in the exhaust stream even when higher concentrations exist in the work area. A set point of 10 percent provides for a greater margin of error where these conditions exist.
- (2) Section 7.2, Ventilation, requires that spray booths in commercial or industrial applications be engineered to ensure adequate airflow to prevent the spray area from exceeding 25 percent of the LFL. Membrane enclosures, however, might not be subject to the same rigorous application of engineering analysis and design. Accordingly, a lower threshold of 10 percent in the exhaust stream is appropriate.

In all cases, the end user is cautioned that any potential to reach a concentration approaching 100 percent LFL within the enclosure, except at the point of spray application, can result in an explosion hazard.

**A.18.7.5** In order to ensure the ventilation system is operating and functioning properly, the following performance characteristics are critical and should either be monitored directly or proven by a combination of design characteristics and related interlocks:

- (1) The enclosure should be maintained at a pressure that is negative in relation to the surrounding environs.
- (2) The airflow at exhaust pickups should be sufficient to capture overspray and flammable vapors in via entrainment.
- (3) The airflow at the ground level throughout the enclosure should be sufficient to entrain all vapors and “sweep” them toward the nearest exhaust pickup.

**A.18.10.1** Figure A.18.10.1 provides an example of the type of information that should be included in the paint spray compliance permit.

**A.19.1** 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, house-keeping, and maintenance personnel.

**A.19.1.2** 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

<b>Outdoor Membrane Enclosures Paint Spray Facility Compliance Permit</b>	
<b>Date:</b> _____	<b>Approval time:</b> _____
	<b>Work completion time:</b> _____
<b>Workpiece:</b> _____	
<b>Contractor:</b> _____	<b>Contact phone:</b> _____
<b>Paint Mfg. &amp; Coating to be applied:</b> _____	
<b>LOCATION:</b> _____	
<p><b>A NEW PERMIT IS REQUIRED DAILY</b></p> <p><b>CHECKLIST</b></p> <p>_____ All electrical used in enclosure and within 1.5 m (5 ft) of enclosures is properly rated in accordance with NFPA 33, Chapter 18.</p> <p>_____ No energized, non-classified electrical running through enclosure or 1.5 m (5 ft) safety zone.</p> <p>_____ Exhaust ventilation is operating and installed in accordance with NFPA 33, Chapter 18.</p> <p>_____ Workpiece, scaffolding, and paint spraying equipment are grounded.</p> <p>_____ Paint spraying equipment is interlocked with ventilation to shut down should ventilation not be running.</p> <p>_____ Workpiece is de-energized, locked out, or tagged.</p> <p>_____ Walk-through of paint spray site found housekeeping in order.</p> <p>_____ Debris and loose combustibles removed from enclosure.</p> <p>_____ 1.5 m (5 ft) safety zone outside enclosure clear of all equipment, containers, vehicles, AC units.</p> <p>_____ Fire extinguishers are present in paint work areas.</p> <p><b>COMPETENT PERSON:</b> _____ <b>SIGNATURE:</b> _____</p>	
<p><b>COMBUSTIBLE GAS READINGS:</b></p> <p><b>Prior to Start of Painting: Time:</b> _____ <b>LFL Reading:</b> _____ %</p> <p>Spray Painting: Time: _____ LFL Reading: _____ %      Spray Painting: Time: _____ LFL Reading: _____ %</p> <p>Spray Painting: Time: _____ LFL Reading: _____ %      Spray Painting: Time: _____ LFL Reading: _____ %</p>	
<p>© 2018 National Fire Protection Association</p> <p style="text-align: right;">NFPA 33</p>	

**▲ FIGURE A.18.10.1 Outdoor Membrane Enclosures Paint Spray Facility Compliance Permit.**



## 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 ignitable atmospheres than those using low flash point liquids, can, nevertheless, result in mists that are capable of propagating a flame in a manner similar to combustible solids in dust explosions.

Theoretical considerations can assist in hazard evaluation in some instances. For example, 3.8 L (1 gal) of the average solvent will occupy approximately  $0.7 \text{ m}^3$  ( $23 \text{ ft}^3$ ) 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  $70 \text{ m}^3$  ( $2500 \text{ ft}^3$ ) to avoid an ignitable mixture, assuming the lower limit of the flammable range of the solvent is 1 percent in air. This is a conservative number; almost all the solvents used in spray finishing have a lower flammable limit greater than 1 percent. In using such theoretical considerations, caution should be exercised to prevent erroneous conclusions. When liquids are sprayed, the area in the direct path of the spray will exceed the lower flammable limit. Vapors from most solvents are heavier than air, and small quantities of vapor can form an ignitable mixture in low, unventilated spaces in the vicinity of or even remote from the point of evaporation before they mix with the full volume of available air by natural diffusion and the mixture becomes too lean to burn. When liquid is sprayed, the rate of evaporation is greatly increased so that the lower flammable limit is quickly reached. For these reasons, a safety factor of 4 to 1 has been traditionally used and the ventilation requirement rounded off to  $75 \text{ m}^3/\text{L}$  ( $10,000 \text{ ft}^3/\text{gal}$ ) evaporated at the maximum flow rate of the spray apparatus.

Adequate mechanical ventilation throughout all areas where ignitable vapors or mists might be present is essential to prevent the formation of flammable mixtures. The volume of air movement necessary 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  $75 \text{ m}^3$  of air per liter of solvent evaporated ( $10,000 \text{ ft}^3/\text{gal}$ ) 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 make-up air 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 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<sup>3</sup> (30 oz/1000 ft<sup>3</sup>) 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.

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

$$\text{N} \quad \frac{\text{Maximum delivery}}{\text{Airflow}} = \text{Maximum concentration} \quad [\text{C.2.2.2}]$$

**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.

$$\text{N} \quad \frac{\text{Maximum concentration}}{\text{MEC}} \times 100 = \% \text{ MEC} \quad [\text{C.2.2.3}]$$

**Table C.2.2.1 Equivalent Units of Measurement**

Property Being Measured	SI Units	U.S. Customary Units
MEC	g/m <sup>3</sup>	oz/1000 ft <sup>3</sup>
Airflow	m <sup>3</sup> /hr	ft <sup>3</sup> /min
Maximum delivery	g/hr	oz/min

**Table C.2.1 Representative Test Data on Specific Powders**

Type	Sample No.	K <sub>St</sub>	P <sub>max</sub>	MEC		Auto-ignition Temperature	
		(m bar/s)	[bar (psig)]	g/m <sup>3</sup>	oz/1000 ft <sup>3</sup>	°C	°F
Epoxy	1	152	6.7	95	95	500	932
	2	194	7.5	60	60	477	891
	3	228	8.1	45	45	472	882
Polyester	1	204	8.3	75	75	458	856
	2	154	8.1	65	65	457	855
	3	70	6.5	70	70	446	835
	4*	177	8.1	65	65	452	845
	5*	148	7.6	60	60	464	867
	6*	184	8	50	50	460	860
Epoxy-Polyester	1	149	7.6	45	45	472	882
	2	101	6.5	115	115	478	892
	3	152	7.2	115	115	475	887
	4*	189	8.2	45	45	482	899

\*Powder contains less than 10 percent bonded or blended aluminum pigments.

Note: Samples supplied by AkzoNobel and tested by FM Global.

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 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 the 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 finishing materials containing nitrocellulose. 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 finishing materials containing nitrocellulose.

**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. When a system has manual guns only, no fast-acting flame detectors are required, but if the powder pattern ignites, the operator relea-

ses the trigger and the pattern quickly burns out. Total heat release is so restricted that no damage results in these types of ignitions.

Losses resulting in greater damage have occurred when the powder supply was not immediately cut off. Typically this happens from inoperable or poorly maintained fast-acting flame detectors.

**D.1.3.1** If equipment is configured to use cyclone, baghouse, or enclosed cartridge collectors connected to the spray booth by ductwork (typical tight systems) and ignition of the collector results, damage can be limited. The collectors need to be properly vented or have explosion suppression. Collector vents should be ducted to the outside. 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. Slide gates or isolation gates need to be installed between the booth and the enclosed collector. Without the use of properly operating gates in the ductwork, the pulse generated by ignition of an enclosed collector can result 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. Fires have been reported in open collector booths, but no explosions have occurred with this type of collector. Normally there is little or no damage. Cases are known in which the fire extended beyond the confines of the spray booth. In these 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 (or other form of suppression 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 13, *Standard for the Installation of Sprinkler Systems*, 2016 edition.

NFPA 30, *Flammable and Combustible Liquids Code*, 2018 edition.

NFPA 51B, *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work*, 2014 edition.

NFPA 68, *Standard on Explosion Protection by Deflagration Venting*, 2018 edition.

NFPA 69, *Standard on Explosion Prevention Systems*, 2014 edition.

NFPA 70®, *National Electrical Code®*, 2017 edition.

NFPA 72®, *National Fire Alarm and Signaling Code®*, 2016 edition.

NFPA 77, *Recommended Practice on Static Electricity*, 2014 edition.

NFPA 86, *Standard for Ovens and Furnaces*, 2015 edition.

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## **E.2 Informational References. (Reserved)**

## **E.3 References for Extracts in Informational Sections.**

*NFPA 70®*, *National Electrical Code®*, 2017 edition.

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## Sequence of Events for the Standards Development Process

Once the current edition is published, a Standard is opened for Public Input.

### Step 1 – Input Stage

- Input accepted from the public or other committees for consideration to develop the First Draft
- Technical Committee holds First Draft Meeting to revise Standard (23 weeks); Technical Committee(s) with Correlating Committee (10 weeks)
- Technical Committee ballots on First Draft (12 weeks); Technical Committee(s) with Correlating Committee (11 weeks)
- Correlating Committee First Draft Meeting (9 weeks)
- Correlating Committee ballots on First Draft (5 weeks)
- First Draft Report posted on the document information page

### Step 2 – Comment Stage

- Public Comments accepted on First Draft (10 weeks) following posting of First Draft Report
- If Standard does not receive Public Comments and the Technical Committee chooses not to hold a Second Draft meeting, the Standard becomes a Consent Standard and is sent directly to the Standards Council for issuance (see Step 4) or
- Technical Committee holds Second Draft Meeting (21 weeks); Technical Committee(s) with Correlating Committee (7 weeks)
- Technical Committee ballots on Second Draft (11 weeks); Technical Committee(s) with Correlating Committee (10 weeks)
- Correlating Committee Second Draft Meeting (9 weeks)
- Correlating Committee ballots on Second Draft (8 weeks)
- Second Draft Report posted on the document information page

### Step 3 – NFPA Technical Meeting

- Notice of Intent to Make a Motion (NITMAM) accepted (5 weeks) following the posting of Second Draft Report
- NITMAMs are reviewed and valid motions are certified by the Motions Committee for presentation at the NFPA Technical Meeting
- NFPA membership meets each June at the NFPA Technical Meeting to act on Standards with “Certified Amending Motions” (certified NITMAMs)
- Committee(s) vote on any successful amendments to the Technical Committee Reports made by the NFPA membership at the NFPA Technical Meeting

### Step 4 – Council Appeals and Issuance of Standard

- Notification of intent to file an appeal to the Standards Council on Technical Meeting action must be filed within 20 days of the NFPA Technical Meeting
- Standards Council decides, based on all evidence, whether to issue the standard or to take other action

#### Notes:

1. Time periods are approximate; refer to published schedules for actual dates.
2. Annual revision cycle documents with certified amending motions take approximately 101 weeks to complete.
3. Fall revision cycle documents receiving certified amending motions take approximately 141 weeks to complete.

## Committee Membership Classifications<sup>1,2,3,4</sup>

The following classifications apply to Committee members and represent their principal interest in the activity of the Committee.

1. M *Manufacturer*: A representative of a maker or marketer of a product, assembly, or system, or portion thereof, that is affected by the standard.
2. U *User*: A representative of an entity that is subject to the provisions of the standard or that voluntarily uses the standard.
3. IM *Installer/Maintainer*: A representative of an entity that is in the business of installing or maintaining a product, assembly, or system affected by the standard.
4. L *Labor*: A labor representative or employee concerned with safety in the workplace.
5. RT *Applied Research/Testing Laboratory*: A representative of an independent testing laboratory or independent applied research organization that promulgates and/or enforces standards.
6. E *Enforcing Authority*: A representative of an agency or an organization that promulgates and/or enforces standards.
7. I *Insurance*: A representative of an insurance company, broker, agent, bureau, or inspection agency.
8. C *Consumer*: A person who is or represents the ultimate purchaser of a product, system, or service affected by the standard, but who is not included in (2).
9. SE *Special Expert*: A person not representing (1) through (8) and who has special expertise in the scope of the standard or portion thereof.

NOTE 1: “Standard” connotes code, standard, recommended practice, or guide.

NOTE 2: A representative includes an employee.

NOTE 3: While these classifications will be used by the Standards Council to achieve a balance for Technical Committees, the Standards Council may determine that new classifications of member or unique interests need representation in order to foster the best possible Committee deliberations on any project. In this connection, the Standards Council may make such appointments as it deems appropriate in the public interest, such as the classification of “Utilities” in the National Electrical Code Committee.

NOTE 4: Representatives of subsidiaries of any group are generally considered to have the same classification as the parent organization.

## Submitting Public Input / Public Comment Through the Online Submission System

Soon after the current edition is published, a Standard is open for Public Input.

Before accessing the Online Submission System, you must first sign in at [www.nfpa.org](http://www.nfpa.org). *Note: You will be asked to sign-in or create a free online account with NFPA before using this system:*

- a. Click on Sign In at the upper right side of the page.
- b. Under the Codes and Standards heading, click on the “List of NFPA Codes & Standards,” and then select your document from the list or use one of the search features.

*OR*

- a. Go directly to your specific document information page by typing the convenient shortcut link of [www.nfpa.org/document#](http://www.nfpa.org/document#) (Example: NFPA 921 would be [www.nfpa.org/921](http://www.nfpa.org/921)). Sign in at the upper right side of the page.

To begin your Public Input, select the link “The next edition of this standard is now open for Public Input” located on the About tab, Current & Prior Editions tab, and the Next Edition tab. Alternatively, the Next Edition tab includes a link to Submit Public Input online.

At this point, the NFPA Standards Development Site will open showing details for the document you have selected. This “Document Home” page site includes an explanatory introduction, information on the current document phase and closing date, a left-hand navigation panel that includes useful links, a document Table of Contents, and icons at the top you can click for Help when using the site. The Help icons and navigation panel will be visible except when you are actually in the process of creating a Public Input.

Once the First Draft Report becomes available there is a Public Comment period during which anyone may submit a Public Comment on the First Draft. Any objections or further related changes to the content of the First Draft must be submitted at the Comment stage.

To submit a Public Comment you may access the online submission system utilizing the same steps as previously explained for the submission of Public Input.

For further information on submitting public input and public comments, go to: <http://www.nfpa.org/publicinput>.

### Other Resources Available on the Document Information Pages

**About tab:** View general document and subject-related information.

**Current & Prior Editions tab:** Research current and previous edition information on a Standard.

**Next Edition tab:** Follow the committee’s progress in the processing of a Standard in its next revision cycle.

**Technical Committee tab:** View current committee member rosters or apply to a committee.

**Technical Questions tab:** For members and Public Sector Officials/AHJs to submit questions about codes and standards to NFPA staff. Our Technical Questions Service provides a convenient way to receive timely and consistent technical assistance when you need to know more about NFPA codes and standards relevant to your work. Responses are provided by NFPA staff on an informal basis.

**Products & Training tab:** List of NFPA’s publications and training available for purchase.

## Information on the NFPA Standards Development Process

**I. Applicable Regulations.** The primary rules governing the processing of NFPA standards (codes, standards, recommended practices, and guides) are the NFPA *Regulations Governing the Development of NFPA Standards (Regs)*. Other applicable rules include NFPA *Bylaws*, NFPA *Technical Meeting Convention Rules*, NFPA *Guide for the Conduct of Participants in the NFPA Standards Development Process*, and the NFPA *Regulations Governing Petitions to the Board of Directors from Decisions of the Standards Council*. Most of these rules and regulations are contained in the *NFPA Standards Directory*. For copies of the *Directory*, contact Codes and Standards Administration at NFPA Headquarters; all these documents are also available on the NFPA website at “www.nfpa.org.”

The following is general information on the NFPA process. All participants, however, should refer to the actual rules and regulations for a full understanding of this process and for the criteria that govern participation.

**II. Technical Committee Report.** The Technical Committee Report is defined as “the Report of the responsible Committee(s), in accordance with the Regulations, in preparation of a new or revised NFPA Standard.” The Technical Committee Report is in two parts and consists of the First Draft Report and the Second Draft Report. (See *Regs* at Section 1.4.)

**III. Step 1: First Draft Report.** The First Draft Report is defined as “Part one of the Technical Committee Report, which documents the Input Stage.” The First Draft Report consists of the First Draft, Public Input, Committee Input, Committee and Correlating Committee Statements, Correlating Notes, and Ballot Statements. (See *Regs* at 4.2.5.2 and Section 4.3.) Any objection to an action in the First Draft Report must be raised through the filing of an appropriate Committee form for consideration in the Second Draft Report or the objection will be considered resolved. [See *Regs* at 4.3.1(b).]

**IV. Step 2: Second Draft Report.** The Second Draft Report is defined as “Part two of the Technical Committee Report, which documents the Comment Stage.” The Second Draft Report consists of the Second Draft, Public Comments with corresponding Committee Actions and Committee Statements, Correlating Notes and their respective Committee Statements, Committee Comments, Correlating Revisions, and Ballot Statements. (See *Regs* at 4.2.5.2 and Section 4.4.) The First Draft Report and the Second Draft Report together constitute the Technical Committee Report. Any outstanding objection following the Second Draft Report must be raised through an appropriate Amending Motion at the NFPA Technical Meeting or the objection will be considered resolved. [See *Regs* at 4.4.1(b).]

**V. Step 3a: Action at NFPA Technical Meeting.** Following the publication of the Second Draft Report, there is a period during which those wishing to make proper Amending Motions on the Technical Committee Reports must signal their intention by submitting a Notice of Intent to Make a Motion (NITMAM). (See *Regs* at 4.5.2.) Standards that receive notice of proper Amending Motions (Certified Amending Motions) will be presented for action at the annual June NFPA Technical Meeting. At the meeting, the NFPA membership can consider and act on these Certified Amending Motions as well as Follow-up Amending Motions, that is, motions that become necessary as a result of a previous successful Amending Motion. (See 4.5.3.2 through 4.5.3.6 and Table 1, Columns 1-3 of *Regs* for a summary of the available Amending Motions and who may make them.) Any outstanding objection following action at an NFPA Technical Meeting (and any further Technical Committee consideration following successful Amending Motions, see *Regs* at 4.5.3.7 through 4.6.5.3) must be raised through an appeal to the Standards Council or it will be considered to be resolved.

**VI. Step 3b: Documents Forwarded Directly to the Council.** Where no NITMAM is received and certified in accordance with the Technical Meeting Convention Rules, the standard is forwarded directly to the Standards Council for action on issuance. Objections are deemed to be resolved for these documents. (See *Regs* at 4.5.2.5.)

**VII. Step 4a: Council Appeals.** Anyone can appeal to the Standards Council concerning procedural or substantive matters related to the development, content, or issuance of any document of the NFPA or on matters within the purview of the authority of the Council, as established by the Bylaws and as determined by the Board of Directors. Such appeals must be in written form and filed with the Secretary of the Standards Council (see *Regs* at Section 1.6). Time constraints for filing an appeal must be in accordance with 1.6.2 of the *Regs*. Objections are deemed to be resolved if not pursued at this level.

**VIII. Step 4b: Document Issuance.** The Standards Council is the issuer of all documents (see Article 8 of *Bylaws*). The Council acts on the issuance of a document presented for action at an NFPA Technical Meeting within 75 days from the date of the recommendation from the NFPA Technical Meeting, unless this period is extended by the Council (see *Regs* at 4.7.2). For documents forwarded directly to the Standards Council, the Council acts on the issuance of the document at its next scheduled meeting, or at such other meeting as the Council may determine (see *Regs* at 4.5.2.5 and 4.7.4).

**IX. Petitions to the Board of Directors.** The Standards Council has been delegated the responsibility for the administration of the codes and standards development process and the issuance of documents. However, where extraordinary circumstances requiring the intervention of the Board of Directors exist, the Board of Directors may take any action necessary to fulfill its obligations to preserve the integrity of the codes and standards development process and to protect the interests of the NFPA. The rules for petitioning the Board of Directors can be found in the *Regulations Governing Petitions to the Board of Directors from Decisions of the Standards Council* and in Section 1.7 of the *Regs*.

**X. For More Information.** The program for the NFPA Technical Meeting (as well as the NFPA website as information becomes available) should be consulted for the date on which each report scheduled for consideration at the meeting will be presented. To view the First Draft Report and Second Draft Report as well as information on NFPA rules and for up-to-date information on schedules and deadlines for processing NFPA documents, check the NFPA website (www.nfpa.org/docinfo) or contact NFPA Codes & Standards Administration at (617) 984-7246.





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