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NFPA 33 Spray Application Using Flammable and Combustible Materials 1989 Edition

National Fire Protection Association Batterymarch Park, Quincy, MA 02269

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Policy Adopted by NFPA Board of Directors on December 3, 1982

The Board of Directors reaffirms that the National Fire Protection Association recognizes that the toxicity of the products of combustion is an important factor in the loss of life from fire. NFPA has dealt with that subject in its technical committee documents for many years.

There is a concern that the growing use of synthetic materials may produce more or additional toxic products of combustion in a fire environment. The Board has, therefore, asked all NFPA technical committees to review the documents for which they are responsible to be sure that the documents respond to this current concern. To assist the committees in meeting this request, the Board has appointed an advisory committee to provide specific guidance to the technical committees on questions relating to assessing the hazards of the products of combustion.

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NATIONAL FIRE PROTECTION ASSOCIATION

NFPA 33

Standard for

Spray Application Using Flammable and Combustible Materials

1989 Edition

This edition of NFPA 33, *Standard for Spray Application Using Flammable and Combustible Materials*, was prepared by the Technical Committee on Finishing Processes, and acted on by the National Fire Protection Association, Inc. at its Annual Meeting held May 15-18, 1989 in Washington, DC. It was issued by the Standards Council on July 14, 1989, with an effective date of August 7, 1989, and supersedes all previous editions.

The 1989 edition of this document has been approved by the American National Standards Institute.

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

Origin and Development of NFPA 33

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

The following are the major changes adopted in this 1989 edition of NFPA 33:

A change to the Scope to emphasize that NFPA 33 addresses only fire and explosion hazards.

Changes to the ventilation requirements to provide more succinct design requirements.

A completely rewritten Chapter 6 on storage and handling of flammable and combustible liquids.

A completely rewritten Chapter 9 on fixed electrostatic apparatus.

A completely rewritten Chapter 11 on drying, curing, and fusion processes.

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This list represents the membership at the time the Committee was balloted on the text of this edition. Since that time, changes in the membership may have occurred.

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

Contents

NFPA 33

Standard for

Spray Application Using Flammable and Combustible Materials

1989 Edition

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

Information on referenced publications can be found in Chapter 16 and Appendix C.

Foreword

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

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

Chapter 1* Scope and Definitions

1-1* Scope.

1-1.1 This standard covers the application of flammable or combustible materials when applied as a spray by compressed air, "airless" or "hydraulic atomization," or by steam, or electrostatic methods or by any other means in continuous or intermittent processes. It also covers the application of combustible powders when applied by powder spray guns, electrostatic powder spray guns, fluidized beds, or electrostatic fluidized beds.

1-1.2 This standard outlines practical requirements to obtain reasonable safety under average contemplated conditions. Where unusual industrial processes are involved, the authority having jurisdiction may for substantiated cause require additional safeguards or modify the requirements of this standard provided equivalent safety is thereby obtained.

1-1.3* This standard does not cover outdoor spray application of buildings, tanks or other similar structures, nor small portable spraying apparatus not used repeatedly in the same location; however, the herein described fundamental safeguards pertaining to cleanliness, care of flammable liquids, dangerous vapor-air or powder-air mixtures, and sources of ignition should be followed where applicable.

1-1.4* This standard does not cover the spray application of noncombustible finishing material. Certain water type finishes, however, although involving little or no hazard in the liquid state may leave highly combustible residues upon evaporation of the liquid carrier. The provisions of this standard for minimizing the hazards of combustible residues shall be followed irrespective of the characteristics of the liquid.

1-1.5 This standard addresses the fire and explosion hazards of the spray application of flammable and combustible materials. It does not address toxicity. It must be recognized that, from a personnel safety standpoint, the materials used in these processes may be present in concentrations that may present a potential health hazard, even though they do not approach a fire or explosion hazard. Where this standard requires certain ventilation practices, the requirements are to minimize fire and explosion hazards and may not be adequate to protect personnel from the toxic effects of exposure to the materials.

1-2 Definitions.

Aerated Solid Powders. Any powdered material used as a coating material which shall be fluidized within a container by passing air uniformly from below. It is common practice to fluidize such materials to form a fluidized powder bed and then dip the part to be coated into the bed in a manner similar to that used in liquid dipping. Such beds are also used as sources for powder spray operations. The combustibility of such materials may be determined by reference to Appendix A-13-5 and to NFPA 654, *Standard for the Prevention of Fire and Dust Explosions in the Chemical, Dye, Pharmaceutical, and Plastics Industries.*

Approved. Acceptable to the "authority having jurisdiction."

NOTE: The National Fire Protection Association does not approve, inspect or certify any installations, procedures, equipment, or materials nor does it approve or evaluate testing laboratories. In determining the acceptability of installations or procedures, equipment or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization concerned with product evaluations which is in a position to determine compliance with appropriate standards for the current production of listed items.

Authority Having Jurisdiction. The "authority having jurisdiction" is the organization, office or individual responsible for "approving" equipment, an installation or a procedure.

NOTE: The phrase "authority having jurisdiction" is used in NFPA documents in a 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, 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 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."

Dry Spray Booth. A spray booth not equipped with a water washing system. A dry spray booth may be equipped with (1) distribution or baffle plates to promote an even flow of air through the booth or cause deposit of overspray before it enters exhaust duct; or (2) overspray dry filters to minimize dusts or residues entering exhaust ducts; or (3) overspray dry filter rolls designed to minimize dusts or residues entering exhaust ducts; or (4) where dry powders are being sprayed, with powder collection systems so arranged in the exhaust to capture oversprayed material.

Electrostatic Fluidized Bed. A container holding powder coating material which is aerated from below so as to form an air-supported expanded cloud of such material that is electrically charged with a charge opposite to the charge of the object to be coated; such object is transported through the container immediately above the charged and aerated materials in order to be coated.

Fluidized Bed. A container holding powder coating material which is aerated from below so as to form an air-supported expanded cloud of such material through which the preheated object to be coated is immersed and transported.

Labeled. Equipment or materials to which has been attached a label, symbol or other identifying mark of an organization 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.

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

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

Liquids.

Flammable. Any liquid having a flash point below 100 °F (37.8 °C) closed cup and having a vapor pressure not exceeding 40 lb per sq in. (absolute) (2068.6 mm Hg) at 100 °F (37.8 °C).

Combustible. Any liquid having a flash point at or above 100 °F (37.8 °C). For further classification see NFPA 321, *Standard on Basic Classification of Flammable and Combustible Liquids*.

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

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

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

A spray area shall include:

(a) The interior of spray booths and rooms except as specifically provided for in Section 11-4.

(b) The interior of ducts exhausting from spraying processes.

(c) Any area in the direct path of spraying operations.

The authority having jurisdiction may, for the purpose of this standard, define the limits of the spray area in any specific case. The "spray area" in the vicinity of spraying operations will necessarily vary with the design and arrangement of equipment and method of operation. When spraying operations are strictly confined to predetermined spaces which are provided with adequate and reliable ventilation, such as a properly constructed spray booth, the "spray area" will ordinarily not extend beyond the booth enclosure. When, however, spraying operations are not confined to adequately ventilated spaces the "spray area" may extend throughout the entire room containing spraying operations.

Spray Booth. A power-ventilated structure provided to enclose or accommodate a spraying operation, to confine and limit the escape of spray, vapor and residue, and to safely conduct or direct them to an exhaust system. Spray booths are manufactured in a variety of forms, including automotive refinishing, downdraft, open-face, traveling, tunnel, and updraft booths.

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

Waterwash Spray Booth. A spray booth equipped with a water washing system designed to minimize dusts or residues entering exhaust ducts and to permit the recovery of overspray finishing material.

Chapter 2* Location of Spray Application Operations

2-1 Spray application operations within the scope of this standard shall be confined to properly designed and constructed spray booths, spray rooms, or properly designated spray areas as defined.

2-2 Spray application operations shall not be conducted in a building classified as assembly, educational, institutional, or residential, except in a room designed for the purpose, protected with an approved system of automatic sprinklers, and separated vertically and horizontally from such occupancies by construction having not less than a two-hour fire resistance rating.

Chapter 3* Spray Area

3-1 Walls and ceilings that enclose or intersect spray areas shall be substantially constructed of steel, concrete, masonry, or other noncombustible materials and shall be securely and rigidly supported.

The interior surfaces of spray areas shall be smooth and designed to prevent pocketing of residues and to facilitate ventilation, cleaning, and washing.

The floor construction of spray areas, if combustible, shall be covered by noncombustible material. (*See Section 8-3 for disposable coverings.*)

3-1.1 Steel shall not be thinner than No. 18 MSG (1.3 mm).

3-1.2 Aluminum or other substantial noncombustible material may be used for intermittent or low volume spraying, subject to the approval of the authority having jurisdiction.

3-1.3 Spray booths used exclusively for powder application may be constructed of other fire retardant materials when approved by the authority having jurisdiction.

3-1.4 Spray rooms shall have at least a one-hour fire resistance rating.

3-2 Where conveyor openings are arranged to carry work into or out of spray areas the opening shall be as small as practical.

3-3 Spray booths shall be separated from other operations by not less than 3 ft (1 m), or by a partition or wall having a one-hour fire resistance rating.

Spray booths shall be installed so that all portions are readily accessible for cleaning. A clear space of not less than 3 ft (1 m) on all sides shall be kept free from storage or combustible construction. This does not preclude the installation of a spray booth against a partition or wall having a one-hour fire resistance rating providing the booth can be maintained and cleaned.

3-4 Where the product to be sprayed is brought into a spray area, removed from it, or manipulated while there by a self-powered vehicle capable of producing ignition, the vehicle shall not be activated in the area unless the spray operation is stopped, the ventilation system is in operation, and the area has been adequately ventilated to ensure a safe atmosphere.

3-5 When spray areas are illuminated through glass panels or other noncombustible transparent materials, fixed lighting units shall be used as a source of illumination. Panels shall effectively isolate the spray area from the area in which the lighting unit is located, and shall be of noncombustible materials of such a nature or so protected that breakage will be unlikely. Panels shall be so arranged that normal accumulations of residue on the exposed surface of the panel will not be raised to a dangerous temperature by the lighting unit. Panels shall be so installed that they may be easily cleaned.

3-6 Spray areas equipped with distribution or baffle plates, or dry-type overspray collection filters shall conform to the following:

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

3-6.2 Filters shall not be used when applying a spray material known to be highly susceptible to spontaneous heating and ignition.

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

3-6.4 Clean filters shall be of a listed type.

3-6.5 Filters shall not alternately be used for different types of coating materials, where the combination of materials may result in spontaneous ignition. (*See also Section 8-9.*)

Chapter 4* Electrical and Other Sources of Ignition

4-1* All electrical equipment, open flames, and other sources of ignition, except finishing operations as described in Section 3-4, shall conform to the requirements of Chapter 4 and:

(a) Electrostatic apparatus shall conform to the requirements of Chapters 9 and 10;

(b) Drying, curing, and fusion apparatus shall conform to the requirements of Chapter 11;

(c) Automobile undercoating spray operations in garages shall conform to the requirements of Chapter 12;

(d) Powder coating equipment shall conform to the requirements of Chapter 13.

4-2* There shall be no open flame, spark-producing equipment, or exposed surfaces exceeding the ignition temperature of the material being sprayed in the areas specified in (a) and (b) below, except as specifically permitted in Sections 4-7, 5-5, and 11-4 and in NFPA 86, *Standard for Ovens and Furnaces*. Further, there shall be no equipment or processes that may produce sparks or particles of hot metal located above or adjacent to the areas in (a) and (b) below, unless means are provided to prevent the sparks or particles of hot metal from entering these areas:

(a) A spray area as herein defined.

(b) An area adjacent to a spray area and defined in Section 4-7 as requiring electrical equipment conforming to

the provisions of NFPA 70, *National Electrical Code®*, for Division 2 locations, unless separated therefrom by a partition extending at least to the boundary of the Division 2 location.

4-3 Space heating appliances, steam pipes, or hot surfaces shall not be located in a spray area where deposits or combustible residues may readily accumulate and be ignited.

4-4 Electrical wiring and equipment shall conform to the provisions of this section and shall otherwise be in accordance with NFPA 70, *National Electrical Code.*

4-5* Unless specifically listed for locations containing deposits of dangerous quantities of flammable or combustible vapors, mists, residues, dusts, or deposits (as applicable), there shall be no electrical equipment in any spray area as herein defined whereon deposits of combustible residue may readily accumulate, except wiring in rigid metal conduit, Type MI cable, or in metal boxes or fittings containing no taps, splices, or terminal connections.

4-6* Electrical wiring and equipment not subject to deposits of combustible residues but located in a spray area as herein defined shall be of explosionproof or other type approved for Class I and Class II, Division 1 locations, and shall otherwise conform to the provisions of NFPA 70, *National Electrical Code*, for Class I or Class II, Division 1 locations. (*See Articles 500, 501, 502, and 516 of the Code.*)

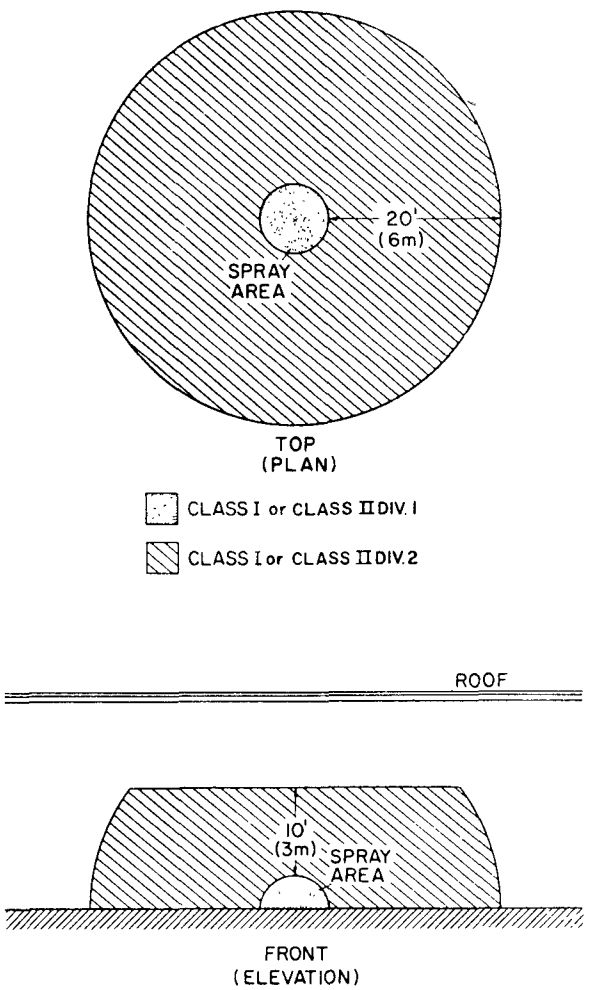

Figure 1 Class 1 or Class II, Division 2 Locations Adjacent to an Unenclosed Spray Operation.

4-7* Electrical wiring and equipment located adjacent to a spray area, as herein defined, shall conform to one of the following: 4-7.1 — 4-7.5.

4-7.1 Equipment outside of, but within 20 ft (6 m) horizontally and 10 ft (3 m) vertically of, any spray area, and not separated from it by partitions extending at least to the boundary of the Division 2 location shall not produce sparks under normal operating conditions, and shall otherwise conform to the provisions of NFPA 70, *National Electrical Code*, for Class I or Class II, Division 2 locations (as applicable). (*See Articles 500, 501, 502, and 516 of the Code.*) (*Also see Figure 1.*)

4-7.2 If spraying operations are conducted within a closed top, open face, or front booth or room, the electrical wiring and equipment outside of the booth or room, but within the space shown in Figures 2A and 2B, shall not produce sparks under normal operating conditions, and shall otherwise conform to the provisions of NFPA 70, *National Electrical Code*, for Class I or Class II, Division 2 locations (as applicable). (*See Articles 500, 501, 502, and 516 of the Code.*) The space within 3 ft (1 m) in all directions from openings other than the open face or front shall be considered as Class I, Division 2 or Class II, Division 2 locations.

The Class I and Class II, Division 2 locations shown in Figure 2 shall extend from the open face or open front of the spray booth or room in accordance with the following:

(a) If the ventilation system is interlocked with the spraying equipment so as to make the spraying equipment inoperable when the ventilating system is not in operation, the space shall extend 5 ft (1.5 m) from the open face or open front of the booth or room, and as otherwise shown in Figure 2, Part A.

(b) If the ventilation system is not interlocked with the spraying equipment so as to make the spraying equipment inoperable when the ventilation system is not in operation, the space shall extend 10 ft (3 m) from the open face or open front of the booth or room, and as otherwise shown in Figure 2, Part B.

4-7.3 If spraying operations are conducted within an open top booth the space 3 ft (1 m) vertically above the booth shall be a Class I or Class II, Division 2 location. The space within 3 ft (1 m) in all directions from openings other than the open top shall also be considered as a Class I or Class II, Division 2 location. Electrical wiring and equipment in these areas shall not produce sparks under normal operating conditions, and shall otherwise conform to the provisions of NFPA 70, *National Electrical Code*, for Class I or Class II, Division 2 locations. (*See Articles 500, 501, 502, and 516 of the Code.*)

4-7.4 If spraying operations are confined to an enclosed spray booth or room, the space adjacent to the booth or room shall be considered nonhazardous due to the spraying operation, except for the space within 3 ft (1 m) in all

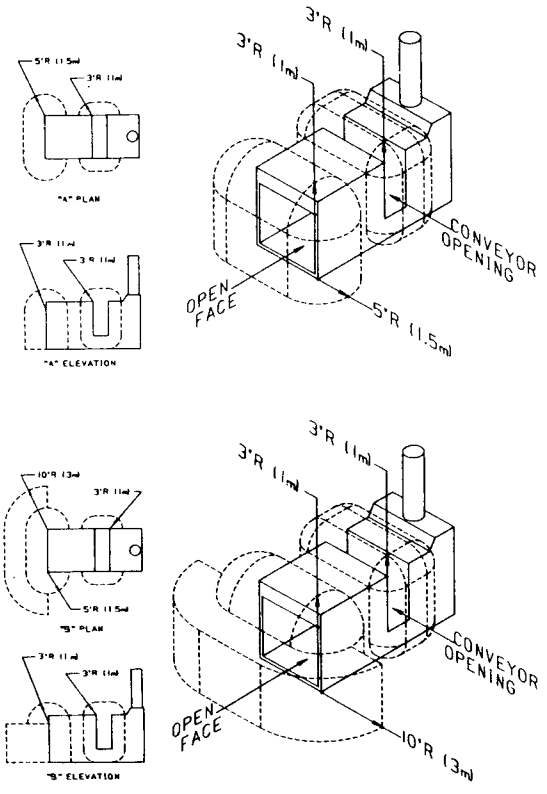

Figure 2 Class I or Class II, Division 2 Locations Adjacent to a Closed Top, Open Faced or Open Front Spray Booth.

A. When ventilation system is interlocked with spray equipment
B. When ventilation system is not interlocked with spray equipment.

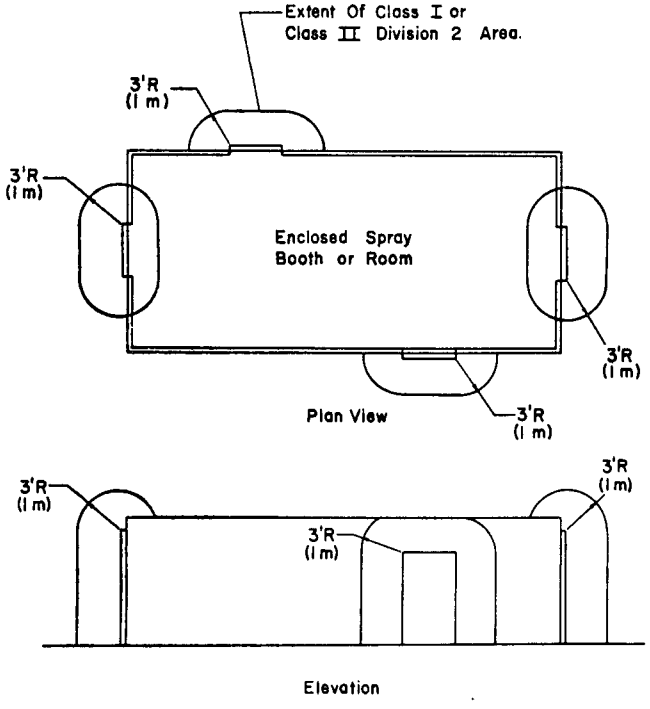

Figure 3 Class I or Class II, Division 2 Locations Adjacent to Openings in an Enclosed Spray Booth or Room.

directions from any openings in the booth or room, as shown in Figure 3. Electrical wiring and equipment within the space within 3 ft (1 m) in all directions from any opening shall not produce sparks under normal operating conditions, and shall otherwise conform to the provisions of NFPA 70, *National Electrical Code*, for Class I or Class II, Division 2 locations (as applicable). (*See Articles 500, 501, 502, and 516 of the Code.*)

4-7.5 When spray application equipment and supply containers are located in adequately ventilated areas and outside of storage or mixing rooms in spray areas, the area within 3 ft (1 m) of vents, fill openings, or system openings and extending to floor or grade shall be Class I or Class II, Division 1; and areas between 3 ft (1 m) and 5 ft (1.5 m) from vents, fill openings, and system openings extending in all directions and up to 18 in. (0.5 m) above floor or grade within 10 ft (3 m) horizontally for liquids shall be Class I, Division 2.

4-8* Electric lamps outside of, but within 20 ft (6 m) of, any spray area as herein defined, and not separated therefrom by a partition, shall be totally enclosed to prevent the falling of hot particles and shall be protected from mechanical injury by suitable guards or by location.

4-9* Portable electric lamps shall not be used in any spray area during spraying operations.

Exception: Where portable electric lamps are required for operations in spaces not readily illuminated by fixed lighting within the spray area, they shall be of the type approved for Class I or Class II, Division 1 locations where readily ignitible residues may be present.

4-9.1* All metal parts of spray booths, exhaust ducts, and piping systems conveying flammable or combustible liquids or aerated combustible solids shall be properly electrically grounded in an effective and permanent manner.

4-9.2* Unless specifically intended to be operated at other than ground potential, airless high fluid pressure spray guns and any conductive object being sprayed shall be properly electrically grounded.

Chapter 5* Ventilation

5-1 Ventilating and exhaust systems shall be in accordance with NFPA 91, *Standard for the Installation of Blower and Exhaust Systems for Dust, Stock and Vapor Removal or Conveying*, where applicable and shall also conform to provisions of this section.

5-2 All spray areas shall be provided with mechanical ventilation adequate to confine and remove flammable or combustible vapors or mists to a safe location, to maintain the concentration of flammable or combustible vapors or mists in the exhaust stream below 25 percent of the lower flammable limit (LFL), and to confine and control combustible residues, dusts, or deposits.

Exception: Confined spaces may represent areas in which ventilation may not be capable of effectively handling the hazardous at-

mosphere associated with spray finishing therein. In such cases, a properly applied inerting procedure, in accordance with NFPA 69, Standard on Explosion Prevention Systems, and acceptable to the authority having jurisdiction, may be more effective in reducing the hazard and may be used.

5-3 Spray areas equipped with overspray collection filters shall have visible gages, audible alarms, or an effective inspection program that indicates that the required air velocity is maintained.

5-4 Powder coating systems shall meet the requirements of Section 13-5.

5-5 Mechanical ventilation shall be kept in operation at all times while spraying operations are being conducted and for a sufficient time thereafter to allow flammable vapors from drying coated articles and drying finishing material residue to be exhausted.

When spray is automatically applied without an attendant constantly on duty, the operating control of spray apparatus shall be so arranged that spray cannot be applied unless exhaust fans are in operation.

5-6* An adequate supply of makeup air to compensate for air exhausted from a spraying operation shall be safely provided to that operation. Makeup air shall be so introduced to an operation as to provide for the efficient operation of exhaust fans and minimize the creation of dead air pockets.

5-7 Equipment to process air exhausted from spray operation for removal of contaminants shall be approved by the authority having jurisdiction.

5-8 Air exhausted from spray operations shall not be directed so that it will contaminate makeup air being introduced into the spray area or other ventilating intakes, nor directed so as to create a nuisance.

5-8.1 Air exhausted from a spray operation shall not be recirculated to be used as makeup air for occupied spaces unless the exhaust air has been decontaminated to return it to a safe acceptable composition and unless listed equipment monitors the decontaminated exhaust air stream to signal the operator and to automatically shut down the spray operation in event of failure of the decontaminating equipment to maintain acceptable air quality standards.

5-8.2 Air exhausted from a spray operation shall not be recirculated to be used as makeup air for an unmanned subsequent spray operation, unless the solid particulate has been safely removed from the exhaust air and unless installed listed equipment monitors the composition of the air exhausted from the second operation to signal the operator and to automatically shut down both spray operations in the event that the composition of the air exhausted from the second operation exceeds 25 percent of the LFL of the used solvents.

5-9 Individual spray booths shall be separately ducted to the building exterior, except for multiple cabinet spray booths with combined frontal areas of not more than 18 sq ft (1.7 m^2) using coating materials not likely to react and cause ignition of the residue, or where permitted in Chapter 13 or in Section 5-10.

5-10* Where treatment of exhaust is necessary for air pollution control or for energy conservation, ducts may be manifolded if the sprayed materials used are not likely to react and cause ignition of the residue in the duct and if:

(a) No nitrocellulose base finishing material is used.

(b) An air cleaning system reduces the amount of overspray carried into the manifolded duct (a booth filter system is adequate).

(c) Automatic sprinkler protection is provided at the junction of each booth exhaust with the manifold in addition to protection recommended in Chapter 7.

(d) The installation is approved by the authority having jurisdiction.

5-11 Exhaust ducts shall be constructed of steel and shall be substantially supported. If dampers are installed, they shall be maintained so that adequate airflow is maintained at all times the ventilating system is in operation. When spray booths are not in use and it is necessary to shut off ducts, noncombustible removable covers completely closing ducts may be used.

5-12 The exhaust duct discharge point shall be not less than 6 ft (1.8 m) from any combustible exterior wall or roof nor shall the exhaust duct discharge in the direction of any combustible construction or unprotected opening in any noncombustible exterior wall within 25 ft (7.6 m).

5-13 Exhaust ducts shall be provided with ample access doors to facilitate cleaning.

5-14 The exhaust fan rotating element shall be nonferrous or the fan shall be constructed so that a shift of the wheel or shaft will not permit two ferrous parts of the fan to rub or strike. There shall be ample clearance between fan rotating element and fan casing to avoid a fire by friction, necessary allowance being made for ordinary expansion and loading to prevent contact between moving parts and the duct or fan housing. Fan blades shall be mounted on a shaft sufficiently heavy to maintain proper alignment even when the blades of the fan are heavily loaded, the shaft preferably to have bearings outside the duct and booth. All bearings shall be of the self-lubricating type, or lubricated from a location outside the duct.

5-15 Electrical motors driving exhaust fans shall not be placed inside any spray area unless they meet the provisions of Section 4-5.

5-16 Belts shall not enter any spray area unless the belt and pulley within the spray area is completely enclosed.

5-17* Freshly sprayed articles shall be dried only in spaces provided with adequate ventilation to prevent the accumulation of flammable vapors. In the event adequate and reliable ventilation is not provided such drying spaces shall be considered a spray area as herein defined. (*See also Chapter 11.*)

Chapter 6* Flammable and Combustible Liquids

Storage, Handling, and Distribution

6-1* Flammable and combustible liquid storage, handling, and mixing operations (paint kitchen) remote from the process area shall conform to the requirements of NFPA 30, *Flammable and Combustible Liquids Code*, where applicable and shall also conform to provisions of this section for storage, handling, and mixing at the process area.

6-2 Storage.

6-2.1 There shall be no more than three flammable liquid storage cabinets in a process area without approval of the authority having jurisdiction. Storage cabinets shall be listed or shall be designed and constructed to meet the requirements of NFPA 30, *Flammable and Combustible Liquids Code*. Any one such cabinet shall contain not more than 60 gal (225 L) of Class I and Class II liquids, or 120 gal (450 L) of Class III liquids.

6-2.2 The quantity of flammable and combustible liquids kept in the vicinity of spraying operations outside an inside storage room or storage cabinet in any one process area shall not exceed the greater of: (1) a supply for one day or one shift; (2) 25 gal (95 L) of Class IA liquids in containers and 120 gal (450 L) of Class IB, IC, II or III liquids in containers; or (3) one approved portable tank not exceeding 660 gal (2,500 L) of Class IB, IC, II or III liquids.

6-3 Mixing.

6-3.1 The withdrawal of flammable or combustible liquids from containers and the filling of containers, including portable mixing tanks, shall be done only in a suitable mixing room or in a spray area. The amount mixed at one time in a spray area shall not exceed 60 gals. The ventilation system shall be in operation and adequate precautions shall be taken to protect against liquid spillage and sources of ignition.

6-3.2 Mixing rooms may be located adjacent to the spray area provided quantities of flammable liquid are less than 2 gal/ft^2 (100 L/m^2) and floor area is less than 150 ft^2 (14 m^2) and provided the installation meets the following provisions:

(a) The mixing room shall be at least 6 ft (1.8 m) from the spray area.

(b) Wall and ceiling construction shall be steel not thinner than No. 18 MSG (1.3 mm) or shall be concrete, masonry or other noncombustible material. Aluminum shall not be used.

(c) The room shall be designed to contain a flammable liquid spill.

(d) The room shall be ventilated at a rate of not less than 1 cfm/ft^2 (1 m^3/3 m^2) with a minimum rate of 150 cfm (4 m^3/min).

(e) An approved automatic fire extinguishing system shall be provided.

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

6-4 Distribution Systems — Piping.

6-4.1 Piping systems conveying flammable or combustible liquids between storage tanks, mixing room (paint kitchen), and spray area shall be of steel or other material having comparable properties of resistance to heat and physical damage; they shall be so installed that a rupture of the system for any reason is unlikely. Piping systems shall be properly bonded and grounded.

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

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

6-4.4 When a pump is used to deliver products, 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 discharge pressure of the pump.

6-4.5* When a remotely located pump is used to deliver product, an automatic means shall be provided to shut off supply of product in event of fire.

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

6-5 Distribution Systems — General.

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

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

6-5.3 The withdrawal of flammable or combustible liquids from containers having a capacity of greater than 60 gal (225 L) shall be by pumps approved for such use.

Exception: Pressure vessels may be used provided they are of limited capacity, not exceeding that necessary for one day's operation, and designed and approved for such use. They shall be provided with a pressure gage and a relief valve in conformance with the ASME Code for Unfired Pressure Vessels.

6-5.4 Containers supplying spray nozzles shall be of closed type or provided with metal covers kept closed. Con-

tainers not resting on floors shall be on substantial supports or suspended by wire cables. Containers supplying spray nozzles by gravity flow shall not exceed 10 gal (38 L) capacity.

6-5.5 Original shipping containers shall not be subjected to air pressure for supplying spray nozzles.

6-5.6 Containers under pressure supplying spray nozzles, air storage tanks, and coolers shall conform to the standards of the ASME *Code for Unfired Pressure Vessels*, for construction, tests, and maintenance.

6-5.7 If a spray liquid heater is used, it shall be low pressure, steam or hot water type, or electric. If electric, it shall be approved and listed for the specific location in which it is used. (*See Chapter 4.*) Heaters shall not be located in spray booths or other locations subject to the accumulation of deposits of combustible residue. Agitators, if used, shall be driven by compressed air, water, or low-pressure steam, or electricity. If powered by an electric motor, the motor shall conform to the requirements of Chapter 4.

Chapter 7* Protection

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

7-2* In sprinklered buildings, the automatic sprinkler system in rooms containing spray application operations shall conform to NFPA 13, *Standard for the Installation of Sprinkler Systems*, provisions for Extra Hazard Occupancy, and in unsprinklered buildings where sprinklers are installed only to protect spray areas, the installation shall conform to such standards insofar as they may be applicable. Sprinkler installations shall also conform to the provisions of this chapter.

NOTE: Sprinklers in rooms containing spray application operations should be on a wet pipe system where practical. Unusual or out-of-the-ordinary spray operations may require open head deluge or a combination of open and closed head automatic sprinkler protection, subject to the approval of the authority having jurisdiction.

7-3 Water supply for sprinklers in rooms containing spray finishing operations shall be sufficient to supply all sprinklers likely to open in one fire without depleting the available water for use in hose streams. Where sprinklers are installed to protect spray areas only, water may be furnished from the domestic supply, subject to the approval of the authority having jurisdiction.

7-4* Where automatic sprinklers protect each spray booth (together with its connecting exhaust) they shall be under an accessibly located separate OS & Y subcontrol valve. Sprinkler systems in stacks or ducts shall be automatic and of a type not subject to freezing.

7-5 Sprinklers protecting spray areas shall be cleaned and protected against overspray residue so that they will operate quickly in event of fire. If covered, polyethylene or cellophane bags having a thickness of 0.003 in. (0.076 mm) or less, or thin paper bags shall be used. Coverings shall be replaced or heads cleaned frequently so that heavy deposits of residue do not accumulate.

7-6 Where automatic sprinkler protection is not available, a spray booth and its exhaust ducts may be protected with a dry chemical extinguishing system installed so as to conform to NFPA 17, *Standard for Dry Chemical Extinguishing Systems*; a carbon dioxide system installed so as to conform to NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems*; or a halogenated extinguishing system installed so as to conform to NFPA 12A, *Standard on Halon 1301 Fire Extinguishing Systems*; or NFPA 12B, *Standard on Halon 1211 Fire Extinguishing Systems.*

7-7 An adequate supply of suitable portable fire extinguishers shall be installed near all spray areas. (*See NFPA 10, Standard for Portable Fire Extingushers.*)

7-8* Fixed powder application equipment shall be protected further by installation of approved flame detection apparatus that will, in event of ignition, react to the presence of flame within one-half second and:

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

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

(c) Actuate an alarm.

Chapter 8* Operations and Maintenance

8-1* Spraying shall not be conducted outside of predetermined spray areas and all provisions of this standard applying to spray areas shall be strictly followed.

8-2 High pressure hose conveying flammable or combustible material in "airless" spray application operations shall be frequently inspected and properly maintained. Hose and equipment shall be so located that, in the event of a leak or rupture, application material will not be discharged into any space having a source of ignition.

8-3* All spray areas shall be kept free from the accumulation of deposits of combustible residues. Combustible coverings (thin paper, plastic, etc.) and strippable coatings may be used to facilitate cleaning operations in spray areas. If residue accumulates to excess in booths, duct or duct discharge points or other spray areas, then all spraying operations shall be discontinued until conditions are corrected.

8-4 Maintenance procedures shall be established to ensure replacing overspray collector filters before excessive restriction to air flow occurs. Overspray collectors shall be inspected after each period of use and clogged filters discarded and replaced.

All discarded overspray collector filters shall be immediately removed to a safe, well-detached location or placed

in a water-filled metal container and disposed of at the close of the day's operation unless maintained completely in water.

8-5* Residue scrapings and debris contaminated with residue shall be immediately removed from premises and properly disposed of.

8-6* Approved metal waste cans shall be provided wherever rags or waste are impregnated with sprayed material and all such rags or waste deposited therein immediately after use. The contents of waste cans shall be properly disposed of at least once daily at the end of each shift.

8-7 Employees' clothing contaminated with sprayed material shall not be left on the premises overnight unless kept in metal lockers.

8-8 Solvents for cleaning operations shall have flash points above 100 °F (37.8 °C). However, for cleaning spray nozzles and auxiliary equipment, solvents having flash points not less than those normally used in spray operations may be used.

Cleaning operations using flammable or combustible solvents shall be conducted inside spray booths with ventilating equipment operated during cleaning, or in other adequately ventilated locations complying with the requirements of Chapter 4.

8-9* Spray booths shall not be alternately used for different types of coating materials, where the combination of the materials may be conducive to spontaneous ignition, unless all deposits of the first used material are removed from the booth and exhaust ducts prior to spraying with the second. Examples of dangerous combinations are:

(a) Deposits of lacquers containing nitrocellulose combined with finishes containing drying oils, such as varnishes, oil-based stains, air-drying enamels, and primers.

(b) Bleaching compounds based on hydrogen peroxide, hypochlorites, perchlorates, or other oxidizing compounds combined with any organic finishing materials.

8-10* Coating materials containing chlorinated solvents shall not be used with spray 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 applies even if the container or system has been constructed with pressure relief devices.

8-11 "No Smoking" signs in large letters on contrasting color background shall be conspicuously posted at all spray areas and paint storage rooms.

8-12* When maintenance operations involve the use of welding, burning, or grinding equipment, such operations shall be done under the supervision of properly designated personnel provided with adequate fire extinguishing equipment.

Chapter 9 Fixed Electrostatic Apparatus

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

9-1.1 When robot programming procedures involve manual manipulation of the robot arm while spraying with the high voltage on, the provisions of Chapter 10 shall also apply.

9-2 General. The installation and use of electrostatic spraying equipment shall comply with the requirements of this chapter and shall also comply with the requirements of all other applicable chapters.

9-3 All automatic electrostatic equipment systems shall comply with the following:

9-3.1 Transformers, high voltage supplies, control apparatus, and all other electrical portions of the equipment, with the exception of high voltage grids, electrodes, and electrostatic atomizing heads and their connections, shall be located outside of the spray area, as defined in Chapter 1, or shall otherwise comply with the requirements of Chapter 4 of this standard.

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

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

9-3.4 Goods being coated using this process shall be supported on conveyors or hangers. The conveyors or hangers shall be so arranged to:

(a) Assure that the parts being coated are electrically connected to ground with a resistance of 1 megohm or less and

(b) Prevent parts from swinging.

9-3.5 Electrostatic apparatus shall be equipped with automatic means that will rapidly deenergize the high voltage elements under any of the following conditions:

(a) Stoppage of ventilating fans or failure of ventilating equipment from any cause;

(b) Stoppage of the conveyor carrying goods through the high voltage field unless stoppage is required by the spray process;

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

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

9-3.6 Safeguards such as adequate booths, fencing, railings, interlocks, or other means shall be placed about the equipment or incorporated therein so that they, either by their location or character or both, assure that a safe separation of the process is maintained.

9-3.7 All electrically conductive objects in the spray area, except those objects required by the process to be at high voltage, shall be adequately grounded. This requirement shall apply to paint containers, wash cans, guards, hose connectors, brackets, and any other electrically conductive objects or devices in the area.

9-3.8 Signs shall be conspicuously posted to:

(a) Designate the process zone as dangerous with regards to fire and accident;

(b) Identify the grounding requirements for all electrically conductive objects in the spray area;

(c) Restrict access to qualified personnel only.

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

9-4 Spray equipment that cannot be classified as nonincendive shall comply with the following:

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

9-4.2 The equipment shall provide an automatic means of rapidly de-energizing the high voltage elements in the event the clearance between the goods being painted and the electrodes or electrostatic atomizing heads falls below that specified in 9-4.1.

9-5 Spray equipment shall be listed or approved.

Chapter 10 Electrostatic Hand Spraying Equipment

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

10-2 Electrostatic hand spraying equipment shall conform with the other applicable provisions of this standard and shall also conform to the provisions of this chapter.

10-3 Electrostatic hand spray apparatus and devices used in connection with coating operations shall be of listed types. The high voltage circuits shall be designed so as not to produce a spark of sufficient intensity to ignite the most hazardous of those vapor-air mixtures or powder-air mixtures likely to be encountered, nor result in appreciable shock hazard upon coming in contact with a grounded object under all normal operating conditions. (*See Article 500, NFPA 70, National Electrical Code.*) The electrostatically charged exposed elements of the hand gun shall be capable of being energized only by an actuator which also controls the coating material supply.

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

10-5 The handle of the spray gun shall be electrically connected to ground by a metallic connection and be so constructed that the operator in normal operating position is in intimate electrical contact with the grounded handle to prevent buildup of a static charge on the operator's body. Signs indicating the necessity for grounding other persons entering the spray area shall be conspicuously posted.

10-6 All electrically conductive objects in the spray area shall be adequately grounded. This requirement shall apply to paint containers, wash cans, and any other electrically conductive objects or devices in the area. The equipment shall carry a prominent permanently installed warning regarding the necessity for this grounding feature.

10-7 Objects being coated shall be maintained in electrical contact with the conveyor or other grounded support. Hooks shall be regularly cleaned to assure adequate grounding of 1 megohm or lower resistance. Areas of contact shall be sharp points or knife edges where possible. Points of support of the object shall be concealed from random spray, where feasible, and where the objects being sprayed are supported from a conveyor, the point of attachment to the conveyor shall be so located as not to collect spray material during normal operation.

Chapter 11 Drying, Curing, or Fusion Processes

11-1 Drying, curing, or fusion apparatus used in connection with spray application of flammable and combustible coatings shall comply with applicable requirements of NFPA 86, *Standard for Ovens and Furnaces.*

11-2 Spray booths, rooms, or other enclosures used for spray application of flammable and combustible coatings shall not be used for drying, curing, or fusion operations.

Exception: As provided for in Sections 11-3 and 11-4.

11-3 If a spray booth, room, or other enclosure is also used for air drying, curing, or fusion operations and the air temperature therin is not elevated above ambient conditions, the ventilation system shall maintain the exhaust stream below 25 percent of the lower flammable limit.

11-4 Spray booths, rooms, or other enclosures used for batch-type spray operations, including automobile refinishing, may alternately be used for drying, curing, or fusion operations provided they meet all applicable requirements of this standard and all of the following requirements:

(a) The interior surfaces (especially the floor) of the spray area shall be kept free of residue.

(b) A high temperature limit switch shall be provided that shall automatically shut off the drying apparatus if the air temperatures exceeds 200 °F (93 °C).

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

(d) Spraying apparatus, drying apparatus, and the ventilating system shall be equipped with suitable interlocks so arranged that:

1. Spraying apparatus cannot be operated when drying apparatus is in operation or while portable radiant drying apparatus is in the spray area and

2. Interlocks comply with NFPA 86, *Standard for Ovens and Furnaces*.

(e) Fuel tanks containing fuel other than gasoline or diesel fuel shall have been removed from any vehicle brought into the spray area.

11-5 Drying, curing, or fusion apparatus shall be affixed with a permanently attached, prominently located warning sign indicating that ventilation shall be maintained during the drying, curing, or fusion period and that spraying shall not be conducted in the vicinity in such manner as to deposit residue on the apparatus.

11-6* All fusion apparatus shall be adequately ventilated so as to remove any vapors generated.

Chapter 12 Automobile Undercoating in Garages

12-1 Automobile undercoating operations in garages, conducted in areas having adequate natural or mechanical ventilation, are exempt from the requirements pertaining to spray coating operations, when (1) undercoating materials not more hazardous than kerosene (as classified by Underwriters Laboratories Inc. in respect to fire hazard rating 30-40) are used, or (2) undercoating materials using only solvents having a flash point in excess of 100 °F (37.8 °C) are used, and (3) no open flames are within 20 ft (6 m) while such operations are conducted.

12-2 Undercoating spray operations not conforming to the provisions of Section 12-1 shall conform to all requirements of this standard pertaining to spray finishing operations.

Chapter 13* Powder Coating

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

(a) Fluidized bed.

(b) Electrostatic fluidized bed.

(c) Powder spray guns.

(d) Electrostatic powder spray guns.

Sections 13-2 to 13-7 are general and apply to all methods of application. Sections 13-8 to 13-10 are applicable to the specific method indicated therein.

13-2 Location. Powder coating operations shall be confined to properly designed enclosures provided with protection according to Chapter 7 of this standard and located in accordance with Section 2-2 of this standard.

13-3 Enclosures. Powder shall be effectively confined by conducting coating operations within:

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

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

13-4 Electrical and Other Sources of Ignition.

(a) Electrical equipment and other sources of ignition shall conform to the requirements of Chapter 4 of this standard, and Articles 500 and 502 of NFPA 70, *National Electrical Code*.

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

(c) To minimize the possibility of ignition by static electrical sparks, powder transport, application, recovery equipment, work pieces, and all other conductive objects shall be grounded with a resistance to ground not exceeding 1 megohm.

13-5* Ventilation.

(a) Nondeposited air-suspended powders shall be safely removed from a spray operation to a powder recovery system. Sufficient airflow shall be provided to maintain the exhaust duct at a powder concentration that will not exceed one-half the "minimum explosive concentration" (MEC) of the powder in use. [*See 13-5(b) for exception.*] If the MEC of the powder has not been established, then the exhaust duct powder concentration shall be maintained below 0.015 oz per cu ft (15 g/m^3). Exhaust equipment shall bear an identification plate stating the ventilation rate for which it was designed (cu ft per minute or m^3/hr).

(b) When, by design, the coating operation is conducted

at an exhaust duct concentration above 50 percent MEC, listed suppression equipment shall be provided. (*See NFPA 69, Standard on Explosion Prevention Systems.*)

(c) Air exhausted from the recovery system of a powder operation shall not be recirculated as input air for that operation unless the particulate composition of the exhaust air has been returned to an acceptable safe level and installed equipment continuously monitors the exhausted air to signal the operator and to automatically shut down the operation in the event the particulate removal equipment fails to maintain the air in this condition.

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

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

(f) Ventilation for spray booths shall be adequate to confine air-suspended powder to the booth and recovery system at all times. Average air velocity through electrostatic booth openings shall not be less than 60 ft per minute (18.3 m/min). Average air velocity through openings of nonelectrostatic booths shall not be less than 100 ft per minute (30.5 m/min).

13-6 Drying, Curing, or Fusion Equipment.

(a) The temperature of the work piece shall not come within 50 °F (10 °C) of the autoignition temperature of the powder.

(b) The provisions of NFPA 86, *Standard for Ovens and Furnaces*, shall apply where applicable.

13-7 Operation and Maintenance.

(a) All portions of the work place surrounding the spray area, including horizontal surfaces such as ledges, beams, pipes, hoods, and booth floors, shall be maintained to prevent the accumulation of powder.

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

(c) Care shall be exercised to prevent tramp iron or spark producing material from being introduced into the powders being applied. Magnetic and filter type separators are recommended.

(d) "No Smoking" signs in large letters on contrasting color background shall be conspicuously posted at all powder coating areas and powder storage rooms.

13-8 Fixed Electrostatic Powder Spraying Equipment. The provisions of Chapter 9 and other sections of Chapter 13 of this standard shall apply to fixed electrostatic equipment, except that electrical equipment not covered therein shall conform to Section 13-4 of this chapter.

13-9 Electrostatic Hand Powder Spraying Equipment. The provisions of Chapter 10 and other sections of Chapter 13 of this standard shall apply to electrostatic hand guns when used in powder coating, except that the high voltage circuits shall be designed so as not to produce a spark of sufficient intensity to ignite any powder-air mixtures likely to be encountered instead of the vapor-air mixtures referred to, and except that electrical equipment not covered therein shall conform to Section 13-4 of this chapter.

13-10 Electrostatic Fluidized Beds.

13-10.1 Electrostatic fluidized beds and associated equipment shall be of approved types. The high voltage circuits shall be so designed that any discharge produced when the charging electrodes of the bed are approached or contacted by a grounded object shall not be of sufficient intensity to ignite any powder-air mixture likely to be encountered, nor result in an appreciable shock hazard.

13-10.2 Transformers, power packs, control apparatus, and all other electrical portions of the equipment, with the exception of the charging electrodes and their connections to the power supply, shall be located outside of the area classified as hazardous or shall otherwise conform to the requirements of Section 13-4 of this chapter.

13-10.3 All electrically conductive objects within the powder coating area shall be adequately grounded. The powder coating equipment shall carry a prominent, permanently installed warning regarding the necessity for grounding these objects.

13-10.4 Objects being coated shall be maintained in electrical contact (less than one megohm) with the conveyor or other support in order to ensure proper grounding. Hangers shall be regularly cleaned to ensure effective contact. Areas of contact shall be sharp points or knife edges where possible.

13-10.5 The electrical equipment and compressed air supplies shall be so interlocked with the ventilation system that the equipment cannot be operated unless the ventilation fans are in operation.

Chapter 14* Organic Peroxides and Plural Component Coatings

14-1 All spray operations involving the use of organic peroxides and other plural component coatings shall be conducted in spray areas protected by approved automatic sprinkler systems.

14-2 Care shall be exercised at all times to prevent the contamination of organic peroxide initiators with any foreign substance. Only spray guns and related handling equipment specifically manufactured for use with organic peroxides shall be used. Separate fluid handling equipment shall be used for the resin and for the catalyst and they shall not be interchanged.

14-2.1 All wetted portions of organic peroxide handling equipment shall be constructed of stainless steel (300 series), polyethylene, Teflon®, or other materials which are specifically recommended for the application.

14-2.2 Care shall be exercised to prevent contamination of organic peroxides with dusts or overspray residues resulting from the sanding or spraying of finishing materials. Such mixing may result in a spontaneous fire or explosion.

14-2.3 All spilled peroxides shall be promptly removed so there are no residues. Spilled material may be absorbed by using a noncombustible absorbent and then promptly disposed of in accordance with the manufacturer's recommendation.

14-3 Organic peroxides shall be stored in a cool segregated area, preferably a detached building apart from other finishing materials. Only minimum daily requirements in proper containers shall be brought to the processing area. At the end of a day's operations any unmixed organic peroxide shall be returned to the organic peroxide storage area. This material shall not be returned to the original container. Organic peroxides shall be kept away from all sources of heat including steam pipes, radiators, open flames or sparks, and solar radiation.

14-4* Care shall be exercised in handling organic peroxides to avoid shock and friction which can cause decomposition and violent reaction.

14-5* Organic peroxides shall not be mixed directly with any cobalt compounds or other promoters or accelerators as violent decomposition or explosion may result. To minimize the possibility of such accidental mixing, these materials shall not be stored adjacent to each other.

14-6 Smoking shall be prohibited and "No Smoking" signs shall be prominently displayed and only nonsparking tools shall be used in any area where organic peroxides are stored, mixed, or applied.

14-7 Only designated personnel trained to use and handle organic peroxides shall be permitted to use these materials.

14-8 Where organic peroxides are used, the Material Safety Data Sheet (MSDS), or its equivalent, shall be consulted.

Chapter 15* Training

15-1 All personnel involved in spray application in processes covered by this standard shall be instructed in the potential safety and health hazards, the operational, maintenance and emergency procedures required, and the importance of constant operator awareness.

15-2 Personnel required to handle or use flammable or combustible materials shall be instructed in the safe handling, storage, and use of the materials, as well as the emergency procedures that may be required.

15-3* All personnel required to enter or to work within confined or enclosed spaces shall be instructed as to the nature of the hazard involved, the necessary precautions to be taken, and in the use of protective and emergency equipment required.

15-4 All personnel shall be instructed in the proper use, maintenance, and storage of all emergency, safety, or personal protective equipment that they may be required to use in their normal work performance.

15-5 Some appropriate form of documentation shall be employed to record the type and date of training provided to each individual involved in these processes.

Chapter 16 Referenced Publications

16-1 The following documents or portions thereof are referenced within this standard and shall be considered part of the requirements of this document. The edition indicated for each reference is the current edition as of the date of the NFPA issuance of this document.

16-1.1 NFPA Publications. National Fire Protection Association, Batterymarch Park, Quincy, MA 02269.

NFPA 10-1988, *Standard for Portable Fire Extinguishers*

NFPA 12-1989, *Standard on Carbon Dioxide Extinguishing Systems*

NFPA 12A-1989, *Standard on Halon 1301 Fire Extinguishing Systems*

NFPA 12B-1985, *Standard on Halon 1211 Fire Extinguishing Systems*

NFPA 13-1989, *Standard for the Installation of Sprinkler Systems*

NFPA 17-1985, *Standard for Dry Chemical Extinguishing Systems*

NFPA 30-1987, *Flammable and Combustible Liquids Code*

NFPA 69-1986, *Standard on Explosion Prevention Systems*

NFPA 70-1990, *National Electrical Code*

NFPA 86-1985, *Standard for Ovens and Furnaces*

NFPA 91-1983, *Standard for the Installation of Blower and Exhaust Systems for Dust, Stock and Vapor Removal or Conveying*

NFPA 321-1987, *Standard on Basic Classification of Flammable and Combustible Liquids*

NFPA 654-1988, *Standard for the Prevention of Fire and Dust Explosions in the Chemical, Dye, Pharmaceutical and Plastics Industries.*

16-1.2 Other Publications.

ASME, *Code for Unfired Pressure Vessels*, 1980 American Society of Mechanical Engineers, United Engineering Center, 345 East 47 St., New York, NY 10017.

Appendix A

This Appendix is not part of the requirements of this NFPA document, but is included for information purposes only.

The following Appendix material is provided to explain basic principles and give loss experience.

A-1 Scope and Definitions — General.

The safety of life and property from fire or explosion as a result of spray applications of flammable and combustible paints and finishes varies depending upon the arrangement and operation of a particular installation.

The principal hazards of spray application operations originate from flammable or combustible liquids or powders and their vapors or mists and from highly combustible residues or powders.

Properly constructed spray booths, with adequate mechanical ventilation, may be used to discharge vapors or powder to a safe location and reduce the possibility of an explosion. In a like manner, the accumulation of overspray residues, many of which are not only highly combustible but subject to spontaneous ignition, can be controlled.

The elimination of all sources of ignition in areas where flammable or combustible liquids, vapors, mists, or combustible residues are present, together with constant supervision and maintenance, are essential to the safe operations of spraying.

The human element necessitates careful consideration of the location of the operations and the installation of extinguishing equipment so that, if a fire does occur, the possibility of its spread to other property will be reduced and the probability of damage to other property by extinguishing agents will be minimized.

A-1-1 Scope.

A-1-1.3(a) Outdoor Application. This standard does not cover the outdoor spray application to buildings, bridges, tanks, or similar structures. With such occasional applications, overspray deposits are not likely to create a hazardous condition and the space in which flammable vapor-air mixtures may be present is limited because of atmospheric dilution.

A-1-1.3(b) Indoor Application. The occasional operation of small portable spraying apparatus for spraying building interiors and similar uses is such that hazardous accumulations of overspray deposits are not likely to occur. Such operations are not within the scope of this standard.

When building or maintenance spraying is considered outside the scope of this standard by the authority having jurisdiction because of the infrequency of application, the following safeguards should be observed:

(a) Adequate ventilation should be provided at all times when conducting indoor spraying operations, particularly in small enclosures.

(b) Spray should not be conducted in the vicinity of open flames or other sources of ignition.

(c) Cans or other containers of paints, thinners, or other protective coatings should be kept tightly closed at all times when they are not required to be open to replenish the supply of such material at the place of application.

(d) Oily or paint-laden rags or waste should be promptly disposed of at the end of each day's operations because of the danger of spontaneous ignition. The same fundamental requirements of cleanliness should be observed as are required in the spray application of coating materials in industrial processes.

A-1-1.4 Waterborne Coatings. Flammable and combustible application of finishing materials contemplated by this standard do not ordinarily include water solutions nor water-emulsion liquids. Certain water-emulsion liquids, however, although involving little or no hazard in the liquid state, may leave highly combustible residues upon evaporation of the liquid carrier. The provisions of this standard for minimizing the hazards of combustible residues should be followed irrespective of the characteristics of the liquid carrier.

A-2 Location of Spray Application Operations.

General. Fires in spray areas develop rapidly with large quantities of heat and smoke generated. Therefore, facilities should be located so that there is adequate egress for operating and maintenance personnel and access for fire fighting operations.

Factories. In factories conducting extensive spray application operations, it is desirable that the process be confined to a building detached or separated by fire walls from storage or other processing buildings wherever practical.

The adaptation of assembly lines or conveyor systems to spray processes may present some additional problems of fire hazard segregation. If conveyor systems extend to or from a detached building, a sprinklered noncombustible connecting passageway may be advisable. If conveyor systems go through floors, the floor openings should be surrounded by deep draft curtains on the ceiling beneath and may be provided with automatically controlled high velocity spray nozzles arranged to set up a counter draft. If conveyor systems pierce fire walls, it is difficult to arrange automatic fire doors to protect the openings in a practical and reliable manner. In some instances, such openings have been provided with noncombustible tunnels extending on each side of fire wall with tunnels protected by specially designed automatic spray or sprinkler systems.

Rooms containing spray application operations should preferably be separated from other occupancies by tight-fitting partitions. In sprinklered buildings, rooms of extensive area having spray finishing operations should be provided with noncombustible draft curtains, extending downward from ceilings as far as practical but not less than 18 in. (46 cm). Such curtains aid in preventing the opening of sprinklers outside the area enclosed by curtains and tend to confine the discharge of water to the immediate area of the fire.

Where spray application operations are located on upper floors of buildings, they should not be located immediately over high concentrations of damageable goods and positive provisions should be made for the waterproofing and drainage of the floor of the spray area.

Waterproof floors shall be arranged to drain to the outside of building, internal drains or other suitable place. Properly designed and guarded drains or scuppers of sufficient number and size to dispose of all surplus water likely

to be discharged by automatic sprinklers over the waterproof area should be provided.

Spray application operations involving flammable or combustible liquids should not be located in any basement area.

A-3 Spray Booths and Spray Rooms — General. Spray booths may be of a wide variety of shapes and sizes to accommodate the various industrial applications of spray finishing. Without the use of a spray booth, the spray area as defined in Chapter 1 may be of considerable magnitude with all of the requirements of this standard for a spray area applicable thereto. 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-4 Electrical and Other Sources of Ignition.

A-4-1 Exceptions. It will be observed that, because of the requirements of special safeguards, electrostatic apparatus, drying, curing, or fusion apparatus and automobile undercoating spray operations in garages are covered in separate chapters.

A-4-2 Sources of Ignition Other than Electrical. It is obvious that there should be no open flames or spark-producing equipment in any area where, because of inadequate ventilation, explosive vapor-air mixtures or mists are present. It is equally obvious that no open flames or spark-producing equipment should be so located that there will be deposited on them highly combustible spray residues. Because some residues may be ignited at very low temperatures, additional consideration must be given to operating temperatures of equipment subject to residue deposits. Many deposits may be ignited at temperatures produced by low pressure steam pipes or by incandescent light globes, even those of explosionproof type.

A-4-5 Electrical Equipment in Spray Areas Subject to Residue Accumulations. From Section 4-5, it will be noted that, in general, electrical equipment is not permitted inside any spray booth, in the exhaust duct from a spray booth, in the entrained air of an exhaust system from a spraying operation, nor in the direct path of spray, unless such equipment is specifically listed for both readily ignitible deposits and flammable vapor.

A-4-6 Electrical Equipment in Spray Areas Not Subject to Residue Accumulation. The determination of the extent of hazardous areas involved in spray application requires an understanding of the dual hazards of flammable vapors, mists, or powders and highly combustible deposits applied to each individual installation.

From Section 4-6, it will be noted that when electrical equipment is installed in locations not subject to deposits of combustible residues but, due to inadequate ventilation, is subject to explosive concentrations of flammable vapors or mists, only approved explosionproof, or other type approved for Class I, Division 1 locations, equipment is permitted.

A-4-7 Electrical Equipment Adjacent to Spray Areas. When spray areas containing dangerous quantities of flammable or combustible vapors, mists, residues, dusts, or deposits under normal operation have been determined, the adjacent unpartitioned areas, which are safe under normal operating conditions, but which may become dangerous due to accident or careless operation, should be given consideration. Equipment known to produce sparks or flames under normal operating conditions should not be installed in these adjacent unpartitioned areas.

When spraying operations are confined to adequately ventilated spray booths or rooms, there should be no dangerous concentrations of flammable vapors, mists, or dusts, nor deposits of combustible residues outside of the spray booth under normal operating conditions.

In the interest of safety, however, it will be noted that, unless separated by partitions, the area within certain distances of the hazardous spray area, depending upon the arrangement, is considered Division 2; that is, it should contain no equipment that produces sparks under normal operation. Furthermore, within this distance, electric lamps must be enclosed to prevent hot particles falling on freshly painted stock or other readily ignitible material and, if subject to mechanical injury, must be properly guarded.

A-4-8 Fixed Lighting. Even though it is contemplated that areas adjacent to spray booths (particularly where coating material stocks are located) will be provided with ventilation sufficient to prevent the presence of flammable vapors or deposits, it is nevertheless advisable that electric lamps be totally enclosed to prevent the falling of hot particles in any area where there may be freshly painted stock, accidentally spilled flammable or combustible materials, or readily ignitible refuse, or flammable or combustible liquid containers accidentally left open.

Where electric lamps are in areas subject to atmospheres of flammable vapor, lamp globes should be replaced when electricity is off; otherwise, there may be a spark from this source.

A-4-9 Portable Lighting. Sufficient lighting for coating operations, booth cleaning, and booth repair work should be provided at the time the equipment is installed in order to avoid the use of "temporary" or "emergency" lamps connected to ordinary extension cords in this area. A satisfactory and practical method of lighting is the use of ¼-in. (0.6-cm) thick wired or tempered glass panels in the top or sides of spray booths with electrical light fixtures outside the booth, hence not in the direct path of the spray.

A-4-9.1 Static Charges. In order to prevent sparks from the accumulation of static electricity, all electrically conductive objects including metal parts of spray booths, exhaust ducts, piping systems conveying flammable or combustible liquids, paint, or solvent tanks or canisters should be properly electrically grounded.

A-4-9.2 Static Charges on Airless Systems. "Airless" spray painting employing high fluid pressures can produce static electricity that may cause a spark. Therefore, the airless spray gun and any conductive object being sprayed, including containers into which the flow from the gun is directed, should be properly electrically grounded. This can be done by either using a hose that contains an electrical conductor, or attaching a properly grounded static wire to the spray gun and electrically grounding the object being sprayed.

A-5 Ventilation — General. Adequate mechanical ventilation, together with vapors or mists of flammable or combustible materials, should not be underestimated, nor should they be viewed with such concern as to assume they cannot be controlled by proper engineering.

A-5-2 Liquid Coating Systems — General, LFL Determination. Paints, varnishes, lacquers, and other coating materials may contain volatile flammable solvents; in addition, such solvents may be added as "thinners." Such solvents, when exposed to the atmosphere, give off vapors that mix with the surrounding air and, if the concentration of these vapors reaches as much as approximately one percent, an explosion may occur, if at the same time a spark or other source of ignition is present.

Spray applications using only combustible liquids with relatively high flash points, although less likely to produce flammable atmospheres than those using low flash point flammable liquids, may nevertheless result in mists that are capable of propagating a flame somewhat similar to combustible solids in dust explosions.

Theoretical considerations may assist in hazard evaluation in some instances. For example, 1 liquid gal (3.8 L) of the average flammable solvent will occupy approximately 23 cu ft (0.6 m^3) when evaporated into vapor at average room temperature. Therefore, if 1 gal (3.8 L) of liquid solvent is completely evaporated and thoroughly mixed with the surrounding air of an enclosure, the enclosure must have a volume of more than 2,300 cu ft (65 m^3) to avoid a flammable mixture if the lower limit of the flammable range of the solvent is one percent in air. This is a conservative number; almost all of the solvents used in spray finishing have an LFL higher than one percent. In attempting to use such theoretical considerations caution should be exercised to prevent erroneous conclusions. When flammable liquids are sprayed, the area in the direct path of the spray will exceed the LFL. Vapors from most flammable solvents are heavier than air and small quantities of vapor may form a flammable mixture at low unventilated spaces in the vicinity of or even remote from the point of evaporation before they so mix with the full volume of available air by natural diffusion that the mixture becomes too "lean" to burn. When flammable liquid is sprayed, the rate of evaporation is greatly increased so that the lower flammable limit is quickly reached. For these reasons, a safety factor of 4 to 1 has been traditionally used and the ventilation requirement rounded off to 10,000 cu ft per gal (74.5 m^3/L) evaporated at maximum flow rate of the spray gun.

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

Spray Booths. In addition to maintaining the enclosure below the LFL, it is also necessary to confine overspray.

When spray booths are provided with adequate ventilation, booths may be so located with respect to the source of their makeup air replenishment that air in the entire space about the booth moves toward spray booth exhausts and "dead air pockets" are minimized. This may eliminate the need for mechanical ventilation in areas adjacent to the booth. With moderately uniform air movement throughout the space about a spray booth, an air change of once every 3 to 5 minutes should be sufficient to prevent the formation in this area of flammable vapors under ordinary conditions.

Where spraying is conducted inside a spray booth using conventional spray equipment, an average air velocity of approximately 100 linear ft per minute (30.5 m/min) should contain overspray. Under these conditions the ventilating fan capacity in cu ft per minute (m^3/min) must then be 100 ft per minute (30.5 m/min) times the total area of booth openings, such as frontal area, conveyor openings, etc., in sq ft (m^2). Where spraying operations are extensive or where special purpose spray booths such as canopy or down-draft spray booths are used, additional ventilation may be necessary.

A lower rate of exhaust ventilation may be employed in electrostatic spraying and other efficient coating methods that produce low volumes of overspray and solvent vapors. Generally, a rate of exhaust of approximately 60 linear ft per minute (18.3 m/min) will maintain the atmosphere well below the explosive limits in these operations because the volume of coating material being applied is normally less than in other types of spraying, resulting in a lower volume of solvent vapors released and overspray created.

Spray Rooms and Open Spraying. Spray rooms should be provided with exhaust system openings near floor level since most solvent vapors are heavier than air. System design should provide uniform air movement to sweep vapors to exhaust openings. While 10,000 cu ft of air per gal (74.5 m^3/L) of solvent evaporated is adequate to maintain solvent vapor below the LFL, additional ventilation may be necessary due to the greater toxicity of some solvents. The authority having jurisdiction should be consulted.

Noncombustible false ceilings or partitions may be used to improve ventilation of spray rooms. False ceilings or partitions extending to the boundaries of the hazardous area will permit the installation of nonsparking electrical equipment above the ceilings, subject to the authority having jurisdiction.

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

A-5-6 Makeup Air. Since the air exhausted from spray applications is normally contaminated and can only be recirculated under rigidly controlled conditions, consideration should be given to the heating of incoming air in cold weather. An efficient and satisfactory method of heating rooms containing several spray booths is to strategically locate air intakes so as to provide a uniform sweep of air throughout the entire room towards exhaust fans and provide each air intake with a safe heating arrangement.

In some heating arrangements, forced makeup or replacement air directly compensating for the contaminated

air exhausted from spray application is used in place of, or to augment, general area heating and ventilation.

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

The features that should be considered include (a) the location of heat sources to conform to Chapter 4; (b) the location of air intakes to prevent recirculating contaminated air and the equipping of air intakes with appropriate screens or filters; (c) automatic temperature and proportioning controls, including an independent excess temperature limit control; (d) an interlocking safety system associated with the heater to automatically provide for its safe ignition and to minimize the hazards that might result from failure of proper cycle of operations, proper pressure of fuel supply, ventilation, and electrical power; (e) an interlocking of the spray booth exhaust and air replacement system to ensure that spray booth exhaust will be running during the operation of air replacement system in order to provide a proper balance of supply and replacement air; and (f) in the case of direct-fired units, the avoidance of concentrations of unburned fuel or products of combustion that would be injurious to personnel if inhaled.

A-5-10 Exhaust Systems. Exhaust systems should be individually ducted to the outside. Where treatment of exhaust is necessary to satisfy EPA requirements or where energy conservation measures are used, this may not be practical. Manifolding booth exhaust systems increases the fire hazard. A fire starting in one booth may spread through the exhaust system and involve other booths. Heat exchangers are sometimes used to preheat the exhaust before it enters the incinerator. This may result in spontaneous ignition of residue accumulations on heat exchanger surfaces.

A-5-17 Additional Ventilation. If there are other operations that give off flammable vapors in the vicinity of a spray application operation, these should be provided with independent mechanical ventilation.

A-6 Flammable and Combustible Liquid Storage and Handling.

A-6-1 For large spray operations, flammable and combustible coating material, thinner, and solvents may be stored in the following locations: underground storage tanks, aboveground tanks, separate buildings, or separate dedicated rooms within the plant. In some cases, paint is then pumped to a paint mixing room (paint kitchen) and then pumped to the spray area with recirculation back to paint kitchen or storage tanks.

For smaller operations, separate storage and paint mixing areas may not be justified. However, it is desirable to minimize 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 metal enclosed structure; 3) use of metal containers with limitations on quantity of paint or solvent located near the spray area.

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

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

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

A-6-4.5 The shut-off should be accomplished by means of an interlock with a fire detection system or the automatic fire extinguishing system for the spray area.

A-7 Protection — General. As indicated in Chapter 6 of the standard, it is inadvisable to keep large quantities of flammable or combustible liquids in areas that expose personnel or important property to injury or loss. The primary reason for this requirement is that fires in flammable liquids are difficult to extinguish by usual methods and, if large quantities are involved, they may spread the fire by flowing over large areas.

For fires in small amounts of flammable or combustible liquids, hand extinguishers, or large extinguishers on wheels, especially designed for such fires are effective. If large quantities of liquids are to be protected, suitable automatic equipment should be provided and special attention should be given to proper dikes, curbs, and drains to prevent the flow to other property.

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

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

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

A-7-4 Spray Booths and Spray Rooms. Automatic sprinklers in spray areas, including the interior of spray booths and exhaust ducts, should be on a wet pipe, preaction or deluge system in order that water may be placed on a fire in the shortest possible time. Automatic sprinklers

in spray booths and exhaust ducts should be of the lowest practical temperature rating. Sprinklers outside the booth at ceiling level should be high temperature rated, 286 °F (141 °C). The delay in application of water with ordinary dry pipe sprinklers may permit a fire to spread so rapidly that final extinguishment is difficult without large resulting damage.

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

Automatic sprinklers should be located so that areas subject to substantial accumulations of overspray residue are protected. Generally, sprinklers are located no more than 4 ft (1.2 m) from side walls of booths and rooms and from dry overspray collectors (where applicable). Sprinklers in booths or rooms should be on extra hazard occupancy spacing of 90 sq ft (8.4 m^2).

Sprinklers or sprinkler systems protecting stacks or ducts should be automatic and of a type not subject to freezing. Dry pendent sprinklers are often used inside buildings near exhaust duct penetrations to the outside. Nonfreeze or dry type sprinkler systems are often used for ducts outside buildings. Sprinklers should be spaced no more than 12 ft (3.7 m) apart in the duct for adequate protection.

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

A-7-8 Automatic Powder Spray Booths. During the first few seconds in the development of a fire in a dry powder spray booth, the following observations may be made:

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

Airborne powder in the spray plumes of the gun(s) burns vigorously so long as the gun feeder(s) continues to supply fuel. Flames from about 2 to 6 ft (0.6 to 1.8 m) in length may extend from the guns but do not intrude into the gun interiors.

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).

These flames are extinguished almost instantly if their supply of airborne fuel is interrupted by shutting down the gun feeders.

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

If a fire in a powder spray booth has been sustained for an appreciable period of time (10- to 60-second delays have been observed), a propagation sequence involving the following steps may be recognized:

Heat exposure effects of the fire, acting upon the deposits of overspray powder that have accumulated on the interior surfaces of the spray enclosure, will modify a layer on the surface of the deposits to form an extremely fragile, tissue-thin structure of powder grains that have been softened only enough to adhere to adjacent grains but not enough to flow together and form a film. This is called a sintered structure.

In response to the effects of vibration and rapidly fluctuating temperature (flickering of flames, etc.) this structure will break into a "mud-cracked" pattern and individual platelets in some regions will curl up, presenting their edges to the fire-involved atmosphere. Exposure to this environment's heat and turbulence will char and dislodge platelets to form airborne glowing embers comparable to those formed by burning piles of autumn leaves.

These embers, if drawn through exhaust ductwork to the powder collector, may ignite it, resulting in explosion.

If this sequence is interrupted within the first seconds of a fire's history, then ember formation and propagation by this mechanism can be stopped. The requirements of Section 7-8 are directed toward this result.

(2) Integrated spray booth/"open" collector. Fire in the spray plumes of the guns is identical to that found in the discussion above. Since there is no exhaust duct work 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.

Attempts to extinguish fires of this type with carbon dioxide, halon, and dry chemical extinguishers have yielded disappointing results: although flame is promptly knocked down, continued production of smoke and ultimate reflash must be expected. The most satisfactory results have been yielded by thoroughly soaking the filter cartridges and residues with water.

A-8 Operations and Maintenance.

General. It should be kept in mind that (1) vapors and mists from volatile flammable or combustible liquids form explosive mixtures with air; (2) deposits of residue may ignite spontaneously or be ignited by temperatures of low-pressure steam pipes; and (3) fires involving flammable or combustible liquids or combustible residues start easily, spread rapidly, and produce intense heat. With a realization of these fundamental facts, it is obvious that the safety objectives sought by the best designed equipment may be nullified by unintentional, or careless, misuse or improper maintenance of the equipment.

The inherent characteristics of the materials used in spraying processes emphasize the fact that supervision of operations, maintenance of equipment, and daily cleaning are essential to reasonable safety. Properly designed equipment can do much to lessen, but cannot eliminate, this necessity.

Self-Inspection. Periodic inspections by a competent and reliable individual should be made to determine that all sprinkler control valves are open, fire extinguishers are properly charged and in place, electric motors and fan bearings are not overheating, fan blades are in alignment, electric wiring is properly fused, guards and globes on electric fixtures are in place, cleanliness is being maintained, and all operating instructions observed.

A-8-1 Control of Spray Residue. When spray finishing any article, there is frequently a part of the spray that does not deposit directly on the article, but deposits on adjacent surfaces as residue material. This part is referred to as overspray. Many of these residues are highly combustible, igniting at very low temperatures, and many will ignite spontaneously, resulting in fast spreading fires. To limit the duration and intensity of fires, the accumulation of deposits must be prevented and controlled as much as practical. Management should prohibit spraying processes in locations not designed for the purpose, irrespective of the pressure of production.

A-8-3 Cleaning. The interior of spray booths, exhaust fan blades, and exhaust ducts should be regularly cleaned 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 may be used in ducts and 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 soaplike or water soluble material immediately after cleaning, adhesive spray deposits may 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, may also be used to facilitate cleaning of the overspray residue.

Properly maintained water wash booths offer lower fire loading than dry booths. In order 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 work 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. The pH of the water in the tank should be checked at least once each shift and chemicals added to keep the paint in the water tank neutralized. Sludge should be removed from the tank at least once each shift.

A-8-5 Spontaneous Ignition. Many residue scrapings, used filters or filter rolls, and spray booth refuse are highly susceptible to spontaneous ignition; hence, they should be carried to a safe, well-detached location and properly disposed of daily. The use of water wash spray booths reduces the possibility of spontaneous ignition. Nitrocellulose residues should not be burned in boilers as the gases of decomposition may cause an explosion.

A-8-6 Disposal. 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-8-9 Bleaching compounds, such as hydrogen peroxide, hypochlorites, perchlorates, or other oxidizing compounds, when in contact with organic finishing materials may cause fires. Hence, if bleaching compounds are to be used in spray booths, these booths should first be thoroughly cleaned and used only for this purpose. The alternate use of spray booths for bleaching compounds and other finishing materials, or the alternate use of lacquers containing nitrocellulose and other types of finishing materials containing drying oils, such as varnishes, oil-based stains, air-drying enamels, primers, etc., without first thoroughly removing all traces of deposits may result in a spontaneous ignition fire.

A-8-10 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 they may 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 control of the subsequent hazard are prevented because of this unpredictability. While 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. Those factors are: heat, pressure, 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, spray gun cups).

A-8-12 Repairing. 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 kept 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 kept readily available.

The use of welding or cutting torches should be pro-

hibited except under the supervision of a competent person familiar with the fire hazards involved.

A-11-6 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-13 Powder Coating.

A-13-5 Ventilation. The probability that a fire which 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 assure that, under "worst case" conditions (maximum rated delivery of all guns going into the exhaust with no allowance for collection of powder on work pieces), a powder-in-air concentration of more than 50 percent MEC cannot be reached.

Calculation of Worst Case Powder-in-Air Concentration as Percent 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. Each of these terms is discussed individually below.

MEC. Specifications usually available from the manufacturers of coating powders may 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 oz per 1,000 cu ft (30 g/m^3) may be used. This is considered representative of the lowest MEC to be found among common coating powders (*see Table 2*).

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

Step 1: Recheck to be sure the following terms have been expressed in the units shown (*See Table 1.*)

Table 1

	English Units	Metric Units
MEC	Ounces per 1,000 Cubic Feet (oz/M ft.^{3})	Grams per Cubic Meter (g/m^3)
Air Flow	Cubic Feet per Minute (cfm)	Cubic Meters per Hour (m^3/hr)
Maximum Delivery	Ounces per Minute (oz/min)	Grams per Hour (g/hr)

NOTE: When proceeding with calculations, do not mix units from one system to the other. Stay in one system only.

Step 2: Divide Maximum Delivery by Air Flow.

$$\frac{\text{Maximum Delivery}}{\text{Air Flow}} = \text{Maximum Concentration}$$

Step 3: Divide Maximum Concentration by MEC and then multiply by 100 to express Maximum Concentration as a percent of MEC.

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

NOTE: 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 hoses 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 may be considered to have adequate ventilation.

Table 2 Test Data on Powders Tested by a Nationally Recognized Testing Laboratory.

Type	Sample No.	English Units MEC oz/1000 cu ft	English Units Auto Ign. Temp. (°F)	Metric Units MEC gms/cu m	Metric Units Auto Ign. Temp. (°C)
Epoxy	1	—	—	—	—
	2	45	—	45	—
	3	65	—	65	—
	4	39	—	39	—
	5	52	—	52	—
	6	46	925	46	496
	7	70	970	70	521
	8	97	998	97	537
	9	91	1002	91	539
	10	78	993	78	534
	11	78	1024	78	551
Polyester	1	65	795	65	424
	2*	71	790	71	439
Polyolefin	1	32	—	32	
	2	32	960	32	516

*Same as Sample 1 but with metallic component in pigment.

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

Exhaust Airflow. Airflow through the exhaust system may be established from equipment specifications. Alternatively, it may 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 feet per minute or cubic meters per hour.

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 these ducts can be made only through application of complicated, precise procedures by highly trained technicians.

A-14 Organic Peroxides. 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 and type and amount of diluent.

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

For purposes of storage and warehousing, NFPA 43B, *Code for the Storage of Organic Peroxide Formulations*, classifies these materials using a five-tiered system, depending on their relative hazard as packaged for shipment. Thus, NFPA 43B recognizes that the different formulations available differ widely in fire hazard. In many cases, the "active oxygen," a measure of the material's catalytic activity and one measure of its reactivity hazard, has been reduced, thus reducing any explosion hazard.

The following precautions are recommended.

1. Organic peroxide formulations should be stored in a cool, dry location that is separated from the work area. The formulations should not be stored with materials with which it may not be compatible. Storage quantity limitations and fire protection requirements are contained in NFPA 43B, *Code for the Storage of Organic Peroxide Formulations*.

2. The amount of organic peroxide in the work area should be limited to that needed for a single day's use. Any organic peroxide remaining at the end of a work day should be returned to the storage area.

3. All necessary precautions, as recommended by the supplier, should be taken when using organic peroxides. Good housekeeping should be strictly observed and any spills should be immediately cleaned. Spilled material or material (such as resin) that has been contaminated with organic peroxide must be immediately and properly disposed of. 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-14-5 Stability. 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 peroxides 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 will decompose quietly when exposed to a slow, gradual increase in temperature. However, these same formulations may 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 will generally burn more slowly than the concentrated or pure material and is less sensitive to shock or impact.

A-15 Training.

General. 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. It therefore is important to maintain an effective and ongoing training program for all employees involved in such work. New employees must be effectively trained before being assigned to a job. After the initial training, employees must receive periodic retraining to assure their knowledge and understanding of normal process procedures as well as with emergency procedures or changes in procedures. Safe work habits must be developed. They do not occur naturally.

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

A-15-3 Confined Space Entry. Any work requiring entry of employees into confined spaces should be conducted in accordance with a written procedure rigidly followed. This procedure should include, but not be limited to:

(a) Analysis of confined space atmosphere for flammable, combustible, toxic, or oxygen-deficient conditions.

(b) Rescue, fire, and emergency procedures.

(c) Locking and tagging procedures for all power and process hazard sources.

(d) Ventilation.

(e) Personal protective equipment.

(f) Proper tools and electrical equipment.

(g) Written entry authorization by qualified responsible individual.

Appendix B Fire Record

This Appendix is not part of the requirements of this NFPA document, but is included for information purposes only.

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.

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 may operate depending on quantity of overspray residue. Final extinguishment is generally by small hose or portable extinguishers.

The leading causes of fire in conventional systems were: (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; and (5) discharge of static electricity.

The leading causes of fire in electrostatic paint spray operations are: (1) ungrounded or improperly grounded objects in the spray area, (2) failure to fully de-energize equipment before cleaning, and (3) pin-hole leaks in the paint hose to the spray gun. Other causes are similar to nonelectrostatic systems, such as smoking and cutting and welding.

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

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 7-8 function normally. Total heat release is so restricted that no damage at all results.

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

A. When equipment is configured to use conventional cyclone, baghouse, or enclosed cartridge collectors connected to the spray booth by duct work, this results in ignition of the collector by the mechanism described in A-7-8. Damage can be limited if the collectors are properly vented and the vents ducted to the outside [maximum explosion vent duct length approximately 10 ft (3 m)]. When the collector is vented inside, burning powder is discharged into the room in substantial quantities. The burning powder may result in a rapid pressurization of the room causing structural damage and/or it may ignite combustibles in the area and open automatic sprinklers at ceiling level. In virtually all cases investigated, the pressure pulse generated by ignition of an enclosed collector has resulted in backstreaming of the duct work 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.

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

Appendix C Referenced Publications

C-1 The following documents or portions thereof are referenced within this standard for informational purposes only and thus are not considered part of the requirements of this document. The edition indicated for each reference is the current edition as of the date of the NFPA issuance of this document.

C-1.1 NFPA Publications. National Fire Protection Association, Batterymarch Park, Quincy, MA 02269.

NFPA 68-1988, *Guide for Venting of Deflagrations*

NFPA 77-1988, *Recommended Practice on Static Electricity.*

C-1.2 Other Publications.

AIA Research Report No. 11, *Fire and Explosion Hazards of Organic Peroxides*, American Insurance Association, 85 John St., New York, NY 10038.

FM Loss Prevention Data Sheets 7-80 and 7-81, *Organic Peroxides*, Factory Mutual Engineeering Corporation, Box 688, Norwood, MA 02060.

Index