

NFPA No.

33



SPRAY APPLICATION 1973



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NATIONAL FIRE PROTECTION ASSOCIATION
International

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Standard for Spray Finishing Using Flammable and Combustible Materials

NFPA No. 33 — 1973

1973 Edition of No. 33

This 1973 edition of the Standard for Spray Finishing Using Flammable and Combustible Materials was adopted by the National Fire Protection Association at its Annual Meeting held May 16, 1973 on recommendation of the NFPA Committee on Finishing Processes. It supersedes the edition of 1969.

Origin and Development of No. 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 No. 34). Revised editions were published in 1926, 1928, 1935, 1937, 1941, 1946, 1950, 1953, 1954, 1955, 1957, 1959, 1960, 1961, 1966, 1969 and 1973.

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CONTENTS

Foreword	33-3
Chapter 1. Scope and Definitions	33-4
Chapter 2. Location of Spray Application Operations	33-6
Chapter 3. Spray Booths	33-7
Chapter 4. Electrical and Other Sources of Ignition	33-10
Chapter 5. Ventilation	33-15
Chapter 6. Flammable and Combustible Liquids Storage and Handling	33-18
Chapter 7. Protection	33-21
Chapter 8. Operations and Maintenance	33-22
Chapter 9. Fixed Electrostatic Apparatus	33-24
Chapter 10. Electrostatic Hand Spraying Equipment	33-26
Chapter 11. Drying, Curing or Fusion Apparatus	33-28
Chapter 12. Automobile Undercoating in Garages	33-29
Chapter 13. Powder Coating	33-30
Chapter 14. Organic Peroxides and Dual Component Coatings	33-33
Appendix	33-35

Standard for
Spray Application Using Flammable
and Combustible Materials

NFPA No. 33 — 1973

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.

In order that the best practical arrangement may be obtained for the particular installation involved and in order that the Standard Requirements may be more clearly understood, an informative Appendix discussing the basic hazards and appropriate safeguards is included in this pamphlet.

The reader is referred to the following other NFPA Standards as being related to this general field of interest:

Fundamental Principles for Prevention of Dust Explosions in Industrial Plants, NFPA No. 63.

National Electrical Code, NFPA No. 70.

Ovens and Furnaces, NFPA No. 86A.

Blowers and Exhaust Systems, NFPA No. 91.

Prevention of Dust Explosions in the Plastics Industry, NFPA No. 654.

Notice

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

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.

1-2 Definitions.

Approved signifies acceptance, by the authority having jurisdiction, of design, equipment, installation, or intended use as required by this standard. Devices having been tested and listed for a specific purpose by a nationally recognized testing laboratory may be deemed acceptable.

Liquids. Flammable liquid shall mean any liquid having a flash point below 100° F (37.8° C) closed cup and having a vapor pressure not exceeding 40 pounds per square inch absolute (2068.6 mm) at 100° F (37.8° C). Combustible liquid shall mean any liquid having a flash point at or above 100° F (37.8° C). For further classification see *Basic Classification of Flammable and Combustible Liquids*, NFPA No. 321.

Aerated Solid Powders. Aerated powders shall mean 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 the *Standard for the Prevention of Dust Explosions in the Plastics Industry*, NFPA No. 654.

***Spraying Area.** Spraying area shall mean any area in which dangerous quantities of flammable vapors or mists, or combustible residues, dusts or deposits are present due to the operation of spraying processes.

A spraying area shall include:

- (a) The interior of spray booths except as specifically provided in 11-4.
- (b) The interior of ducts exhausting from spraying processes.
- (c) Any area in the direct path of spray or any area containing dangerous quantities of air-suspended powder or air-suspended combustible residue, dust, deposits, vapor or mists as a result of spraying operations.

The authority having jurisdiction may, for the purpose of this standard, define the limits of the spraying area in any specific case. The "spraying 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 "spraying area" will ordinarily not extend beyond the booth enclosure. When, however, spraying operations are not confined to adequately ventilated spaces the "spraying area" may extend throughout the entire room containing spraying operations.

Spray Booth. Spray booth or spray room shall mean 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.

Waterwash Spray Booth. Waterwash spray booth shall mean 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.

Dry Spray Booth. Dry spray booth shall mean 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.

Fluidized Bed. Fluidized bed shall mean 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.

Electrostatic Fluidized Bed. Electrostatic fluidized bed shall mean a container holding powder coating material which is aerated from below so as to form an air-supported expanded cloud of such material which 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.

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 two hours fire resistance rating.

Chapter 3. Spray Booths

***3-1** Spray booths shall be substantially constructed of steel not thinner than No. 18 MSG, securely and rigidly supported, or of concrete or masonry, except that aluminum or other substantial noncombustible material may be used for intermittent or low volume spraying, subject to the approval of the authority having jurisdiction. Spray booths shall be designed to sweep air currents toward the exhaust outlet.

3-2 The interior surfaces of spray booths shall be smooth and continuous without edges and otherwise designed to prevent pocketing of residues and facilitate cleaning and washing without injury.

3-3 The floor surface of a spray booth and operator's working area, if combustible, shall be covered with noncombustible material of such character as to facilitate the safe cleaning and removal of residues.

3-4 Distribution or baffle plates, if installed to promote an even flow of air through booth or cause the deposit of overspray before it enters exhaust duct, shall be of noncombustible material and readily removable or accessible on both sides for cleaning. Such plates shall not be located in exhaust ducts.

3-5 Dry Type Overspray Collectors — (Exhaust Air Filters). In conventional dry type spray booths, overspray dry filters or filter rolls, if installed, shall conform to the following:

(a) The spraying operations except electrostatic spraying operations shall be so designed, installed and maintained that the average air velocity over the open face of the booth (or booth cross section during spraying operations) shall be not less than 100 linear feet per minute. Electrostatic spraying operations shall be conducted with an average air velocity over the open face of the booth or booth cross section during spraying operations of not less than 60 linear feet per minute. Depending on the volume of the finishing material being applied and its flammability and explosion characteristics, these minimums may need to be increased. Visible gauges or audible alarms or pressure activated devices shall be installed to indicate or insure that the required air velocity is maintained. Dry spray booth equipped with a filter roll which is automatically advanced when the air velocity is reduced to that specified in this paragraph, shall be arranged to cause shutdown of spraying operations if the filter roll fails to advance automatically.

Maintenance procedures shall be established to assure replacing filter pads before excessive restriction to air flow occurs. Filter pads shall be inspected after each period of use and clogged filter pads discarded and replaced. Filter rolls shall be inspected to insure proper replacement of filter media.

(b) All discarded filter pads and filter rolls 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.

(c) The location of filters in a spray booth shall be so as to not reduce the effective booth enclosure of the articles being sprayed.

(d) Space within spray booth on the down stream and up stream sides of filters shall be protected with approved automatic sprinklers.

(e) Filters or filter rolls shall not be used when applying a spray material known to be highly susceptible to spontaneous heating and ignition.

(f) Those parts of the booth which act as supports for, or holders of filters or filter rolls shall be noncombustible.

(g) Clean filters or filter rolls shall be noncombustible or of a type having a combustibility not in excess of Class 2 filters as listed by Underwriters' Laboratories, Inc.

(h) Filters and filter rolls shall not be alternately used for different types of coating materials, where the combination of materials may be conducive to spontaneous ignition. See also 8-9.

3-6 Each spray booth having a frontal area larger than nine square feet shall have a metal deflector or curtain not less than 2½ inches deep installed at the upper outer edge of the booth, over the opening.

3-7 Where conveyors are arranged to carry work into or out of spray booths, the openings therefor shall be as small as practical.

3-8 Where the product to be sprayed is brought into a spraying area, removed from it, or manipulated while there by a self-powered vehicle capable of producing ignition, the vehicle shall not be activated while in the area unless the spraying operation is stopped, the ventilation system is in operation and the area has been sufficiently purged of vapors to insure a nonflammable atmosphere.

***3-9** Each spray booth shall be separated from other operations by not less than three feet, or by a greater distance, or by such partition or wall as the inspection department having jurisdiction may

require to reduce the danger from juxtaposition of hazardous operations.

3-10 Spray booths shall be so installed that all portions are readily accessible for cleaning. A clear space of not less than three feet on all sides shall be kept free from storage or combustible construction.

3-11 When spraying areas are illuminated through glass panels or other transparent materials, only fixed lighting units shall be used as a source of illumination. Panels shall effectively isolate the spraying area from the area in which the lighting unit is located, and shall be of a noncombustible material 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 radiation or conduction from the source of illumination.

Chapter 4. Electrical and Other Sources of Ignition

***4-1** All electrical equipment, open flames and other sources of ignition shall conform to the requirements of Chapter 4, except as follows:

(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.

(e) Finishing operations as described in 3-8.

***4-2** There shall be no open flame, spark producing equipment or exposed surfaces exceeding the ignition temperature of the material being sprayed in any spraying area as herein defined, nor within 20 feet thereof, unless separated by a partition, except as specifically permitted in 4-2 .1, 4-7, 11-3 and in *Ovens and Furnaces*, NFPA No. 86A, paragraph 200-7.

4-2.1 Equipment to process air exhausted from spray operation for removal of contaminants shall be approved by the authority having jurisdiction.

***4-3** Space heating appliances, steam pipes or hot surfaces shall not be located in a spraying area where deposits of 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 the *National Electrical Code*, NFPA No. 70.

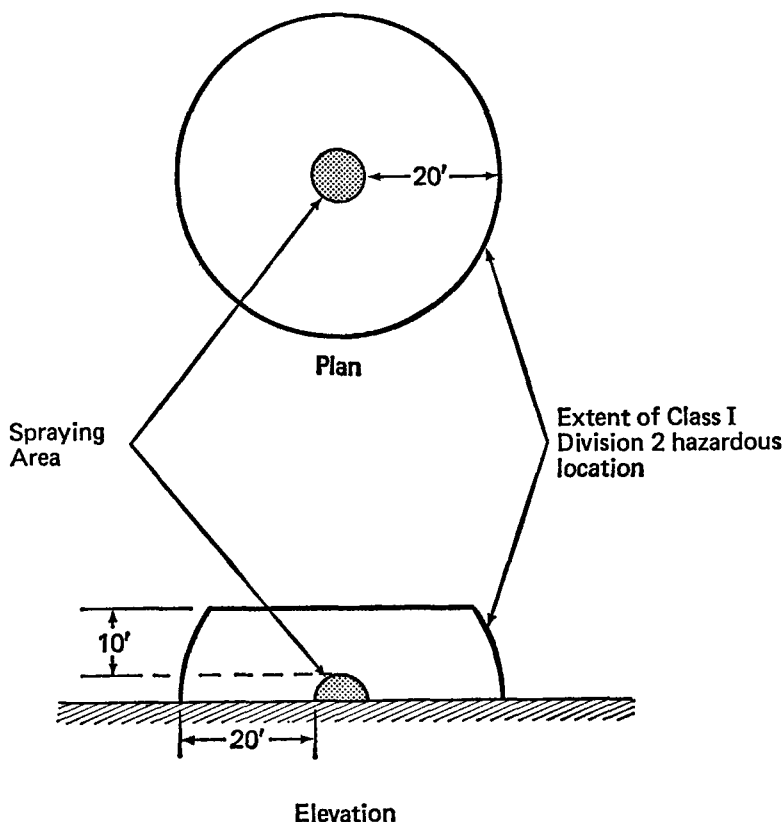
4-5 Unless specifically approved for locations containing both deposits of readily ignitable residue and explosive vapors, there shall be no electrical equipment in any spraying area, as herein defined, whereon deposit of combustible residues may readily accumulate, except wiring in rigid metal conduit, 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 spraying area as herein defined shall be of explosion-proof or other type approved for Class I, Division 1, Group D locations and shall otherwise conform to the

provisions of the *National Electrical Code*, NFPA No. 70, for Class I, Division 1 locations. (See Articles 500, 501, and 516 of the Code.)

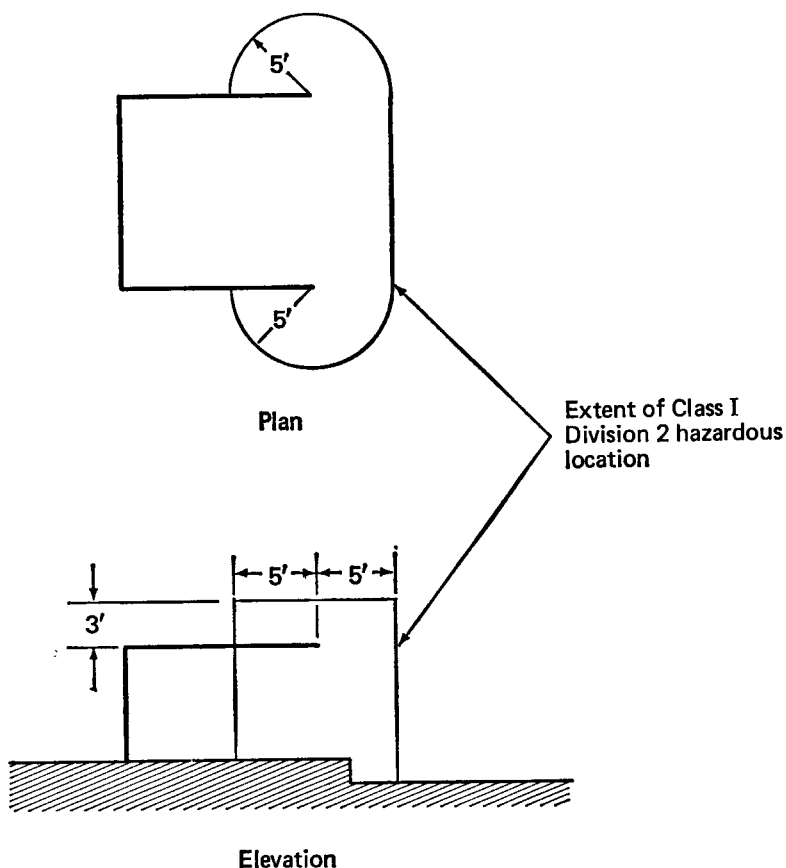
4-7 Electrical wiring and equipment located adjacent to a spraying area, as herein defined, shall conform to one of the following: 4-7.1-4-7.4.

4-7.1 Equipment outside of, but within twenty feet horizontally and ten feet vertically, of any spraying area, and not separated from it by partitions, shall not produce sparks under normal operating conditions, and shall otherwise conform to the provisions of the *National Electrical Code*, NFPA No. 70, for Class I, Division 2 locations. (See Articles 500, 501 and 516 of the Code.) See Figure 1.



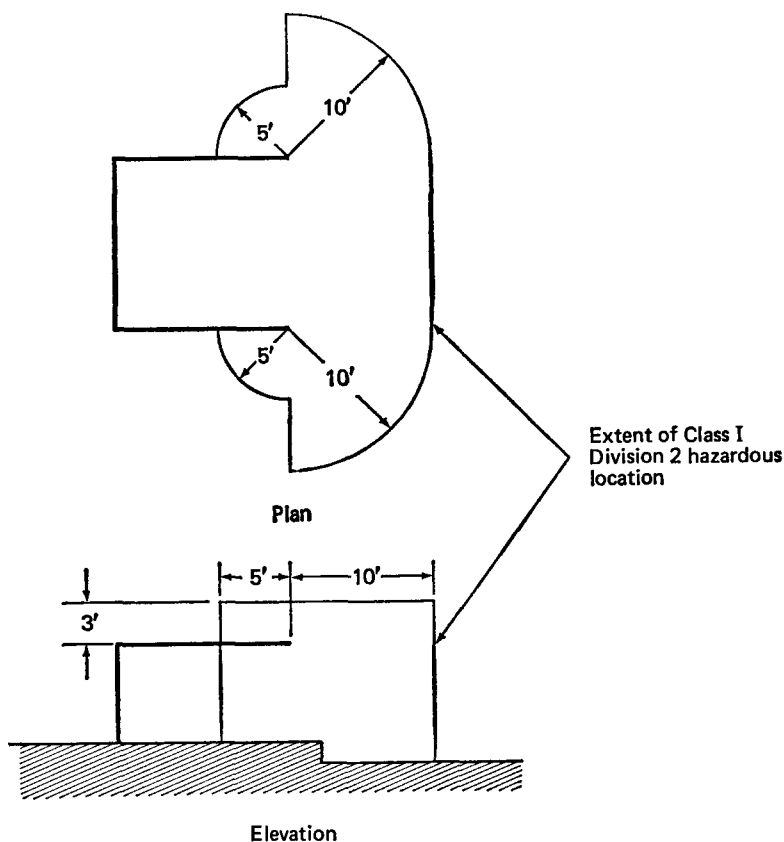
4-7.2 If spraying operations are conducted within a closed top, open face or front booth or room, the electrical wiring and equipment outside of the booth or room, but within the space shown in Figures 2 and 3, shall not produce sparks under normal operating conditions, and shall otherwise conform to the provisions of the *National Electrical Code*, NFPA No. 70, for Class I, Division 2 locations. (See Articles 500, 501 and 516 of the Code.) The space within three feet in all directions from openings other than the open face or front shall be considered as Class I, Division 2 location.

The Class I, Division 2 locations shown in Figures 2 and 3 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 five feet from the open face or open front of the booth or room, and as otherwise shown in Figure 2.
- (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 ten feet from the open face or open front of the booth or room, and as otherwise shown in Figure 3.

4-7.3 If spraying operations are conducted within an open top booth, the electrical wiring and equipment within the space five feet above the booth and within the space shown in Figure 3 as a Class I, Division 2 location adjacent to openings, shall not produce sparks under normal operating conditions, and shall otherwise conform to the provisions of the *National Electrical Code*, NFPA No. 70, for Class I, Division 2 locations. (See Articles 500, 501 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 three feet in all directions from any openings in the booth or room. Electrical wiring and equipment within the space within three feet in all directions from any opening shall not produce sparks under normal operating conditions, and shall otherwise conform to the provisions of the *National Electrical Code*, NFPA No. 70 for Class I, Division 2 locations. (See Articles 500, 501 and 516 of the Code.)

4-8 Electric lamps outside of, but within twenty feet of any spraying 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 spraying area during spraying operations. Portable electric lamps, if used during cleaning or repairing operations, shall be of the type approved for Class I, Group D, Division 1 locations.

4-9.1 All metal parts of spray booths, exhaust ducts and piping systems conveying flammable or combustible liquids or aerated 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 the *Standard for Blower and Exhaust Systems for Vapor Removal*, NFPA No. 91 where applicable and shall also conform to provisions of this section.

5-2 All spraying areas shall be provided with mechanical ventilation adequate to remove flammable vapors, mists or powders to a safe location and to confine and control combustible residues so that life or property is not endangered.

5-3 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.

5-4 Except as permitted in Chapter 13, each spray booth shall have an independent exhaust duct system discharging to building exterior. Multiple cabinet spray booths in which identical spray finishing material is used with a combined frontal area of not more than eighteen square feet may have a common exhaust.

5-5 Fan rotating element shall be nonferrous or nonsparking or the casing shall consist of or be lined with such material. 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 outside duct.

5-6 Electric motors driving exhaust fans shall not be placed inside booths or ducts. (See also Chapter 4.)

5-7 Belts shall not enter duct or booth unless belt and pulley within the duct or booth are completely enclosed.

5-8 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.

5-9 Exhaust ducts shall be protected against mechanical damage and have a clearance from unprotected combustible construction or other combustible material of not less than 18 inches, except if combustible construction is provided with the following protection applied to all surfaces within 18 inches, clearances may be reduced to the distance indicated:

- | | | |
|-----|--|-----------|
| (1) | 28 gauge sheet metal on $\frac{1}{4}$ -inch asbestos mill board | 12 inches |
| (2) | 28 gauge sheet metal on $\frac{1}{8}$ -inch asbestos mill board spaced out one inch on noncombustible spacers | 9 inches |
| (3) | 22 gauge sheet metal on 1-inch rockwool bats reinforced with wire mesh or the equivalent | 3 inches |
| (4) | Where ducts are protected with an approved automatic sprinkler system, properly maintained; the clearance may be reduced to 6 inches | |

5-10 The spray booth exhaust discharge point shall be not less than six feet from any combustible exterior wall or roof nor discharge in the direction of any combustible construction or unprotected opening in any noncombustible exterior wall within 25 feet.

5-11 Air exhausted from spray operations shall not be directed so that it will contaminate makeup air being introduced into the spraying area or other ventilating intakes, nor directed so as to create a nuisance.

5-11.1 Air exhausted from a spray operation shall not be recirculated to be used as input air for occupied spaces unless the exhaust air has been decontaminated to return it to a safe acceptable composition and unless installed 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. (Reference ACGIH TLV 1971.)

5-11.2 Air exhausted from a spray operation shall not be recirculated to be used as input air for a second unmanned spray operation unless the solid particulate has been removed from the exhaust air and unless installed 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 event the composition of the air exhausted from the second operation exceeds 25 percent of the LFL of the used solvents.

5-12 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.

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

5-14 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 spraying area as herein defined. (See also Chapter 11.)

Chapter 6. Flammable and Combustible Liquids

Storage and Handling

6-1. The storage of flammable or combustible liquids in connection with spraying operations shall conform to the requirements of the *Flammable and Combustible Liquids Code*, NFPA No. 30 where applicable.

6-1.1 Bulk storage of flammable or combustible liquids shall be in a separate, properly constructed building detached from other important buildings or cut off from them by construction having at least one-hour fire resistance rating. Lesser quantities of flammable or combustible liquids may be stored for use within a building under conditions meeting the other provisions of this chapter.

6-1.2 The storage of flammable and combustible liquids in containers and portable tanks inside buildings shall meet the requirements of the *Flammable and Combustible Liquids Code*, NFPA No. 30, for the "Design and Construction of Inside Storage Rooms," or "General or Industrial Plant Warehouses."

6-1.3 The design, construction, and installation of storage tanks for flammable and combustible liquids shall comply with the *Flammable and Combustible Liquids Code*, NFPA No. 30, requirements for "Tank Storage."

6-1.4 The design and construction of wood or metal storage cabinets shall meet the requirements of the *Flammable and Combustible Liquids Code*, NFPA No. 30, and any one such cabinet shall contain not more than 60 gallons of Class I and Class II liquids, or 120 gallons of Class III liquids. When approved by the authority having jurisdiction, more than one such cabinet may be located in a single fire area.

6-1.5 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 fire area shall not exceed the greater of: (1) a supply for one day or one shift; (2) 25 gallons of Class IA liquids in containers, and 120 gallons of Class IB, IC, II or III liquids in containers, or (3) one approved portable tank not exceeding 660 gallons of Class IB, IC, II, or III liquids.

6-2 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 or glass containers shall not be used for transportation or storage.

6-3 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 spraying area when the ventilating system is in operation. Adequate precautions shall be taken to protect against liquid spillage and sources of ignition.

6-4 Except as provided in 6-6, the withdrawal of flammable or combustible liquids from containers having a capacity of greater than 60 gallons shall be by approved pumps.

6-5 Containers supplying spray nozzles shall be of closed type or provided with metal covers kept closed. Containers 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 gallons capacity.

6-6 Original shipping containers shall not be subjected to air pressure for supplying spray nozzles. Pressure vessels supplying spray nozzles shall be of limited capacity, not exceeding that necessary for one day's operation; shall be designed and approved for such use; shall be provided with a visible pressure gauge; and shall be provided with a relief valve; all in conformance with the ASME Code for Unfired Pressure Vessels.

6-7 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.

6-7.1 All containers or piping to which is attached a hose or flexible connection shall be provided with a shutoff valve at the connection. Such valves shall be kept shut when spraying operations are not being conducted, except when a circulating system is used and it is provided with an automatically operated anti-runaway control.

6-7.2 When a pump is used to deliver products, automatic means shall be provided to prevent pressure in excess of the design working pressure of accessories, piping and hose.

6-7.3 All pressure 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 withdrawn from service and discarded.

6-8 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 nor other locations subject to the accumulation of deposits or combustible residue. Agitators, if used, shall be driven by compressed air, water, or low-pressure steam, or electric. If powered by an electric motor, the motor shall conform to the requirements of Chapter 4.

6-8.1 Unless flammable and combustible liquid piping, hose and equipment have been designed to meet the requirements of high pressure processes (those employing pressures in excess of 100 psig) such equipment shall not be used for this purpose.

6-8.2 If flammable or combustible liquids are supplied to spray nozzles by positive displacement pumps, means shall be provided to prevent the discharge pressure exceeding the safe operating pressure of the system. Any discharge shall be to a safe location.

6-9 Whenever flammable or combustible liquids are transferred from one container to another, both containers shall be effectively bonded and grounded to dissipate static electricity. *Recommended Practice on Static Electricity*, NFPA No. 77, provides information on static protection.

6-10. Piping systems conveying flammable or combustible liquids 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.

Chapter 7. *Protection

***7-1** Spraying 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 the *Standard for the Installation of Sprinkler Systems*, NFPA No. 13, provisions for Extra Hazard Occupancy, and in unsprinklered buildings where sprinklers are installed only to protect spraying 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.†

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 spraying 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 accessible located separate OS&Y sub-control valve. Sprinkler systems in stacks or ducts shall be automatic and of a type not subject to freezing.

7-5 Sprinklers protecting spraying areas shall be kept as free from deposits as practical by cleaning daily if necessary. (See also Chapter 8.)

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 the *Standard for Dry Chemical Extinguishing Systems*, NFPA No. 17 or protected with a carbon dioxide system installed so as to conform to the *Standard for Carbon Dioxide Systems*, NFPA No. 12.

7-7 An adequate supply of suitable portable fire extinguishers shall be installed near all spraying areas. (See *NFPA Standards for Installation of Portable Fire Extinguishers*, No. 10, and *Maintenance and use of Portable Fire Extinguishers*, No. 10A.)

† 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.

Chapter 8. *Operations and Maintenance

8-1 Spraying shall not be conducted outside of predetermined spraying areas and all provisions of this standard applying to spraying 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 spraying areas shall be kept free from the accumulation of deposits of combustible residues. If residue accumulates to excess in booths, duct or duct discharge points or other spraying areas, then all spraying operations shall be discontinued until conditions are corrected.

8-4 Scrapers, spuds or other such tools used for cleaning purposes shall be of non-sparking material.

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, 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 "No Smoking" signs in large letters on contrasting color background shall be conspicuously posted at all spraying areas and paint storage rooms.

8-11 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 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 and is not hand held or manipulated.

9-2 The installation and use of electrostatic spraying equipment shall conform to all other applicable chapters of this standard, and shall also conform to the requirements of this chapter.

9-3 Electrostatic apparatus and devices used in connection with coating operations shall be of approved types.

9-4 Transformers, power packs, 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 spraying area as defined in Chapter 1, or shall otherwise conform to the requirements of Chapter 4 of this standard.

9-5 Electrodes and electrostatic atomizing heads shall be adequately supported in permanent locations and shall be effectively insulated from ground. Electrodes and electrostatic atomizing heads which are permanently attached to their bases, supports, or reciprocators, shall be deemed to comply with this section. Insulators shall be nonporous. Fine wire elements when used shall be under tension at all times and be of unkinked hardened steel or material of comparable strength.

9-6 High voltage leads shall be properly insulated and protected from mechanical injury 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. An automatic means shall be provided for grounding the electrode system when the primary of its high voltage supply is electrically de-energized for any reason.

9-7 A safe distance shall be maintained between goods being painted and electrodes or electrostatic atomizing heads or conductors of at least twice the sparking distance. A suitable sign indicating this safe distance shall be conspicuously posted near the assembly.

9-8 Goods being coated using this process shall be supported on conveyors or hangers. The conveyors or hangers shall be so

arranged as to assure that the parts being coated are electrically connected to ground and to maintain safe distances between the goods and the electrodes or electrostatic atomizing heads at all times. Goods shall be supported to prevent swinging or movement which would reduce the clearance to less than that specified in 9-7.

9-9 Electrostatic apparatus shall be equipped with automatic means which will rapidly de-energize 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.

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

(d) Reduction of clearance below that specified in 9-7.

9-10 Safeguards such as adequate booths, fencing, railings or other means shall be so placed about the equipment or incorporated therein that they, either by their location or character or both, assure that a safe isolation of the process is maintained from plant storage or personnel. If mechanical guards are used such guards shall be at least 5 feet from processing equipment.

9-11 All electrically conductive objects in the spraying 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 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.

9-12 Signs designating the process zone as dangerous as regards fire and accident shall be conspicuously posted.

9-13 All insulators shall be kept clean and dry.

9-14 The spraying area shall be so ventilated as to insure safe conditions from a fire and health standpoint. See the *Standard for Blower and Exhaust Systems*, NFPA No. 91.

9-15 All areas used for spraying, including the interior of the booth, shall be protected by automatic sprinklers where this protection is available. Where this protection is not available, other approved automatic extinguishing equipment shall be provided.

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 approved types. The high voltage circuits shall be designed so as to not produce a spark of sufficient intensity to ignite the most hazardous of those vapor-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, *National Electrical Code*, NFPA No. 70. 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, power packs, 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 spraying 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 spraying area shall be conspicuously posted.

10-6 All electrically conductive objects in the spraying 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 insure this contact and 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 to not collect spray material during normal operation.

10-8 The electrical equipment shall be so interlocked with the ventilation of the spraying area that the equipment cannot be operated unless the ventilation fans are in operation.

10-9 The spraying operation shall take place within a spraying area which is adequately ventilated to remove solvent vapors released from the operation. See 3-5 (a) and Chapter 5.

Chapter 11. Drying, Curing or Fusion Apparatus

11-1 Drying, curing or fusion apparatus in connection with spray application of flammable and combustible coatings shall conform to the *Standard for Ovens and Furnaces*, NFPA No. 86A, where applicable and shall also conform to the following:

11-2 Spray booths, rooms or other enclosures used for spraying operations shall not alternately be used for the purpose of drying by any arrangement which will cause a substantial increase in the surface temperature of the spray booth, room or enclosure. The susceptibility to spontaneous heating and ignition of overspray residue may be greatly increased at temperatures above normal. Hence the use of hot air drying in a space which has been used for spray application is apt to create a severe hazard.

11-3 Except as specifically provided in 11-4, drying, curing or fusion units utilizing a heating system having open flames or which may produce sparks shall not be installed in a spraying area as defined in Chapter 1, but may be installed adjacent thereto when equipped with an interlocked ventilating system arranged to:

- (a) Thoroughly ventilate the drying space before heating system can be started;
- (b) Maintain a safe atmosphere at any source of ignition;
- (c) Automatically shut down heating system in the event of failure of the ventilating system.

11-4 Automobile refinishing spray booths or enclosures, otherwise installed and maintained in full conformity with this standard, may alternately be used for drying with portable electrical infrared drying apparatus but only when conforming with the following:

- (a) Interior (especially floors) of spray enclosures shall be kept free of overspray deposits.
- (b) During spray operations, the drying apparatus and electrical connections and wiring thereto shall not be located within spray enclosure nor in any other location where spray residue may be deposited thereon.
- (c) Spraying apparatus, drying apparatus, and ventilating system of spray enclosure shall be equipped with suitable interlocks so arranged that:

- (1) Spraying apparatus cannot be operated while drying apparatus is inside spray enclosure.

- (2) Spray enclosure will be purged of spray vapors for a period of not less than three minutes before drying apparatus can be energized.
- (3) Ventilating system will maintain a safe atmosphere within the enclosure during the drying process and drying apparatus will automatically shut off in the event of failure of the ventilating system.

(d) All electrical wiring and equipment of drying apparatus shall conform to the applicable sections of the *National Electrical Code*, NFPA No. 70. Only equipment of a type approved for Class I, Division 2 locations shall be located within 18 inches of floor level. All metallic parts of drying apparatus shall be properly electrically bonded and grounded.

(e) Drying apparatus shall contain a prominently located permanently attached warning sign indicating that ventilation shall be maintained during the drying period and spraying shall not be so conducted in the vicinity that spray will deposit on apparatus.

11-5 In powder coating processes, the powder is heated after or during application to bring about its fusion into a complete integral film. During such fusion many powders may release hazardous vapors. For this reason all fusion facilities shall be adequately ventilated to remove such vapors.

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 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 or other sources of ignition are within 20 feet while such operations are conducted.

12-2 Undercoating spray operations not conforming to the provisions of 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 2-2 of this standard.

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

- (1) Completely enclosed, adequately ventilated rooms of noncombustible construction with smooth surfaces designed to prevent accumulation of powder and to facilitate cleaning or
- (2) Adequately ventilated spray booths meeting the requirements of 3-1 through 3-3 and 3-6 through 3-11 of this standard, and (b) by using effectively enclosed, adequately ventilated containers (tanks, bins, etc.) of noncombustible material.

13-4 Electrical and Other Sources of Ignition.

(a) Electrical equipment and other sources of ignition shall conform to the requirements of 4-9 and 4-9.1 of this standard, and Articles 500 and 502 of the *National Electrical Code*, NFPA No. 70.

(b) When the part being coated is at elevated temperature care shall be taken to insure that the temperature of the part does not exceed the ignition temperature of the powder being used.

(c) To minimize the possibility of ignition by static electrical sparks, powder transport, application and recovery equipment shall be grounded.

13-5 Ventilation.

(a) Nondeposited air-suspended powders shall be safely removed from the operation via exhaust ducts to a powder recovery system. Due to the fact that such applied powders are of various composition, particle size and density and respond differently in the various application methods, no specific rates of exhaust have been established. Measurements have shown that the minimum explosive concentration of these powders generally used is in the range of .02 oz. per cubic foot (20 grams per cubic meter) of air. This value can be used as a design factor to determine the amount of air which must be introduced into an operation to maintain the atmosphere at the various positions of the operation below this concentration.

(b) 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 event the particulate removal equipment fails to maintain the air in this condition.

(c) Any enclosures of a powder coating operation (booth, recovery enclosure, etc.) which are effectively "tight" enclosures shall be provided with adequate blowout openings to safely relieve internal pressure in case of mixture ignition. See *Explosion Venting Guide*, NFPA No. 68.

13-6 Drying, Curing or Fusion Equipment.

(a) The temperature of the part shall never exceed the ignition temperature of the powder.

(b) The provisions of the *Standard for Ovens and Furnaces*, NFPA No. 86A, shall apply where applicable.

13-7 Operation and Maintenance.

(a) All areas including horizontal surfaces such as ledges, beams, pipes, hoods and booth floors shall be periodically cleaned 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 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 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 powder coating area or shall otherwise conform to the requirements of 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 with the conveyor or other support in order to insure proper grounding. Hangers shall be regularly cleaned to insure effective contact and areas of contact shall be sharp points or knife edges where possible.

13-10.5 The electrical equipment 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 Dual Component Coatings

14-1 All spraying operations involving the use of organic peroxides and other dual component coatings shall be conducted in approved sprinklered spray booths under conditions meeting the requirements of this standard.

14-2 Extreme 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 pressure vessels and inserts specific for the application shall be used for the resin and for the organic peroxide and they shall not be interchanged.

14-2.1 Organic peroxide pressure tank inserts shall be constructed of stainless steel, polyethylene, or other chemically non-reactive materials.

14-2.2 Extreme care shall be exercised to prevent any mixing of dusts or overspray residues resulting from the sanding or spraying of finishing materials containing organic peroxides with other 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, detached building apart from other finishing materials, and only minimum daily requirements shall be brought to the processing area; such material remaining at the spraying station at the end of a day's operations shall be carefully disposed of. Organic peroxides shall be kept away from all sources of heat including steam pipes, radiators, open flames or sparks and solar radiation. (See Appendix A. 1400.)

14-4 Extreme 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 accelerators or promoters as violent decomposition or explosion may result.

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 specifically trained personnel shall be permitted to work with these materials.

Appendix.

A-1-1 Scope. Flammable and combustible application or 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.

This standard does not cover the outdoor application of spray to buildings, bridges, tanks or similar structures. With such occasional applications, over-spray 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.

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) Spraying 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-1-2 The authority having jurisdiction may, for the purpose of this standard, define the limits of the spraying area in any specific case.

NOTE: The "spraying 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 "spraying area" should ordinarily not extend beyond the booth enclosure.

When, however, spraying operations are not confined to adequately ventilated spaces the "spraying area" may extend throughout the entire room containing spraying operations.

A-2-1 General. The safety of life and property from fire or explosion as a result of spray application of flammable and combustible paints and finishes may be severe or mild 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 which may be deposited in the area of operations.

Properly constructed spray booths, provided with adequate mechanical ventilation, may be so utilized as to discharge vapors or powder to a safe location and reduce to a minimum the possibility of an explosion. In 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 intelligent 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-2-2 In factories conducting extensive spray application operations, it is desirable that the processes 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 inches. 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.

In industrial and similar business buildings, spray application operations should be so located and protected as to minimize possible damage to other property by fire or by extinguishing agents.

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 spraying 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, conforming to *Manual for Waterproofing and Draining of Floors*, NFPA No. 92M.

Spray application operations should not be conducted in any basement area.

A-3-1 Spray Booths. 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 "spraying area" as defined in Chapter 1, may be of considerable magnitude, with all of the requirements of this standard for a "spraying area" applicable thereto. Spray booth assemblies are not listed by the Underwriters' Laboratories, Inc., although many component devices and types of equipment used in connection with spray applications are listed for specific purposes. It is important that only equipment suitable for specific purposes be utilized in connection with the handling and application of flammable or combustible liquids, or powders.

A-3-9 In some situations each spray booth should be separated from other operations by a distance greater than three feet or by a greater distance, or by such partition or wall as the inspection department having jurisdiction may require to reduce the danger from juxtaposition of hazardous operations. Where dipping, drying or baking operations are permitted in the same room with spray application operations, the authority having jurisdiction should be consulted before installation. (See also 4-1.)

A-4-1 Electrical and Other Sources of Ignition. It is obvious that there should be a total absence of 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 explosion-proof type.

In order to prevent sparks from the accumulation of static electricity all metal parts of spray booths, exhaust ducts and piping systems conveying flammable or combustible liquids should be properly electrically grounded. "Airless" spray painting, employing high fluid pressures can produce static electricity which may cause a spark. Therefore, the "airless" spray gun and any metallic object being sprayed should be properly electrically grounded. This can be done by either using a hose that contains a static electricity conductor, properly grounded, or attaching a properly grounded static wire to the spray gun and properly electrically grounding the object being sprayed.

The area in the vicinity of spraying operations which may contain dangerous quantities of flammable vapors or mists or residue deposits will necessarily vary with design and arrangement of equipment and methods of operation.

When spraying areas containing hazardous quantities of vapor or mists or residue under normal operation have been determined, the adjacent unpartitioned-off 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-off areas.

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 unjustified 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 $\frac{1}{4}$ inch 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.

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 ignitable refuse, or flammable or combustible liquid containers accidentally left open.

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

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 together with intelligent judgment of the objectives, applied to each individual installation.

A-4-2 Notes on Electrical Installations.

(1) As stipulated in Definitions the authority having jurisdiction may, for any specific installation, determine the extent of the hazardous "spraying area."

(2) From 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 or in the direct path of spray, unless such equipment is specifically listed for both readily ignitable deposits and flammable vapor. At present no such equipment is approved by a nationally recognized laboratory. Electric motors driving exhaust fans are specifically prohibited inside spray booths and exhaust ducts under 5-6.

(3) From 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 explosion-proof, or other type approved for Class I, Division 1 locations, equipment is permitted.

(4) When spraying operations are confined to adequately ventilated spray booths 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 "spraying area," depending upon the arrangement, is considered Division 2, that is, it should contain no equipment which 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 ignitable material and if subject to mechanical injury must be properly guarded.

(5) 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-4-3 High pressure steam pipes and equipment in connection with steam spraying processes should be covered with standard molded magnesia insulation $1\frac{1}{2}$ inches thick or the equivalent and be provided with a clearance of at least one inch between insulation and combustible material or combustible construction. Pipe covering should have sewed canvas cemented surface finish or the equivalent.

A-5 Ventilation. Adequate mechanical ventilation, together with the proper control of deposited residues and proper handling of flammable and combustible liquids, constitute major factors in the fire control of spraying hazards.

In general, if sufficient ventilation is provided to prevent the formation of explosive atmospheres outside of the immediate discharge from the spray gun, residues from spraying operations will be directed to and confined to spaces provided for their control.

Vapors or Mists. The possibility of explosions and fires from the 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.

Paints, varnishes, lacquers and other coating materials may contain volatile flammable solvents and in addition such solvents may

be added as "thinners." Such solvents when exposed to the atmosphere give off vapors which mix with the surrounding air and if the concentration of these vapors reaches as much as approximately 1 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 explosive atmospheres other than those using low flash point flammable liquids, may nevertheless result in mists of enriched atmospheres 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, one liquid gallon of the average flammable solvent will occupy approximately 23 cubic feet when evaporated into vapor at average room temperature. Therefore, if one gallon 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 2300 cubic feet to avoid an explosive mixture if the lower limit of the explosive range of the solvent is 1 percent in air. In attempting to utilize such theoretical considerations extreme caution should be exercised to prevent erroneous conclusions. For example, vapors from most flammable solvents are heavier than air and small quantities of vapor may form an explosive 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 explode. When flammable liquid is sprayed, the rate of evaporation is greatly increased so that the lower explosive limit is quickly reached.

Adequate mechanical ventilation throughout all areas where flammable vapors or mists may be present is essential to prevent the formation of explosive 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.

Where spraying is intermittently conducted entirely inside a conventional cabinet spray booth, an average air velocity of approximately 100 linear feet per minute across the open frontal booth area should ordinarily be sufficient for vapor removal. Under these conditions the ventilating fan capacity in c.f.m. must then be 100 feet per minute times the frontal area in square feet. Where spraying operations are extensive, or where canopy or down draft spray booths are used, additional ventilation is generally necessary.