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STANDARDS

for

# SPRAY FINISHING USING FLAMMABLE MATERIALS

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NATIONAL FIRE PROTECTION ASSOCIATION
International

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# National Fire Protection Association

International

Executive Office: 60 Batterymarch St., Boston 10, Mass.

The National Fire Protection Association was organized in 1896 to promote the science and improve the methods of fire protection and prevention, to obtain and circulate information on these subjects and to secure the cooperation of its members in establishing proper safeguards against loss of life and property by fire. Its membership includes over a hundred and eighty-five national and regional societies and associations and nearly fifteen thousand individuals, corporations, and organizations. Membership in the National Fire Protection Association is open to any society, corporation, firm or individual interested in the protection of life or property against loss by fire.

This pamphlet is one of a large number of publications on fire safety issued by the Association. The standards prepared by the technical committees of the National Fire Protection Association and adopted in the conventions of the Association, are intended to prescribe reasonable measures for minimizing fire losses. All interests concerned have opportunity through the National Fire Protection Association to participate in the development of the standards and to secure impartial consideration of matters affecting them.

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This standard adopted by the NFPA on May 19, 1953 incorporates revisions recommended by the Committee. The present edition supersedes the edition of 1950. For prior history of this standard dating back to 1922, see National Fire Codes, Vol. I, Flammable Liquids, Gases, Chemicals and Explosives, published by the NFPA.

Prior editions of this standard have also been adopted and published by the National Board of Fire Underwriters in NBFU Pamphlet No. 33 with identical text (except for cover and introductory matter). It is anticipated that in normal course the present edition will be similarly adopted by the NBFU.

## STANDARDS FOR SPRAY FINISHING USING FLAMMABLE MATERIALS.

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# STANDARDS FOR SPRAY FINISHING USING FLAMMABLE MATERIALS.

## FOREWORD.

The safety of life and property from fire or explosion in the spray application of flammable paints 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.

## STANDARD REQUIREMENTS.

### SCOPE.

1. These Standards cover the application of combustible paint, varnish, lacquer, stain and similar finishing materials when applied as a spray in continuous or intermittent processes.

2. These Standards do not cover small portable spraying apparatus which are not used repeatedly in the same location; however, the herein described fundamental safeguards should be followed where applicable.

3. These Standards do not cover the spray application of non-combustible finishing material.

4. These Standards outline practical minimum requirements to obtain reasonable safety under average contemplated conditions. Where unusual industrial processes are involved the Inspection Department having jurisdiction may for substantiated cause require additional safeguards or modify the requirements of these Standards provided equivalent safety is thereby obtained.

### CHAPTER 1.

### DEFINITIONS.

101. SPRAYING AREA. Any area in which dangerous quantities of flammable vapors or combustible residues, dusts or deposits are present due to the operation of spraying processes.

A spraying area includes:

(a) The interior of spray booths.

(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 combustible residue, dust, deposits, spray or vapor as a result of spraying operations.

The inspection department having jurisdiction may, for the purpose of these standards, 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.

102. 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.

103. 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 FINISHING OPERATIONS.

201. Spray finishing operations preferably should be located in one-story buildings separated from other important buildings by adequate clear space or standard fire walls and under automatic sprinkler protection.

202. Spray finishing operations shall not be conducted in a residence building, institutional building or public building, except in a room designed for the purpose, protected with an approved system of automatic sprinklers and separated vertically and horizontally from other areas by construction having not less than 2 hours fire resistance.

203. (a) In manufacturing, mercantile, and similar business buildings, spray finishing operations should be so located and

protected as to minimize possible damage to other property by fire or by extinguishing agents.

(b) Where spray finishing 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.

(c) 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 shall be provided, conforming to "Standards for Waterproofing of Floors and Drainage and the Installation of Scuppers (NFPA No. 92)."

204. Spray finishing operations preferably should not be conducted in any basement area.

205. Rooms containing spray finishing 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 non-combustible 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.

206. Except for occasional small operations involving "spot touch-up" work, spraying should be confined to properly constructed spray booths.

NOTE: The extent of the hazardous "spraying area" is generally materially increased if spraying is not confined to properly constructed spray booths or areas separated by tight fitting partitions.

## CHAPTER 3.

## SPRAY BOOTHS.

301. Spray booths shall be substantially constructed of steel not thinner than No. 18 U. S. gauge, securely and rigidly supported, or of concrete or masonry, except that aluminum or other substantial non-combustible material may be used for intermittent or low volume spraying, subject to the approval of the inspection department having jurisdiction. Spray booths shall be designed to sweep air currents toward the exhaust outlet.

302. 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.

303. The floor of the spray booth and operators' working area, if combustible, shall be covered with non-combustible, non-sparking material of such character as to facilitate the safe cleaning and removal of residues.

304. 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 non-combustible material and readily removable or accessible on both sides for cleaning. Such plates shall not be located in exhaust ducts.

305. 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.

306. Where conveyors are arranged to carry work into or out of spray booths, the openings therefore shall be as small as practical.

307. 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. Where dipping, drying or baking operations are permitted in the same room with spraying operations, the inspection department having jurisdiction should be consulted before installation. (See also Section 401.)

308. 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.

309. 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 non-combustible 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.

401. Electrostatic Apparatus shall conform to the requirements of Chapter 9; drying and baking apparatus shall conform to the requirements of Chapter 10; all other electrical equipment and all other sources of ignition shall conform to the requirements of Chapter 4.

402. There shall be no open flame or spark producing equipment in any spraying area as herein defined, nor within 20 feet thereof, unless separated by a partition.

403. Space heating appliances, steam pipes or hot surfaces shall not be located in a spraying area where deposits of combustible residues may readily accumulate.

404. Electrical wiring and equipment shall conform to the provisions of this section and shall otherwise be in accordance with the National Electrical Code.

405. Unless specifically approved for locations containing both deposits of readily ignitible residue and explosive vapors, there shall be no electrical equipment in any spraying area, as herein defined, whereon deposits of combustible residues may readily accumulate, except wiring in rigid conduit or in boxes or fittings containing no taps, splices or terminal connections.

406. 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 type approved for Class I, Group D locations and shall otherwise conform to the provisions of the National Electrical Code (No. 70), Article 500, Class I, Division 1.

407. Electrical wiring, motors, and other equipment outside of but within twenty (20) feet of any spraying area, as herein defined, and not separated therefrom by partitions, shall not produce sparks under normal operating conditions and shall otherwise conform to the provisions of the National Electrical Code (No. 70), Article 500, Class I, Division 2.

408. Electric lamps outside of, but within twenty (20) 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.

409. 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 hazardous Class I locations.

410. All metal parts of spray booths, exhaust ducts and piping systems conveying flammable liquids shall be properly electrically grounded in an effective and permanent manner.

NOTES ON ELECTRICAL INSTALLATIONS.

(1) As stipulated in Definitions (Section 101) the inspection department having jurisdiction may, for any specific installation, determine the extent of the hazardous "spraying area."

(2) From the above Section 405 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 approved for both readily ignitible 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 Section 506.

(3) From the above Section 406, 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, only approved explosion-proof equipment is permitted.

(4) When spraying operations are confined to adequately ventilated spray booths there should be no dangerous concentrations of flammable vapors, 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 20 feet of the hazardous "spraying area" is considered Division 2, that is, it should contain no equipment which produces sparks under normal operation. Furthermore, within this 20-foot 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.

(5) It will be observed that because of the requirements of special safeguards, electrostatic apparatus and drying and baking ovens are covered in separate chapters.

## CHAPTER 5.

## VENTILATION.

501. Ventilating and exhaust systems shall be in accordance with the Standards for Blower and Exhaust Systems for Vapor Removal (Pamphlet No. 91) where applicable and shall also conform to provisions of this section.

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

503. Spraying operations shall not be conducted unless mechanical ventilation is in operation. When spray is automat-

ically applied without an attendant constantly on duty and, where practical, when spraying is under manual control, the operating control of spray apparatus should be so arranged that spray cannot be applied unless exhaust fans are in operation.

504. Each spray booth shall have an independent exhaust duct system discharging to building exterior, except 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. If more than one fan serves one booth, all fans shall be so interconnected that one fan cannot operate without operating all.

505. Fan rotating element shall be non-ferrous or non-sparking 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 perfect 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.

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

507. Belts shall not enter duct or booth unless belt and pulley within the duct or booth are thoroughly enclosed.

508. Exhaust ducts shall be constructed of steel and shall be substantially supported. Exhaust ducts should be without dampers; however, if manually adjustable dampers are installed, they shall be kept in a full open position at all times ventilating system is in operation. When spray booths are not in use and it is necessary to shut off ducts during cold weather, non-combustible removable covers completely closing ducts may be used.

509. (a) Exhaust ducts shall have a clearance from unprotected combustible construction or other combustible material of not less than 18 inches.

(b) If combustible construction is provided with the following protection applied to all surfaces within 18 inches, clearances may be reduced to the distances indicated:

(1) 28 gauge sheet metal on ¼-inch asbestos mill board..... 12 inches

(2) 28 gauge sheet metal on ⅛-inch asbestos mill board spaced out one inch on non-combustible spacers.... 9 inches

(3) 22 gauge sheet metal on 1-inch rock-wool bats reinforced with wire mesh or the equivalent..... 3 inches

510. Unless spray booth exhaust duct terminal is from a waterwash spray booth, the terminal 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 non-combustible exterior wall within 25 feet.

511. Air exhausted from spraying operations shall not be recirculated. Exhaust ducts should pass directly through the nearest outside wall or through the building roof. Ducts should not pass through fire walls or floors.

512. When necessary to facilitate cleaning, exhaust ducts shall be provided with an ample number of access doors.

513. Air intake openings to rooms containing spray finishing operations shall be adequate for the efficient operation of exhaust fans and shall be so located as to minimize the creation of dead air pockets.

514. Freshly sprayed articles shall be dried only in spaces provided with adequate ventilation to prevent the formation of explosive 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 10.)

## CHAPTER 6.

## FLAMMABLE LIQUIDS — STORAGE AND HANDLING.

601. The storage and handling of flammable liquids shall be in accordance with accepted good practice* and shall conform to the provisions of this section.

602. The quantity of flammable liquids kept in the vicinity of spraying operations shall be the minimum required for operations and should ordinarily not exceed a supply for one day or one shift. Bulk storage of portable containers of flammable liquids shall be in a separate, properly constructed building detached from other important buildings or cut off in a standard manner.

603. Where spraying is only occasional and involves the use of many different colors or types of flammable liquids, not exceeding a total quantity of 50 gallons in original closed con-

*See NFPA Suggested Ordinance on Flammable Liquids, No. 30-L and NBFU Standards for the Storage, Handling and Use of Flammable Liquids, No. 30.

tainers may be stored in a properly constructed metal cabinet located near spraying operations.

604. Original closed containers, approved portable tanks, approved safety cans or a properly arranged system of piping shall be used for bringing flammable liquids into spray finishing room. Open or glass containers shall not be used.

605. Except as provided in Section 608 the withdrawal of volatile flammable liquids from containers having a capacity of greater than 60 gallons shall be by approved pumps. For withdrawal from portable drums, hand pumps are recommended.

606. The withdrawal of volatile flammable liquids from containers and the filling of containers shall be done only when ventilating system is in operation and the location of such flammable liquid handling shall be so ventilated that any flammable vapors formed shall be immediately exhausted to outside of building.

607. Containers supplying spray nozzles shall be of closed type or provided with metal covers kept closed. Containers not resting on floors shall be on metal supports or suspended by wire cables. Containers supplying spray nozzles by gravity flow shall not exceed 10 gallons capacity.

608. Original shipping containers shall not be subjected to air pressure for supplying spray nozzles. Containers under air pressure 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 set to operate not in excess of 125% of working pressure.

609. Containers under air pressure supplying spray nozzles, air storage tanks and coolers shall conform to the standards of the A.S.M.E. Code for unfired pressure vessels for construction, tests and maintenance.

610. All containers or piping to which is attached a hose or flexible connection shall be provided with a shut-off valve at the connection. Such valves shall be kept shut when not in use.

611. If a spray liquid heater is used it should preferably be low-pressure steam or hot water type. If electric, it shall be approved and listed for the specific location in which it is used. Heaters shall not be located in spray booths nor other locations subject to the accumulation of deposits or combustible residue. Agitators, if used, should preferably be driven by compressed air, water or low-pressure steam. If electric motor is used, see Chapter 4.

612. (a) Unless flammable liquid piping and equipment has been designed to meet the requirements of high pressure processes (airless atomization) employing pressures in excess of 100 p.s.i.g., existing circulating systems should not be used for this purpose.

(b) If flammable liquids are supplied to spray nozzles by positive displacement pumps, pump discharge line shall be provided with an approved relief valve discharging to pump suction or a safe detached location.

613. (a) Whenever flammable liquids are transferred from one container to another, both containers shall be effectively grounded to prevent discharge sparks of static electricity.

(b) Piping systems for flammable liquids shall be permanently grounded (see Section 410).

## CHAPTER 7.

## PROTECTION.

701. Spray finishing operations should preferably be located in buildings protected throughout with an approved system of automatic sprinklers.

702. In sprinklered buildings, the automatic sprinkler system in rooms containing spray finishing operations shall conform to the Standards for the Installation of Sprinkler Equipments (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 section.

703. Sprinklers in rooms containing spray finishing operations should be on a wet pipe system. Sprinklers connected to conventional dry pipe systems may not be expected to control spray hazard fires.

704. 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 inspection department having jurisdiction.

705. Water supply for sprinklers in rooms containing spray finishing operations should 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 inspection department having jurisdiction.

706. Each spray booth having a frontal area in excess of nine square feet should be protected with an automatic system

of one or more sprinklers. Sprinkler heads shall be located to effect water distribution throughout entire booth.

707. Interior of ducts should be protected with sprinklers. Such sprinklers should be installed not more than 12 feet apart in horizontal ducts and shall be accessible through duct access doors.

708. Automatic sprinklers protecting each spray booth (together with its connecting exhaust) shall be under an accessibly located separate O. S. and Y. sub-control valve. Where sprinklers in ducts or stacks are subject to freezing, they may be open head and only under manual control, subject to the approval of the inspection department having jurisdiction.

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

710. An adequate supply of suitable first aid fire appliances shall be installed near all spraying areas. (See Standards for First Aid Fire Appliances, No. 10.)

## CHAPTER 8.

## OPERATIONS AND MAINTENANCE.

801. Spraying shall not be conducted outside of predetermined spraying areas and all provisions of these Standards applying to spraying areas should be strictly followed.

802. All spraying areas shall be kept as free from the accumulation of deposits of combustible residues as practical, with cleaning conducted daily if necessary.

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

804. Residue scrapings and debris contaminated with residue shall be immediately removed from premises and properly disposed of.

805. Approved metal waste cans shall be provided wherever rags or waste are impregnated with finishing 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.

806. Spray finishing employees' clothing shall not be left on the premises overnight unless kept in metal lockers.

807. (a) Solvents used for cleaning purposes should preferably be non-flammable as there are a number of such cleaning materials which are practical for this purpose.

(b) The use of flammable solvents for cleaning operations shall be restricted to those having flash points no less than kerosene except solvents with flash points not less than those

normally used in spraying operations may be used for cleaning spray nozzles and auxiliary equipment, provided such cleaning is conducted inside spray booths and ventilating equipment is operating during cleaning.

808. Spray booths, exhaust ducts or other locations used for the application of bleaching compounds shall not be used until all traces of other finishing materials have been removed; nor shall they be used for other purposes unless all traces of bleaching compounds have been removed.

809. Spray booths shall not alternately be used for lacquers, and other materials such as varnishes, stains, ground coats, etc., unless all traces of the finishing material formerly used have been removed from booth and exhaust duct.

810. If there are excessive accumulations of residue in booths, ducts or duct discharge points or other spraying areas, then all spraying operations should be discontinued until conditions are corrected.

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

812. Conspicuous signs should be posted at all spraying areas and paint storage rooms conveying the following warning:

**NO WELDING—The use of welding or cutting equipment in, on, or around this spray booth and duct (or paint storage room) is dangerous because of fire and explosion. Welding and cutting shall be done only under the supervision of the foreman in charge.**

## CHAPTER 9.

## ELECTROSTATIC APPARATUS.

900. Where installation and use of electrostatic spraying equipment is judged by enforcing authorities to be permissible, such installation and use shall conform to all other chapters of these Standards, and shall also conform to the requirements of this chapter.

901. Electrostatic apparatus and devices used in connection with paint spraying operations shall be of approved types.

902. Transformers, power packs, control apparatus, and all other electrical portions of the equipment, with the exception of high voltage grids 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 these Standards.

903. Electrodes and electrostatic atomizing heads shall be rigidly supported in permanent locations and shall be effec-

tively insulated from ground. Insulators shall be non-porous and non-combustible. Fine wire elements when used should be under tension at all times and should be of unkinked hardened steel or material of comparable strength.

904. High voltage leads to electrodes and electrostatic atomizing heads 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 and discharging any accumulated residual charge on the electrode assembly or the secondary circuit of the high voltage transformer when the transformer primary is disconnected from the source of supply.

905. A space 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 stating the sparking distance shall be conspicuously posted near the assembly.

906. Goods being painted using this process are to be supported on conveyors. The conveyors shall be so arranged as to maintain safe distances between the goods and the electrodes or electrostatic atomizing heads at all times. Any irregularly shaped or other goods subject to possible swinging or movement shall be rigidly supported to prevent such swinging or movement which would reduce the clearance to less than that specified in Section 905 above.

907. This process is not approved where goods being painted are sprayed and manipulated by hand. Special approval must be obtained for such operations.

908. Electrostatic apparatus shall be equipped with automatic controls which will operate without time delay to disconnect the power supply to the high voltage transformer and to signal the operator 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 of an imminent ground at any point on the high voltage system.

(d) Reduction of clearance below that specified in Section 905.

909. Adequate booths, fencing, railings or guards shall be so placed about the equipment 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. Such railings, fencing and guards shall be of conducting material, adequately grounded, and should be at least 5 ft. from processing equipment.

910. Signs designating the process zone as dangerous as regards fire and accident should be posted.

911. All insulators shall be kept clean and dry.

912. Where booths are required to control overspray material such booths shall be ventilated by exhausting air equivalent to 100 ft. per minute across the open areas of the equipment. Where electrostatic atomization is used the spraying area shall be so ventilated as to insure safe conditions from a fire and health standpoint. (See Standards for Blower and Exhaust Systems, No. 91.)

913. All areas used for spraying, including interior of 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.

## DRYING APPARATUS.

1001. Drying and baking apparatus in connection with spray application of flammable finishes shall conform to the Standards for "Class A Ovens and Furnaces" (NFPA No. 86) where applicable and shall also conform to the following.

1002. 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 material increase in the surface temperature of the spray booth, room or enclosure.

NOTE: The susceptibility to spontaneous heating and ignition of over-spray 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 finishing may create a severe hazard.

1003. Drying or baking 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.

## APPENDIX.

**A. 200. General.** The safety of life and property from fire or explosion as a result of spray application of flammable paints and finishes may be severe or mild depending upon the arrangement and operation of a particular installation.

The principal hazards of spray operations originate from flammable liquids and their vapors 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 to a safe location and reduce to a minimum the possibility of a vapor 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 either flammable liquids, vapors 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.

In factories conducting extensive spray finishing, it is desirable that finishing 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 finishing processes may present some additional problems of fire hazard segregation. If conveyor systems extend to or from a detached finishing building, a sprinklered non-combustible 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 opening in a practical and reliable manner. In some instances such openings have been provided with non-combustible tunnels extending on each side of fire wall with tunnels protected by specially designed automatic spray or sprinkler systems.

**A. 300. 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 these standards for a "spraying area" applicable thereto. Spray booth assemblies are no longer 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 spraying of flammable liquids.

**A. 400. 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 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 incandescent light globes, even of the explosion-proof type, or low pressure steam pipes.

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

For the usual cabinet spray booth it has been generally considered that limited areas not separated by partitions and in the front of a booth may be dangerous. When, however, ventilation is inadequate and spraying is not strictly confined to the inside of the booth, the dangerous area may extend throughout the entire room.

On the other hand, when adequate, reliable, supervised ventilation is provided and spraying operations strictly confined to the predetermined designated spaces, the hazardous areas may not extend beyond the booth enclosure.

When areas of spraying known to contain hazardous quantities of vapor or residue under normal operation have been de-

termined, the unpartitioned-off areas adjacent to hazardous areas which are safe under normal operating conditions but which may become dangerous due to accident or careless operation should be considered. In these adjacent areas, equipment known to produce sparks or flames under normal operating conditions should not be installed.

Sufficient lighting for operations, booth cleaning, and repair should be provided at the time of equipment installation in order to avoid the unjustified use of "temporary" or "emergency" electric lamps connected to ordinary extension cords. A satisfactory and practical method of lighting is the use of ¼ 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.

Areas adjacent to a spray booth, particularly where paint stocks are located, should be provided with ventilation sufficiently adequate and reliable 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 liquids, or readily ignitible refuse or flammable 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 and highly combustible deposits together with intelligent judgment of the objectives, applied to each individual installation.

**A. 500. Ventilation.** Adequate mechanical ventilation, together with the proper control of deposited residues and proper handling of flammable 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 space of spraying, residues from spraying operations will be directed to and confined to the spaces provided for their control.

**Vapors.** The possibility of explosions and fires from the vapors of flammable liquids 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 finishing materials may contain volatile flammable solvents and in addition such solv-

ents 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%, an explosion may occur, if at the same time a spark or other source of ignition is present.

Theoretical considerations may assist in hazard evaluation in some instances. For example, one 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 solvent is completely evaporated and thoroughly mixed with the surrounding air of an enclosure, the enclosure must be over 2,300 cubic feet to avoid an explosive mixture if the lower limit of the explosive range of the solvent is 1% 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 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 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 (fan capacity in c.f.m. divided by the frontal area in square feet) should ordinarily be sufficient for vapor removal. Where spraying operations are extensive, or where canopy or down draft spray booths are used, additional ventilation is generally necessary. When spray booths are provided with adequate ventilation, booths may be so located with respect to finishing room air intake that air in the entire finishing room moves toward spray booth exhausts and "dead air pockets" are eliminated, thus making unnecessary additional mechanical ventilation for the finishing room. With moderately uniform air movement throughout a finishing room, an air change of once every three to five minutes should be sufficient to prevent the formation of explosive vapors under ordinary conditions.

Where large objects such as railway cars are being sprayed, it is frequently necessary to provide multiple air inlets and exhausts 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 overhead duct air inlets and exhausting air at the floor level.

Since the air exhausted from spray finishing rooms should not be recirculated, consideration should be given to the heating of incoming air in cold weather. Total heat lost by ventilation should be the same, irrespective of whether air intake is from other portions of the building or filters in through loose fitting doors and windows, or enters through openings designed for the purpose. 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 steam heating coils.

If there are driers or dip tanks in the spray finishing rooms which give off flammable vapors, these should be provided with independent mechanical ventilation.

**Spray Residue.** When spray finishing any article there is frequently a part of the spray known as overspray that does not deposit directly on the article, resulting in deposits on adjacent surfaces. Many of these residues are highly combustible, igniting at very low temperatures and many will ignite spontaneously, resulting in quick hot fires.

Properly constructed spray booths are designed to confine these residues within the booth and its connecting exhaust duct and are so arranged that should a fire occur in the booth or duct it may be extinguished without spreading to adjacent property and in the extinguishment of the fire other property will not be damaged by water or other extinguishing agents. Spray booth exhaust ducts should not be installed in close proximity to combustible construction or terminate so that a fire in discharged residue can communicate to combustible construction.

It is obvious that in order to limit the duration and intensity of fires in booths and exhaust ducts, the accumulation of deposits must be prevented as much as is practical. In some industrial plants where spraying is a continuous daily operation, spray booths and ducts are coated with a water soluble material and washed down with pressure water streams at the end of each day's operation and then immediately recoated with this water soluble material to facilitate washing the following day.