NFPA 30B
Code for the Manufacture and Storage of Aerosol Products

1998 Edition

National Fire Protection Association, 1 Batterymarch Park, PO Box 9101, Quincy, MA 02269-9101
An International Codes and Standards Organization

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NFPA 30B

Code for the

Manufacture and Storage of Aerosol Products

1998 Edition

This edition of NFPA 30B, *Code for the Manufacture and Storage of Aerosol Products,* was prepared by the Technical Committee on Aerosol Products and acted on by the National Fire Protection Association, Inc., at its Annual Meeting held May 18–21, 1998, in Cincinnati, OH. It was issued by the Standards Council on July 16, 1998, with an effective date of August 5, 1998, and supersedes all previous editions.

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

This edition of NFPA 30B was approved as an American National Standard on August 6, 1998.

Origin and Development of NFPA 30B

Prior to the development of NFPA 30B, *Code for the Manufacture and Storage of Aerosol Products*, fire protection requirements for the storage of flammable aerosols were set forth in NFPA 30, *Flammable and Combustible Liquids Code*, where they were treated as Class IA flammable liquids. During the late 1970s and early to mid-1980s, because of both actual fire incidents and full-scale fire testing, it became apparent that flammable aerosol products presented a severe fire challenge. Industry initiatives led to further full-scale fire testing and, eventually, to the establishment of an NFPA Technical Committee Project specifically directed at providing fire protection guidance for both manufacturing facilities and storage facilities.

The Technical Committee on Aerosol Products began its work in January, 1988. The committee formed two task groups, one on manufacturing and another on storage, to draft the technical language of this document. The results of the intense efforts of the two task groups culminated with adoption of the first edition of NFPA 30B at the 1990 NFPA Annual Meeting.

The Technical Committee on Aerosol Products has continued to work on improvements to NFPA 30B. The second edition was published in 1994 with several major revisions to clarify the document's requirements and to more accurately reflect the fire behavior of aerosol products, particularly with regard to the classification of aerosol products. The Technical Committee on Aerosol Products has continued its work, resulting in the 1998 edition — the third incarnation of NFPA 30B. Some of the improvements and revisions found in the 1998 edition include the following:

- The scope of the document has been clarified to preclude application to post-consumer processing of aerosol containers.
- Additional chemical heat of combustion data has been added to Appendix A to assist the user in classifying aerosol products.
- Specific fire alarm component requirements have been removed because they are adequately addressed by NFPA 72.
- Section 3-12 has been revised to require deflagration suppression system(s) in flammable propellant pump rooms.
- Table 3-13 has been revised to expand provisions for equipment interlocks.
- Chapter 4 has been reformatted to clarify the scope of each section.
- Provisions for segregated aerosol storage in mercantile occupancies have been clarified.
- Definition of "net weight" has been added to clarify permitted quantities of aerosol products.
- Sprinkler design Tables 4-2(e) and 4-2(f) have been consolidated into new Table 4-3(e) and revised to incorporate ESFR ceiling sprinkler design criteria.

Technical Committee on Aerosol Products

Michael J. Madden, *Chair*
Gage-Babcock & Assoc., CA [SE]

David L. Fredrickson, S. C. Johnson & Son Inc., WI [M]
Rep. Chemical Specialties Mfrs. Assn.
Robert O. George, 3M Co., MN [U]
David Grandaw, Fenwal Safety Systems, Inc.,/William Holdings, IL [M]
William A. Gregg, IV, Precision Valve Corp., SC [M]
Rep. Chemical Specialties Manufacturers Assn.
Richard J. Hild, Verlan Fire Insurance Co., MD [I]
Edmund M. Kelly, Chubb Group of Insurance Co., GA [I]
James Koskan, SUPERVALU, Inc., MN [U]
Thomas J. Kramer, Schirmer Engr Corp., IL [SE]
John A. LeBlanc, Factory Mutual Research Corp., MA [I]
Michael J. Nappi, Potomac Electric Power Co., DC [U]
Rep. Edison Electric Inst.
Donald E. Rowson, Industrial Hydrocarbons, Inc., CA [SE]
Todd E. Schumann, Industrial Risk Insurers, IL [I]
Thomas Siciliano, Jr., Reckitt & Colman, Inc., NJ [M]
Rodney P. Smith, The Kartridg Pak Co., IA [M]
David C. Tabar, The Sherwin-Williams Co., OH [M]
Jack Thacker, Allan Automatic Sprinkler Corp. of Southern California, CA [IM]
Rep. Nat'l Fire Sprinkler Assn.
William P. Thomas, Jr., Kemper Nat'l Insurance Cos., IL [I]
James W. Tomes, Tomes, Van Rickley & Assoc., CA [U]
Rep. The Home Depot

Alternates

Efrein Correa, Carter-Wallace, Inc., NJ [M]
(Alt. to D. L. Fredrickson)
John F. Devlin, Schirmer Engr Corp., VA [SE]
(Alt. to T. J. Kramer)
Laura Dion, Tomes, Van Rickley & Assoc., CA [U]
(Alt. to J. W. Tomes)
D. Douglas Fratz, Chemical Specialties Manufacturers Assn., DC [M]
(Alt. to W. A. Gregg)
Rick Glenn, Gage-Babcock & Assoc., IL [SE]
(Alt. to M. J. Madden)
Kenneth E. Isman, Nat'l Fire Sprinkler Assn., NY [IM]
(Alt. to J. Thacker)
Donald B. Pounder, Grinnell Corp., RI [M]
(Voting Alt. to GC Rep.)
Douglas Raymond, The Sherwin-Williams Co., OH [M]
(Alt. to D. C. Tabar)
Thomas K. Terrebonne, Kemper Nat'l. Insurance Cos., MO [I]
(Alt. to W. P. Thomas, Jr.)
William A. Thornberg, Industrial Risk Insurers, CT [I]
(Alt. to T. E. Schumann)

Gregory E. Harrington, NFPA Staff Liaison

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

Committee Scope: This Committee shall have primary responsibility for documents on safeguarding against the fire and explosion hazards associated with the manufacturing, handling, and storage of aerosol products.

Contents

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Code for the

Manufacture and Storage of Aerosol Products

1998 Edition

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

A reference in parentheses () following a section or paragraph indicates material that has been extracted from another NFPA document. The complete title and current edition of an extracted and referenced document are found in Chapter 7.

Information on referenced publications can be found in Chapter 7 and Appendix F.

Chapter 1 General

1-1 Scope.

1-1.1 This code shall apply to the manufacture, storage, and display of aerosol products as herein defined.

1-1.2* This code shall not apply to the manufacture, storage, and display of aerosol products that contain only a nonflammable base product and a nonflammable propellant.

1-1.3* This code shall not apply to the storage and display of containers whose contents are comprised entirely of LP-Gas products.

1-1.4 This code shall not apply to post-consumer processing of aerosol containers.

1-2* Purpose. The purpose of this code is to provide minimum requirements for the prevention and control of fires and explosions in facilities that manufacture, store, or display aerosol products.

1-3 Equivalency. Nothing in this code is intended to prevent the use of systems, methods, or devices of equivalent or superior quality, strength, fire resistance, effectiveness, durability, and safety over those prescribed by this code, provided technical documentation is submitted to the authority having jurisdiction to demonstrate equivalency, and the system, method, or device is approved for the intended purpose.

1-4* Retroactivity. The provisions of this code are considered necessary to provide a reasonable level of protection from loss of life and property from fire and explosion. They reflect situations and the state of the art at the time the code was issued. Unless otherwise noted, it is not intended that the provisions of this code be applied to facilities, equipment, structures, or installations that were existing or approved for construction or installation prior to the effective date of the code, except in those cases where it is determined by the authority having jurisdiction that the existing situation involves a distinct hazard to life or adjacent property.

1-5 Applicability.

1-5.1 Chapters 2, 3, and 6 shall apply to facilities or portions of facilities that manufacture aerosol products, including gas-filling, product-filling, and packaging operations.

1-5.2 Chapters 2, 4, and 6 shall apply to facilities or portions of facilities that store aerosol products, such as storage areas, storage rooms, and warehouses.

1-5.3 Chapters 2, 5, and 6 shall apply to the storage and display of aerosol products in mercantile occupancies.

1-6 Definitions.

Aerosol.* A product that is dispensed from an aerosol container by a propellant.

Aerosol Container.* A metal can, up to a maximum size of 33.8 fl oz (1000 ml), or a glass or plastic bottle, up to a maximum size of 4 fl oz (118 ml), that is designed and intended to dispense an aerosol.

Approved.* Acceptable to the authority having jurisdiction.

Authority Having Jurisdiction.* The organization, office, or individual responsible for approving equipment, an installation, or a procedure.

Back Stock Area. The area of a mercantile occupancy that is physically separated from the sales area and not intended to be accessible to the public.

Base Product (Concentrate).* The contents of an aerosol container, excluding the propellant.

Basement. A story of a building or structure having one-half or more of its height below ground level and to which access for fire-fighting purposes is restricted.

Bonding. The process of connecting two or more conductive objects together by means of a conductor.

Carton. A cardboard or fiberboard box that encloses a product.

Chemical Heat of Combustion (ΔH_c). The amount of heat released, in Btu/lb (kJ/g), when a substance is oxidized to yield stable end products, including water as a vapor, as measured under actual fire conditions in a normal ambient (air) atmosphere.

Code.* A standard that is an extensive compilation of provisions covering broad subject matter or that is suitable for adoption into law independently of other codes and standards.

Cold Filling.* The pressurizing of an aerosol container by cooling the propellant (and sometimes the product) below its boiling point and transferring it into the aerosol container before the valve is put in place. The operation is usually carried out at atmospheric pressure (that is, high pressure is not needed).

Combustible Liquid.* A liquid having a flash point at or above 100°F (37.8°C).

Combustible liquids shall be subdivided as follows:

(a) Class II liquids shall include those having flash points at or above 100°F (37.8°C) and below 140°F (60°C).

(b) Class IIIA liquids shall include those having flash points at or above 140°F (60°C) and below 200°F (93°C).

(c) Class IIIB liquids shall include those having flash points at or above 200°F (93°C).

Combustion Efficiency. The ratio of chemical heat of combustion to theoretical heat of combustion.

Early Suppression Fast-Response (ESFR) Sprinklers. A type of fast-response sprinkler listed for its capability to provide fire suppression of specific high-challenge fire hazards.

Encapsulated. A method of packaging consisting of a plastic sheet completely enclosing the sides and top of a pallet load that contains a combustible commodity or a combustible package or a group of combustible commodities or combustible packages. Totally noncombustible commodities on wood pallets enclosed only by a plastic sheet as described are not considered to fall under this definition. Banding, that is, stretch wrapping around the sides only of a pallet load, is not considered to be encapsulated. The term encapsulated does not apply to individual plastic-enclosed items inside a large, nonplastic enclosed container.

Face Sprinklers. Standard sprinklers located in transverse flue spaces along the aisle or in the rack, within 1 ½ ft (0.46 m) of the aisle face of storage and used to oppose vertical development of fire on the external face of storage. (**231C:** 1-3)

Fire Area. An area of a building separated from the remainder of the building by construction that has a fire-resistance rating of at least 1 hour and that has all communicating openings properly protected by an assembly that has a fire protection rating of at least 45 minutes.

Flammable Liquid.* A liquid having a flash point below 100°F (37.8°C) and having a vapor pressure not exceeding 40 psia (2068 mm Hg) at 100°F (37.8°C) shall be known as a Class I liquid.

Class I liquids shall be subdivided as follows:

(a) Class IA liquids shall include those having flash points below 73°F (22.8°C) and having a boiling point below 100°F (37.8°C).

(b) Class IB liquids are those having flash points below 73°F (22.8°C) and having a boiling point at or above 100°F (37.8°C).

(c) Class IC liquids shall include those having flash points at or above 73°F (22.8°C) and below 100°F (37.8°C).

Flammable Propellant. See definition of Propellant.

Grounding (Earthing). The process of connecting one or more conductive objects to the ground. A specific form of bonding.

Horizontal Barrier. A solid barrier in the horizontal position covering the entire rack, including all flue spaces at certain height increments, to prevent vertical fire spread. (**231C:** 1-3)

Mercantile Occupancy. A building or structure, or any portion thereof, used for the display, sale, and purchase of goods, wares, and merchandise.

Net Weight.* Total weight of base product and propellant as indicated on aerosol container label.

Propellant.* The liquefied or compressed gas that expels the contents from an aerosol container when the valve is actuated. A propellant is considered flammable if it forms flammable mixtures with air or if a flame is self-propagating in a mixture of the propellant and air.

Protection for Exposures. Fire protection for structures on property adjacent to an aerosol product manufacturing or storage facility. Fire protection for such structures shall be acceptable where located either within the jurisdiction of any public fire department or adjacent to plants having private fire brigades capable of providing cooling water streams on the adjacent property.

Rack.* Any combination of vertical, horizontal, and diagonal structural members that support stored materials or commodities.

Sales Display Area. The area of a mercantile occupancy that is open to the public for the purpose of viewing and purchasing goods, wares, and merchandise. Individuals are free to circulate among the items, which are typically displayed on shelves, racks, or on the floor.

Separate Inside Storage Area. A room or building used for the storage of aerosol products and separated from other occupancies. Such areas include the following:

Attached Building. A building that has only one common wall with a building that has other occupancies.

Cut-Off Room. A room within a building that has at least one exterior wall.

Fenced Enclosure. A segregated area meeting the requirements of 4-3.8.2.2.

Inside Room. A room totally enclosed within a building and having no exterior walls.

Shall. Indicates a mandatory requirement.

Shelf Storage. Storage on structures that are less than 2 ½ ft (0.75 m) deep, with shelves usually 2 ft (0.6 m) to 3 ft (0.9 m) apart vertically and seldom exceeding 15 ft (4.5 m) in total height.

Should. Indicates a recommendation or that which is advised but not required.

Solid Shelving. Shelving that is solid, slatted, or of other construction, that is located in racks, and that obstructs sprinkler discharge down into the racks.

Theoretical Heat of Combustion. The amount of heat released, in Btu/lb (kJ/g), when a substance is completely oxidized to yield stable end products, including water as a vapor, as measured using an oxygen bomb calorimeter. Alternatively, the theoretical heat of combustion can be calculated from heat of formation data, heat of combustion data, or molecular calculation data as reported in the literature and assuming all products are in the vapor state.

Unstable Liquid. A liquid that, in the pure state or as commercially produced or transported, will vigorously polymerize, decompose, undergo condensation reaction, or become self-reactive under conditions of shock, pressure, or temperature.

Warehouse.

Aerosol Warehouse. A detached building or a separate portion of a building used for the storage, shipping, and receiving of aerosol products.

General-Purpose Warehouse. A detached building or a separate portion of a building used only for the storage, shipping, and receiving of mixed commodities.

1-7* Classification of Aerosol Products. Aerosol products manufactured after September 1, 1994, shall be classified by means of the calculation of their chemical or theoretical heats of combustion and shall be designated Level 1, Level 2, or Level 3 in accordance with the definitions given in 1-7.1 through 1-7.3 and in Table 1-7.

Exception: In lieu of classification by means of the chemical heats of combustion, aerosol products shall be permitted to be classified by means of data obtained from properly conducted full-scale fire tests that utilize a 12-pallet test array and are conducted at an approved testing laboratory. (See Appendix C for information on the 12-pallet test array.)

Table 1-7 Aerosol Classification

If the chemical heat of combustion is		Aerosol Classification Level
>	≤	
0	8,600 Btu/lb (20 kJ/g)	1
8,600 Btu/lb (20 kJ/g)	13,000 Btu/lb (30 kJ/g)	2
13,000 Btu/lb (30 kJ/g)	— —	3

1-7.1 Level 1 aerosol products are those with a total chemical heat of combustion that is less than or equal to 8,600 Btu/lb (20 kJ/g).

1-7.2 Level 2 aerosol products are those with a total chemical heat of combustion that is greater than 8,600 Btu/lb (20 kJ/g), but less than or equal to 13,000 Btu/lb (30 kJ/g).

1-7.3 Level 3 aerosol products are those with a total chemical heat of combustion that is greater than 13,000 Btu/lb (30 kJ/g).

1-8 Marking of Packages of Aerosol Products. Manufacturers of aerosol products manufactured after September 1, 1994, shall ensure that all cartons or packages of aerosol products are identified on at least one side with the classification of the aerosol products contained therein, in accordance with Section 1-7. Cartons or packages shall be clearly marked as follows:

Level _____ Aerosols

Chapter 2 Basic Requirements

2-1 Site Requirements. Distances between buildings used for the manufacture or storage of aerosol products and adjacent buildings or property lines that are or can be built upon shall be based on sound engineering principles.

2-2 Building Construction.

2-2.1 Openings in fire walls or fire barriers shall be kept to a minimum. All openings (i.e., personnel doorways, ductwork, conveyor line, etc.) shall be protected with automatic-closing or self-closing fire doors or dampers. Fire doors shall be installed in accordance with NFPA 80, *Standard for Fire Doors and Fire Windows.* Fire dampers shall be installed in accordance with manufacturer's instructions and NFPA 90A, *Standard for the Installation of Air Conditioning and Ventilating Systems.*

2-2.2 Means of egress shall comply with applicable provisions of NFPA *101®, Life Safety Code®*. The design and construction of conveyor lines and other physical obstacles, such as in the flammable propellant charging and pump rooms, shall not allow entrapment of personnel and shall provide for direct access to exits.

2-3 Electrical Installations.

2-3.1 All electrical equipment and wiring, including heating equipment, shall be installed in accordance with NFPA 70, *National Electrical Code®*. Electrical equipment and wiring in areas where flammable liquids or flammable gases are handled shall meet the additional requirements of Articles 500 and 501 of NFPA 70, *National Electrical Code.*

2-3.2 Aerosol product storage and display areas shall be considered unclassified for purposes of electrical installation.

2-4 Heating Equipment. Heating equipment shall be installed in accordance with the applicable requirements of NFPA 31, *Standard for the Installation of Oil-Burning Equipment;* NFPA 54, *National Fuel Gas Code;* NFPA 58, *Liquefied Petroleum Gas Code;* NFPA 8502, *Standard for the Prevention of Furnace Explosions/Implosions in Multiple Burner Boilers;* and NFPA 8501, *Standard for Single Burner Boiler Operation.*

2-5 Flammable Liquids and Gases. Areas in which flammable liquids and flammable gases are handled or stored shall meet the applicable requirements of NFPA 30, *Flammable and Combustible Liquids Code*, and NFPA 58, *Liquefied Petroleum Gas Code.*

2-6 Fire Protection.

2-6.1 Automatic Sprinkler Protection. Installations of automatic sprinklers, where required by this code, shall be installed in accordance with NFPA 13, *Standard for the Installation of Sprinkler Systems*, and shall also meet applicable requirements of NFPA 231, *Standard for General Storage;* NFPA 231C, *Standard for Rack Storage of Materials;* and the provisions of this code.

2-6.2 Standpipe and Hose System. Installations of standpipe and hose systems, where required by this code, shall be designed and installed in accordance with NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*, and with the provisions of this code. Only combination or spray hose nozzles shall be used.

2-6.3 Portable Fire Extinguishers. Fire extinguishers shall be provided in accordance with NFPA 10, *Standard for Portable Fire Extinguishers.*

2-6.4 Water Supplies.

2-6.4.1 In addition to the water supply requirements for automatic sprinkler systems, a minimum water supply of 500 gpm (1900 L/min) shall be provided for combined inside and outside hose streams for buildings that are protected throughout by an automatic sprinkler system or 1000 gpm (3800 L/min) for buildings that are not sprinklered. The water supply shall be sufficient to provide the required hose stream demand for a minimum duration of 2 hours. The water supply system shall be designed and installed in accordance with NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances.*

Exception: As modified by the provisions of this code.

2-6.4.2 Installations of fire pumps and tanks that are needed to supply the required fire protection water shall be installed in accordance with NFPA 20, *Standard for the Installation of Centrifugal Fire Pumps*, and NFPA 22, *Standard for Water Tanks for Private Fire Protection.*

2-7 Fire Alarms. Fire alarm systems shall be installed, tested, and maintained in accordance with applicable requirements of NFPA 72, National Fire Alarm Code®.

2-8 Sources of Ignition. In areas where flammable gases or flammable vapors might be present, precautions shall be taken to prevent ignition by eliminating or controlling sources of ignition. Sources of ignition include, but are not limited to the following:

(a) Open flames
(b) Lightning
(c) Hot surfaces
(d) Radiant heat
(e) Smoking
(f) Cutting and welding
(g) Spontaneous ignition
(h) Frictional heat or sparks
(i) Static electricity
(j) Electrical arcs and sparks
(k) Stray currents
(l) Ovens, furnaces, and other heating equipment
(m) Automotive vehicles
(n) Material-handling equipment

Chapter 3 Manufacturing Facilities

3-1* Scope. This chapter shall apply to the manufacture of aerosol products.

3-2 Definitions. For the purposes of this chapter, the following terms shall have the definitions given below.

Base Product Filler (Concentrate Filler). A machine used to fill the aerosol container with the base product prior to addition of the propellant.

Button Tipper (Actuator Placer).* The machine that places the valve actuator (spray tip) onto the aerosol container after the base product has been added.

Local Ventilation. A ventilation system whose exhaust inlet is located close to the point of vapor release so as to remove the vapor from the point of release.

Propellant Charging Room (Gas House, Gassing Room). A room in which the propellant is added to the aerosol containers.

Propellant Charging Pump (Charging Pump). A pump used to boost the liquid propellant to the pressure required by the propellant filler, usually 300 to 1200 psi (2070 to 8280 kPa). Tank farm transfer pumps normally supply the suction side of the propellant charging pump at pressures of 15 to 100 psi (100 to 690 kPa) above the propellant's vapor pressure.

Propellant Filler (Gasser, Propellant Charger).* A machine that adds the propellant to the aerosol container.

Pump Room. A room outside the propellant charging room in which flammable propellant charging pumps and, in some cases, vacuum pumps are located.

Reject Container Receptacle. A receptacle used to store scrap, partially filled, or fully filled aerosol containers prior to disposal.

Test Bath (Hot Tank, Water Bath).* A water tank in which pressurized aerosol containers are tested to verify the container strength and to detect leaks by immersion in water.

Vacuum Pump. A pump used to evacuate the head space (above the base product) of an aerosol container prior to addition of the propellant.

Valve Crimper (Crimper). A machine that seals the valve cup or valve ferrule to the aerosol container.

3-3 Basic Requirements.

3-3.1 Manufacturing buildings shall be located at least 25 ft (8 m) from the nearest property line that is or can be built upon.

3-3.2 Flammable propellant storage tanks shall be located in accordance with the provisions of NFPA 58, *Liquefied Petroleum Gas Code.*

3-3.3 Flammable and combustible liquids shall be stored in accordance with the provisions of NFPA 30, *Flammable and Combustible Liquids Code.*

3-3.4 Flammable propellant charging and pump rooms shall be separated from adjacent buildings or structures by noncommunicating walls or by a distance of at least 5 ft (1.5 m) and from inside areas by noncommunicating walls. Flammable propellant charging and pump rooms shall be separated from flammable propellant storage tanks and from flammable and combustible liquids storage by a distance of at least 25 ft (8 m).

3-4* Building Construction.

3-4.1 Buildings or structures involved in the manufacturing of aerosol products shall have no basement or any space below the finish floor of the ground level.

Exception: Subject to the approval of the authority having jurisdiction, buildings or structures shall be permitted to have basements or below–ground level areas provided they are ventilated at a minimum flow rate of 1 ft³/min · ft² (0.3 m³ /min · m²) of floor area and provided the nearest entrance or access point is located at least 50 ft (15.1 m) in any direction from the nearest point of the gas house.

3-4.2 Flammable propellant charging operations shall be limited to the ground floor.

3-4.3 Flammable propellant charging and pump rooms shall be classified as High Hazard Areas, as defined by NFPA *101, Life Safety Code.*

3-4.4 Damage-Limiting Construction.

3-4.4.1 The walls and roof of flammable propellant charging and pump rooms shall be of damage-limiting construction, except for required deflagration vents. *(See also 3-4.5.)*

3-4.4.2 The walls, roof, and all structural members shall be designed to withstand a static pressure of at least five times the release pressure of the deflagration vent closure, but in no case less than 100 lb/ft² (4.8 kPa).

3-4.5 Deflagration venting shall be provided in all new construction of the following areas:

(a) Flammable propellant charging rooms
(b) Flammable propellant pump rooms
(c) Areas in which Class IA liquids or unstable liquids are handled

3-4.5.1* Deflagration venting shall be designed at a ratio of not less than 1 ft²(0.09 m²) of vent area for 30 ft³ (0.85 m³) of room volume.

3-4.5.2 Deflagration vents shall relieve to a safe location to avoid injury to personnel and to minimize property damage.

3-4.5.3* In existing rooms where deflagration venting cannot be installed, a deflagration suppression system that meets the requirements of NFPA 69, *Standard on Explosion Prevention Systems*, shall be installed.

3-5 Ventilation.

3-5.1* Mechanical exhaust ventilation shall be provided for flammable concentrate–filling areas and for flammable propellant charging and pump rooms in accordance with 3-5.2 or 3-5.3, as applicable. Ventilation systems shall include exhaust systems and make-up air systems.

3-5.2 Mechanical exhaust ventilation for the flammable propellant charging and pump rooms shall meet the following requirements.

(a) The ventilation shall be nonrecirculating.

(b) Make-up air shall be taken either directly from outside or from areas of the building where flammable vapors are not present.

(c) Air inlets and outlets shall be located so that air flows uniformly across the floor of the room. The bottom of the air inlets and outlets shall be no more than $\frac{1}{2}$ ft (0.15 m) above the floor.

(d)* The required rate of ventilation shall be determined by the following formula:

$$VR = \frac{(100 - LEL)(V)(R)}{(DL)(LEL)}$$

where:

VR = required ventilation flow rate, ft^3/min (m^3/hr) (Note: To convert ft^3/min to m^3/hr, multiply *VR* by 1.70.)

LEL = lower explosive limit of the specific propellant being used, percent by volume

V = volume of vapor produced per unit volume of liquid propellant, ft^3/gal (m^3/L)

R = estimated volume of propellant lost during normal filling operations plus 20 percent for occasional system leakage, gal/min (L/hr)

DL = design level, which is the ratio of the desired allowable vapor concentration, in percent by volume, to the lower explosive limit, as defined above (Normally, *DL* is not more than 0.1.)

In no case shall the ventilation rate be less than one air change per minute.

Exception: Where provided at all propellant fillers and subject to the approval of the authority having jurisdiction, local exhaust ventilation shall be permitted to replace up to 75 percent of the volumetric flow rate of the ventilation required by 3-5.2. In no case shall the ventilation rate be less than one air change per minute.

(e) Emergency ventilation shall be activated automatically at not more than 20 percent of the lower explosive limit. It shall be designed to provide 150 percent of the air flow rate determined in 3-5.2(d) or two air changes per minute, whichever is greater.

(f)* Exhaust discharge stacks shall be separated horizontally by at least 10 ft (3 m) from make-up air intakes and shall terminate at least 10 ft (3 m) above the roof and at least 3 ft (1 m) above any other building within 25 ft (7.6 m).

(g) Exhaust ventilation air flow shall be monitored so as to enable automatic shutdown of the propellant-filling line in the event of failure of the ventilation system.

(h) All fan blades utilized by the exhaust and make-up air systems shall be nonsparking.

(i) The room shall be maintained at a negative pressure in relation to the ambient air.

3-5.3 Mechanical exhaust ventilation shall be provided for flammable base product-filling areas. For areas that contain production operations likely to emit hazardous concentrations of flammable vapors, general area mechanical ventilation shall be provided at a minimum flow rate of 1 $ft^3/min \cdot ft^2$ (0.3 $m^3/min \cdot m^2$) of floor area. Ventilation shall be arranged to uniformly sweep the entire floor area.

Exception: When provided at all of the following and subject to the approval of the authority having jurisdiction, local exhaust ventilation shall be permitted to replace up to 75 percent of the volumetric flow rate of the general area ventilation required by 3-5.3:

(a) Base product filler

(b) Button tipper

(c) Valve crimper

3-5.4* Aerosol container test baths shall be enclosed and provided with exhaust ventilation. Exhaust discharge stacks shall meet the requirements of 3-5.2(f).

3-5.5 Local exhaust ventilation shall be provided for reject aerosol container receptacles that are located within buildings.

3-6 Electrical Equipment. Electrical equipment and wiring in flammable propellant charging and pump rooms shall be suitable for Class I, Division 1 locations.

3-6.1 If the vacuum pumps for propellant charging are remotely installed (i.e., not in the charging room), the area within 5 ft (1.5 m) of the extremities of the pumps shall be classified as a Class I, Division 2 location.

3-6.2* Electrical equipment and wiring in areas where flammable liquids are handled shall be suitable for the classification of the area, as defined in Table 2-5.7.3 of NFPA 30, *Flammable and Combustible Liquids Code*.

3-6.3 The area enclosed by the test bath shall be classified as a Class I, Division 1 location. The area within 5 ft (1.5 m) in all directions of the hot tank shall be classified as a Class I, Division 2 location.

3-7* Control of Static Electricity. All equipment involved in the manufacture of aerosol products shall be suitably bonded and grounded.

3-8* Combustible Gas Detection Systems. Flammable propellant charging and pump rooms shall be provided with an approved gas detection system that is equipped with audible or visible alarms. The gas detection system shall be interlocked in accordance with Section 3-13. Annunciation of the gas detection system alarm shall be within the charging and pump rooms and in nearby production areas.

3-9 Automatic Sprinkler Protection.

3-9.1* Flammable propellant charging and pump rooms shall be protected by either a wet-pipe or a deluge-type automatic sprinkler system. The system shall be designed to meet the

requirements of an extra-hazard, Group II occupancy, as set forth in NFPA 13, *Standard for the Installation of Sprinkler Systems.*

3-9.1.1 Deluge systems shall be activated by an approved heat detection system.

3-9.1.2 Wet-pipe sprinkler systems shall use ordinary temperature-rated sprinklers.

3-9.2 Production areas that contain base product fillers, button tippers, valve crimpers, test baths, and aerosol can packaging equipment shall be protected by a wet-pipe automatic sprinkler system installed in accordance with NFPA 13, *Standard for the Installation of Sprinkler Systems.* The sprinkler system shall be designed to protect the highest level of storage or production hazard that is present.

Exception: Storage of up to 2500 lb (1135 kg) net weight of Level 2 or Level 3 aerosol products per production line or rework production line shall be permitted in production areas, such as in staging areas (e.g., awaiting transfer to a warehouse), provided they are stacked no more than one palletload high and there is no warehouse storage of aerosol products within 25 ft (7.6 m) of the production line. All other storage shall be protected in accordance with Tables 4-3(a) through 4-3(e), as applicable.

3-9.3 Where acceptable to the authority having jurisdiction, an automatic sprinkler system shall be permitted to be equipped for the injection of aqueous film-forming foam (AFFF). Such systems shall be designed and installed in accordance with NFPA 11, *Standard for Low-Expansion Foam;* NFPA 13, *Standard for the Installation of Sprinkler Systems;* and NFPA 16, *Standard for the Installation of Deluge Foam-Water Sprinkler and Foam-Water Spray Systems.*

3-10 Fixed Extinguishing Systems. Where automatic fire extinguishing systems are provided to protect production equipment, such as mixers, solvent tanks, or fixed open containers, such systems shall be designed and installed in accordance with the following, as applicable:

NFPA 11, *Standard for Low-Expansion Foam*

NFPA 11A, *Standard for Medium- and High-Expansion Foam Systems*

NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems*

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

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

NFPA 17, *Standard for Dry Chemical Extinguishing Systems*

NFPA 2001, *Standard on Clean Agent Fire Extinguishing Systems*

3-11 Spill Control.

3-11.1* Drainage systems shall be provided to direct leaks and spills to a safe location. Curbs, scuppers, or special drainage systems shall be permitted to be used to control the spread of fire.

3-11.2 If drainage systems are connected to public sewers or discharge into public waterways, the drainage systems shall be equipped with traps, separators, or other devices that will divert flow to a safe location.

3-12 Deflagration Suppression Systems.

3-12.1 A deflagration suppression system meeting the requirements of NFPA 69, *Standard on Explosion Prevention Systems,* shall be installed in flammable propellant charging rooms and flammable propellant pump rooms.

3-12.2 Where installed, an engineered deflagration suppression system shall meet the requirements of NFPA 69, *Standard on Explosion Prevention Systems,* and shall use approved radiant energy detectors.

3-13 Equipment Interlocks. Equipment shall be interlocked so that the system inputs listed in Table 3-13 result in the associated process/equipment responses given.

Table 3-13 Equipment Interlocks

	Process/Equipment Response						
System Inputs	**Propellant Supply Shutdown**	**Propellant Venting**	**Aerosol Line Shutdown**	**Audible and Visual Alarms**	**Fire Alarms**	**Standard Ventilation Rate**	**Emergency Ventilation Rate**
Gas detection at 20% LEL	NR	NR	NR	Yes	NR	N/A	On
Gas detection at 40% LEL	Yes	NR	Yes	Yes	NR	N/A	On
Loss of ventilation	Yes	Yes	Yes	Yes	NR	N/A	N/A
Emergency stop	Yes	Yes	Yes	Yes	NR	N/A	On
Deflagration suppression system disarm or trouble	Yes	Yes	Yes	Yes	NR	On	N/A
Halon 1301 deflagration suppression system actuation	Yes	Yes	Yes	Yes	Yes	Off	Off

(continues)

Table 3-13 Equipment Interlocks ***(Continued)***

System Inputs	Process/Equipment Response						
	Propellant Supply Shutdown	Propellant Venting	Aerosol Line Shutdown	Audible and Visual Alarms	Fire Alarms	Standard Ventilation Rate	Emergency Ventilation Rate
Water deflagration suppression system actuation	Yes	Yes	Yes	Yes	Yes	N/A	On
Loss of power	Yes	Yes	Yes	Yes	NR	N/A	N/A
Gas detection system fault	Yes	Yes	Yes	Yes	NR	N/A	On
Automatic sprinkler actuation	Yes	Yes	Yes	Yes	Yes	N/A	N/A

NR = Not Required
N/A = Not Applicable

3-14 Process Operating Requirements.

3-14.1 Packaging and Conveyor System. Guide rails, starwheels, can screws (worms), and other parts of the conveying system shall be designed to minimize crushing and tipping of containers. Manual or automatic devices shall be installed to stop packaging machinery and conveyors in the event of a jam.

3-14.2 Crimper Vacuum Pump Discharge Vent. The discharge vent for the crimper vacuum pump shall terminate at a safe location outside, not less than 12 ft (3.7 m) above adjacent ground level. The vent outlet shall be located or arranged so that flammable gas or vapor will not be trapped by eaves or other obstructions and shall be at least 5 ft (1.5 m) from any building openings.

3-14.3 Propellant Charging Equipment.

3-14.3.1 The propellant pump and all equipment subject to pressure from the pump shall be suitable for the working pressure of the system. Pump discharge pressures shall not be limited, provided they do not exceed the working pressure of the system.

3-14.3.2 Vacuum pump and propellant pump discharge piping on any equipment that handles flammable gases or liquids shall meet the following requirements:

(a) The discharge vent shall terminate at a safe location outside and at least 10 ft (3 m) away from any air intake.

(b) The discharge vent shall terminate at least 10 ft (3 m) above the roof and at least 3 ft (1 m) above the highest point of any building within 25 ft (7.6 m).

(c) Discharge vent manifolds shall not be allowed.

3-14.4 Flammable Liquid Propellant Pump.

3-14.4.1 If located inside a building, the propellant pump shall be located either in the propellant charging room or in a separate pump room having suitable ventilation, as described in Section 3-5.

3-14.4.2 If located outside, the propellant charging pump shall be located at least 25 ft (7.6 m) from the following:

(a) Any opening in the adjacent wall of the production facility

(b) Walls or buildings other than the production facility or propellant charging room

(c) Any area subject to vehicular travel

(d) Other sources of ignition

3-14.4.3 Pressure-containing metal parts shall be constructed of the following materials:

(a) Steel

(b) Stainless steel

(c) Ductile (nodular) iron (ASTM A 395 or A 536, grade 60-40-18 or 65-45-12)

(d) Malleable iron (ASTM A 47)

(e) Higher strength grey iron (ASTM A 48, Class 40B)

(f) Brass

(g) Other materials equivalent to any of the above

3-14.4.4 Pressure-containing parts, plungers, or pistons shall not be constructed of ceramic materials.

3-14.4.5 Bypass regulator bonnet vents, safety relief valves, and hydrostatic relief valves on equipment located within buildings shall be vented to a safe location outside. Discharge vents shall terminate at least 10 ft (3 m) above the roof and at least 3 ft (1 m) above the highest point of any building within 25 ft (7.6 m).

3-14.5 Test Baths.

3-14.5.1 When test baths are heated, they shall be heated with steam or hot water. Open-flame heaters shall not be used with Level 2 or Level 3 aerosol products.

3-14.5.2 Provisions shall be made to prevent overheating and subsequent rupture of containers when containers become lodged or stranded in the bath.

3-15 Aerosol Product Laboratories.

3-15.1 Aerosol laboratories shall be considered as Class A laboratory units and, as such, shall comply with NFPA 45, *Standard on Fire Protection for Laboratories Using Chemicals.*

3-15.2 Tests for total discharge, rate of spray, spray pattern, and net weight shall be conducted with proper ventilation.

3-15.3 When the entire contents of an aerosol container must be used to perform a test or the contents of the container must be removed for internal examination of the container, the following precautions shall be taken:

(a) The container shall be placed in a laboratory hood.

(b) The container shall be grounded.

(c) The container shall be pierced with a nonsparking device.

(d) Only one container at a time shall be punctured or sprayed.

(e) When more than one container is to be evacuated at a time, the operation shall be conducted in the propellant charging room, outdoors, or within equipment or facilities specifically designed for this purpose.

3-15.4 Where propellant-filling equipment is similar to that utilized within production operations, the laboratory shall be considered to be a pilot plant and shall meet the construction and ventilation requirements of Chapter 3 of this code.

3-15.4.1 Cold-filling of flammable propellant shall be prohibited for standard or routine evaluations.

Exception: Cold-filling of small numbers of samples used for special testing shall be permitted where alternate filling methods cannot be used.

3-15.4.2 Manual filling of flammable propellant in an aerosol laboratory shall be conducted inside a well-ventilated laboratory hood.

Chapter 4 Storage in Warehouses and Storage Areas

4-1 Basic Requirements.

4-1.1 All cartons of aerosol products shall be identified on at least one side with the classification of the aerosol products contained therein, in accordance with Section 1-7. Cartons shall be clearly marked as follows:

Level _____ Aerosols

4-1.2* Fire retardant cartons shall not be considered an acceptable alternative to the protection requirements of Chapter 4.

4-2* Storage of Level 1 Aerosol Products. Level 1 aerosol products shall be considered equivalent to Class III commodities, as defined in NFPA 231, *Standard for General Storage*, and NFPA 231C, *Standard for Rack Storage of Materials*. In cases where the storage of Level 1 aerosol products is required to be protected, such storage shall be protected in accordance with the requirements set forth in NFPA 231 and NFPA 231C.

4-3 Storage of Level 2 and Level 3 Aerosol Products.

4-3.1 The storage of Level 2 and Level 3 aerosol products shall be in accordance with Section 4-3.

Exception: Level 2 aerosol products in containers whose net weight is less than 1 oz (28 g) shall be considered to be equivalent to Group A plastics, as defined in NFPA 231, Standard for General Storage, and NFPA 231C, Standard for Rack Storage of Materials. In cases where the storage of such products is required to be protected, such storage shall be in accordance with the requirements set forth in NFPA 13, Standard for the Installation of Sprinkler Systems, NFPA 231, or NFPA 231C.

4-3.2 Fire Protection — Basic Requirements.

4-3.2.1 Storage of Level 2 and Level 3 aerosol products shall not be permitted in basement areas of warehouses.

Exception: As provided for in 4-3.3.

4-3.2.2 Encapsulated storage of Level 2 and Level 3 aerosol products shall not be permitted. Stretch-wrap of aerosol containers in lieu of cartons shall not be permitted; however, stretch-wrapping of cartons of aerosol products shall be permitted.

4-3.2.3 Level 2 and 3 aerosol products whose containers are designed to vent at pressures less than 210 psig (1450 kPa gauge) shall not be stored.

4-3.2.4 Noncombustible draft curtains of at least 2 ft (0.61 m) depth shall be installed as follows:

(a) At the interface between the ESFR sprinkler design area and the standard response sprinkler design area

(b) At the interface between the design areas utilizing ordinary-temperature sprinklers and high-temperature sprinklers.

4-3.2.5 Storage of mixed commodities within or adjacent to aerosol product storage areas shall meet all applicable requirements of this chapter.

4-3.2.6 Storage of idle or empty pallets shall meet all applicable requirements of NFPA 231, *Standard for General Storage*.

4-3.2.7 Where required by this chapter, wet-pipe automatic sprinkler protection shall be provided in accordance with Tables 4-3(a) through 4-3(e). Protection shall be based on the highest level of aerosol product present.

4-3.2.8 Protection criteria that is developed based on full-scale fire tests performed at an approved test facility shall be considered an acceptable alternative to the protection criteria set forth in Tables 4-3(a) through 4-3(e). Such alternative protection criteria shall be subject to the approval of the authority having jurisdiction.

4-3.2.9 Installation of in-rack sprinklers shall be in accordance with NFPA 231C, *Standard for Rack Storage of Materials*, as modified by Table 4-3(e).

4-3.2.10 Installations of hose connections shall meet the requirements of NFPA 231, *Standard for General Storage*, or NFPA 231C, *Standard for Rack Storage of Materials*, whichever is applicable.

Exception: Subject to the approval of the authority having jurisdiction, hose stations need not be installed in storage areas.

4-3.2.11 Storage height and clearance requirements between storage and sprinklers shall comply with Tables 4-3(a) through 4-3(e).

4-3.2.12 Solid shelving that is installed in racks that contain Level 3 aerosol products shall be protected in accordance with Table 4-3(e). Solid shelving that is installed in racks that contain Level 2 aerosol products and that are protected by spray sprinklers shall also be protected in accordance with Table 4-3(e). Solid shelving shall not be installed in racks that are protected by a ceiling sprinkler system that utilizes ESFR sprinklers.

4-3.2.13* ESFR ceiling sprinklers are permitted to be used in conjunction with the in-rack sprinkler protection criteria in Table 4-3(e) where the following conditions are met:

(a) Roof height does not exceed 30 ft (9.14 m)

(b) Storage height does not exceed 25 ft (7.62 m)
(c) Clearance between top of storage and sprinkler deflectors is at least 3 ft (0.91 m)
(d) Ceiling sprinkler design criteria is 12 sprinklers operating at 75 psig (517 kPa gauge)
(e) All in-rack sprinklers are quick-response type

Table 4-3(a) Arrangement and Protection of Palletized and Solid-Pile Level 2 Aerosol Storage[1]

Maximum Ceiling Height (ft)	30	30	25	25
Maximum Pile Height (ft)	5	15	18	20
Sprinkler	Standard or Large orifice	ESFR (K = 13.5 to 14.5)	Large drop 0.64 in.	ESFR (K = 13.5 to 14.5)
Temperature Rating[2]	High	Ordinary	Ordinary	Ordinary
Sprinkler Spacing (ft²)	100 max.	80–100	80–100	80–100
Sprinkler Demand	0.30 gpm/ft² over 2500 ft²	12 sprinklers at 50 psi	15 sprinklers at 50 psi	12 sprinklers at 50 psi
Hose Stream Demand (gpm)	See 2-6.4			
Duration (hr)	2	1	2	1

Note: For SI units, 1 ft = 0.3048 m; 1 ft² = 0.0929 m²; 1 gpm/ft² = 40.743 L/min·m²; 1 psi = 6.895 kPa; 1 gpm = 3.785 L/min.
[1]All fire tests on which this table is based were conducted with spray, large drop, or ESFR sprinklers. This does not include spray or large drop sprinklers equipped with quick-response links. The Response Time Index (RTI) of spray and large drop sprinklers shall not be less than 181 $(ft \cdot sec)^{1/2}$ [100 $(m \cdot sec)^{1/2}$].
[2]When sprinklers having higher temperature ratings are used, such as near unit heaters, refer to NFPA 13, *Standard for the Installation of Sprinkler Systems*.

Table 4-3(b) Arrangement of Protection for Palletized and Solid-Pile Level 3 Aerosols[1]

Maximum Ceiling Height (ft)	30	30	25	20	20
Maximum Pile Height (ft)	5	15	15	10	5
Sprinkler	Standard, Large, or Extra-large orifice[3]	ESFR (K = 13.5 to 14.5)	ESFR (K = 13.5 to 14.5)	Large Drop 0.64 in.	Standard orifice
Temperature Rating[2]	High	Ordinary	Ordinary	Ordinary	High
Sprinkler Spacing (ft²)	100 max.	80–100	80–100	80–100	100 max.
Sprinkler Demand	0.60 gpm/ft² over 2500 ft²	12 sprinklers at 75 psi	12 sprinklers at 50 psi	15 sprinklers at 75 psi	0.30 gpm/2500 ft²
Hose Stream Demand (gpm)	See 2-6.4				
Duration (hr)	2	1	1	2	2

Note: For SI units, 1 ft = 0.3048 m; 1 ft² = 0.0929 m²; 1 gpm/ft² = 40.743 L/min · m²; 1 psi = 6.895 kPa; 1 gpm = 3.785 L/min.
[1]All fire tests on which this table is based were conducted with spray, large drop, or ESFR sprinklers. This does not include spray or large drop sprinklers equipped with quick-response links. The Response Time Index (RTI) of spray and large drop sprinklers shall not be less than 181 $(ft \cdot sec)^{1/2}$ [100 $(m \cdot sec)^{1/2}$].
[2]When sprinklers having higher temperature ratings are used, such as near unit heaters, refer to NFPA 13, *Standard for the Installation of Sprinkler Systems*.
[3]Extra-large orifice sprinklers shall have a minimum operating pressure of 10 psi (69 kPa).

Table 4-3(c) ESFR (K = 13.5 to 14.5) Arrangement and Protection of Level 2 Rack Storage[1]

Maximum Ceiling Height (ft)	30	25
Maximum Storage Height (ft)	15	20
Temperature Rating[2]	Ordinary	Ordinary
Sprinkler Spacing (ft²)	80–100	80–100
Sprinkler Demand	12 sprinklers at 50 psi	12 sprinklers at 50 psi
Hose Stream Demand (gpm)	250	250
Duration (hr)	1	1

Note: For SI units, 1 ft = 0.3048 m; 1 ft² = 0.0929 m²; 1 gpm/ft² = 40.743 L/min · m²; 1 psi = 6.895 kPa; 1 gpm = 3.785 L/min.
[1]Single and double-row racks only.
[2]When sprinklers having higher temperature ratings are used, such as near unit heaters, refer to NFPA 13, *Standard for the Installation of Sprinkler Systems.*

Table 4-3(d) ESFR (K = 13.5 to 14.5) Arrangement and Protection of Level 3 Rack Storage[1]

Maximum Ceiling Height (ft)	30	25
Maximum Storage Height (ft)	15	15
Temperature Rating[2]	Ordinary	Ordinary
Sprinkler Spacing (ft²)	80–100	80–100
Sprinkler Demand	12 sprinklers at 75 psi	12 sprinklers at 50 psi
Hose Stream Demand (gpm)	250	250
Duration (hr)	1	1

Note: For SI units, 1 ft = 0.3048 m; 1 ft² = 0.0929 m²; 1 gpm/ft² = 40.743 L/min·m²; 1 psi = 6.895 kPa; 1 gpm = 3.785 L/min.
[1]Single and double-row racks only.
[2]When sprinklers having higher temperature ratings are used, such as near unit heaters, refer to NFPA 13, *Standard for the Installation of Sprinkler Systems.*

Table 4-3(e) Protection of Rack Storage of Level 2 and Level 3 Aerosols with In-Rack Sprinklers

Level	Maximum Ceiling Height	Maximum Storage Height	Ceiling Sprinkler Type and Arrangement[1,5]	Clearance: Storage to Sprinklers	Ceiling Design	In-Rack Sprinkler Type and Arrangement[1,2]	In-Rack Design	Duration
2	None	None	Standard spray, high temperature, $^1/_2$ in. or $^{17}/_{32}$ in. orifice, SR, 100 ft² max. spacing	15 ft max. If clearance exceeds 15 ft, a barrier with face sprinklers below is required.	0.30 gpm/ft² over 2500 ft²	Ordinary temperature sprinklers, 8 ft apart max. One line at each tier except top. Locate in longitudinal flue spaces in double row racks.[3]	30 gpm per sprinkler minimum. Based on operation of hydraulically most remote: (a) 8 sprinklers if one level (b) 6 sprinklers each of 2 levels if only 2 levels (c) 6 sprinklers on top 3 levels if 3 or more levels	2 hr

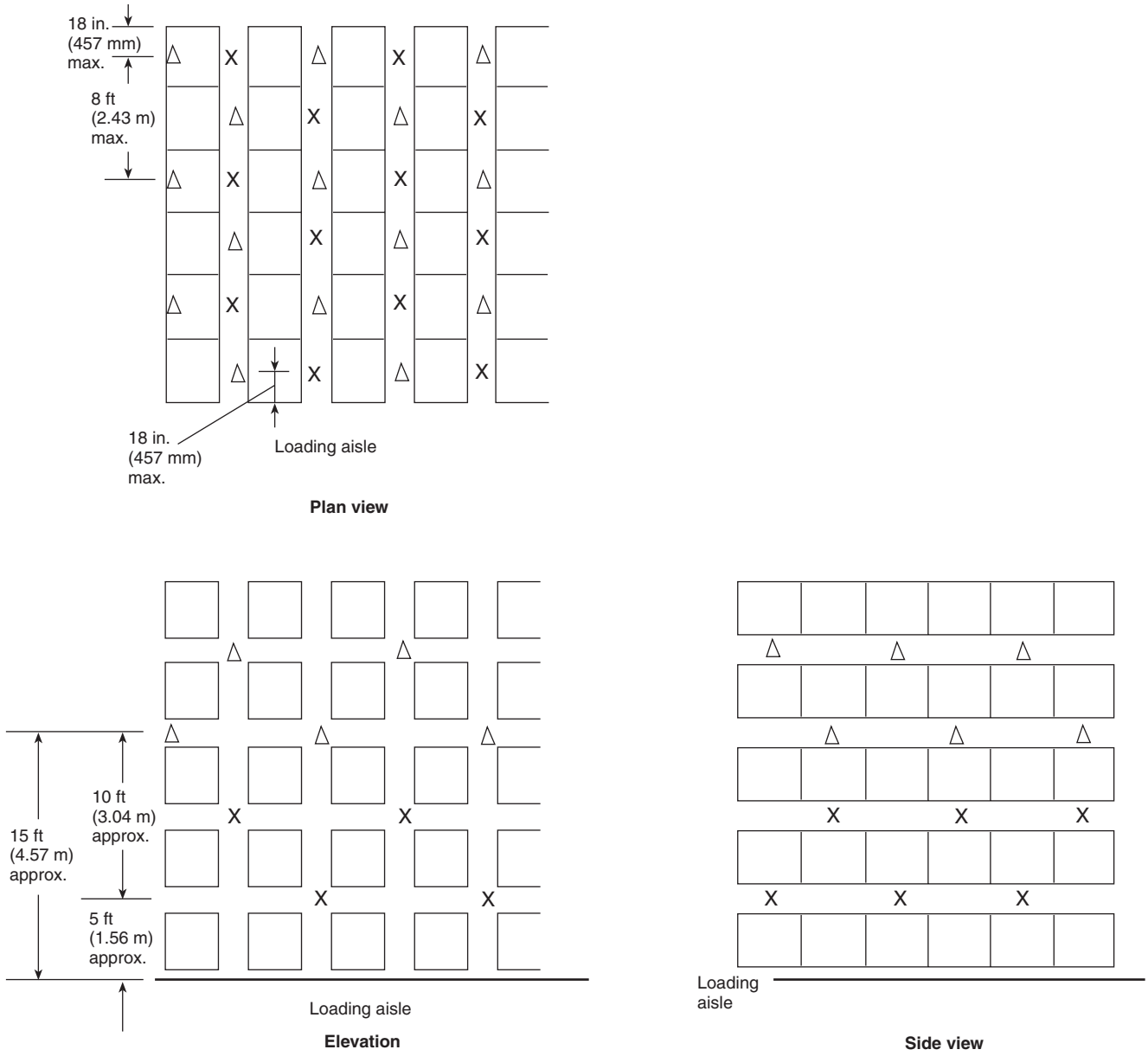
(continues)

Table 4-3(e) Protection of Rack Storage of Level 2 and Level 3 Aerosols with In-Rack Sprinklers *(Continued)*

Level	Maximum Ceiling Height	Maximum Storage Height	Ceiling Sprinkler Type and Arrangement[1,5]	Clearance: Storage to Sprinklers	Ceiling Design	In-Rack Sprinkler Type and Arrangement[1,2]	In-Rack Design	Duration
3	None	None	Standard spray, high temperature, $^{17}/_{32}$ in. or $^{5}/_{8}$ in. orifice, SR, 100 ft² max. spacing	5 ft or less	0.30 gpm/ft² over 2500 ft²	Ordinary temperature sprinklers, 8 ft apart max. One line at each tier except top. Locate in longitudinal flue spaces and on face of each tier except top tier.	30 gpm per sprinkler minimum. Based on operation of hydraulically most remote: (a) 8 sprinklers if one level (b) 6 sprinklers each of 2 levels if only 2 levels (c) 6 sprinklers on top 3 levels if 3 or more levels	2 hr
				More than 5 ft to 15 ft	0.60 gpm/ft² over 1500 ft² to 2500 ft². Interpolate for clearances between 5 ft and 15 ft.			
				More than 15 ft or more than 5 ft where barriers are used	0.30 gpm/ft² over 2500 ft² plus a barrier above top tier of storage with face sprinklers below			
3	30 ft	25 ft	Standard spray, high temperature, $^{17}/_{32}$ in. or $^{5}/_{8}$ in. orifice, SR, 100 ft² max. spacing	Up to 15 ft	0.60 gpm/ft² over 2500 ft²	Ordinary temperature sprinklers, 8 ft apart max. One line at each tier except top. Locate in longitudinal flue spaces and stagger vertically.[4]	30 gpm per sprinkler minimum. Based on operation of hydraulically most remote: (a) 8 sprinklers if one level (b) 6 sprinklers each of 2 levels if only 2 levels (c) 6 sprinklers on top 3 levels if 3 or more levels	2 hr
				More than 15 ft	0.60 gpm/ft² over 2500 ft² plus a barrier above top tier of storage with face sprinklers below			

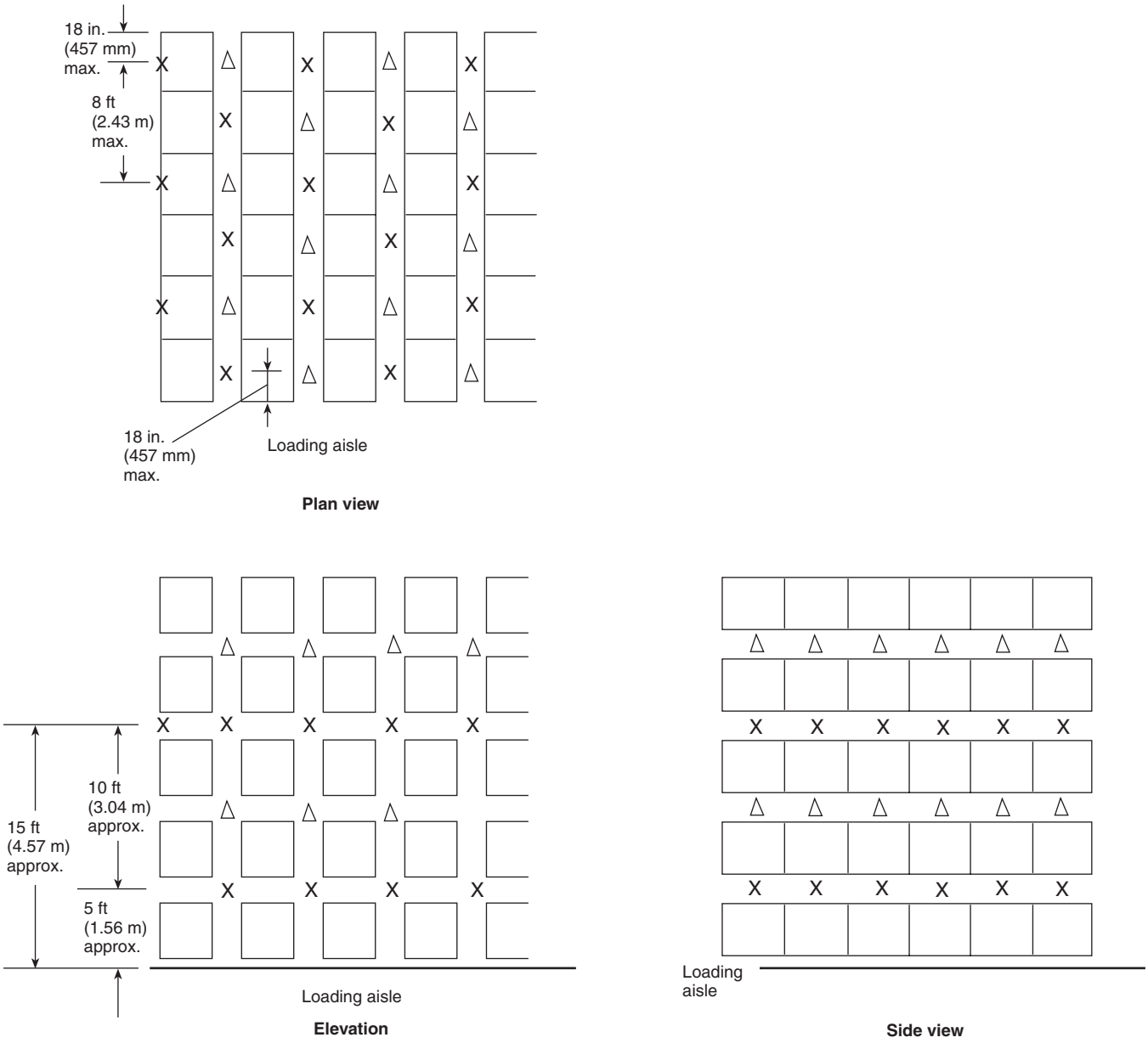
Note: For SI units, 1 ft = 0.3048 m; 1 ft² = 0.0929 m²; 1 gpm/ft² = 40.743 L/min · m²; 1 psi = 6.895 kPa; 1 gpm = 3.785 L/min.

[1]SR = Standard Response. $^{5}/_{8}$-in. orifice (extra-large orifice) sprinklers shall have a minimum operating pressure of 10 psi (69 kPa).
[2]Provide at least 6 in. (150 mm) between sprinkler deflectors and top of storage tier.
[3]Where the distance between transverse flues does not exceed 6 ft (1.8 m), multiple-row rack storage shall comply with Figure 4-3(a). Where the distance between transverse flues exceeds 6 ft (1.8 m), multiple-row rack storage shall comply with Figure 4-3(b).
[4]Multiple-row rack storage shall comply with Figure 4-3(b).
[5]ESFR ceiling protection, where provided, shall comply with 4-3.2.13.



1. Distance between top level of in-rack sprinklers and top of storage shall be no more than 5 ft (1.56 m) when only in-rack sprinklers are provided in addition to ceiling sprinklers.
2. Horizontally staggered face sprinklers shall be provided at 15-ft (4.57-m) vertical intervals.
3. Distance between transverse flues shall be no more than 6 ft (1.8 m).
4. Each square in the figure represents a storage cube measuring 4 ft to 5 ft (1.25 m to 1.56 m) on a side.
5. Symbol △ or X indicates sprinklers on vertical or horizontal stagger.

Figure 4-3(a) In-rack sprinkler arrangement for multiple-row racks, Level 2 aerosol products.



1. Distance between top level of in-rack sprinklers and top of storage shall be no more than 5 ft (1.56 m) when only in-rack sprinklers are provided in addition to ceiling sprinklers.
2. Horizontally staggered face sprinklers shall be provided at 15-ft (4.57-m) vertical intervals.
3. Each square in the figure represents a storage cube measuring 4 ft to 5 ft (1.25 m to 1.56 m) on a side.
4. Symbol △ or X indicates sprinklers on vertical or horizontal stagger.

Figure 4-3(b) In-rack sprinkler arrangement for multiple-row racks, Level 2 and Level 3 aerosol products.

4-3.3 Limited Quantity Storage in Occupancies Other than Warehouses.

4-3.3.1 Storage of Level 2 and Level 3 aerosol products in a single fire area in occupancies other than warehouses or mercantile occupancies, such as assembly, business, educational, industrial, and institutional occupancies, shall be permitted up to either of the following quantities:

(a) A maximum of 1000 lb (454 kg) net weight of Level 2 aerosol products

(b) A maximum of 500 lb (227 kg) net weight of Level 3 aerosol products.

In no case shall the combined net weight of Level 2 and Level 3 aerosol products exceed 1000 lb (454 kg).

4-3.3.2 These quantities shall be permitted to be doubled if the quantities in excess of those stated in 4-3.3.1 are stored in storage cabinets that meet the requirements of Section 4-3 of NFPA 30, *Flammable and Combustible Liquids Code.*

4-3.3.3 Where Level 2 and Level 3 aerosol products are stored in quantities greater than those allowed by 4-3.3.1, such quantities shall be stored in a separate inside storage area meeting the requirements of 4-3.7.

4-3.4 Limited Quantity Storage in General-Purpose Warehouses.

4-3.4.1 Subject to the approval of the authority having jurisdiction, solid pile, palletized, or rack storage of Level 2 and Level 3 aerosol products shall be permitted in a general-purpose warehouse that is either unsprinklered or not protected in accordance with this code, up to either of the following quantities:

(a) A maximum of 2500 lb (1135 kg) net weight of Level 2 aerosol products

(b) A maximum of 1000 lb (454 kg) net weight of Level 3 aerosol products

In no case shall the combined net weight of Level 2 and Level 3 aerosol products exceed 2500 lb (1135 kg).

4-3.4.2 Subject to the approval of the authority having jurisdiction, solid pile or palletized storage of Level 2 and Level 3 aerosol products shall be permitted in a general-purpose warehouse that is protected throughout by an automatic sprinkler system up to a maximum total quantity of 12,000 lb (5450 kg) combined net weight of Level 2 and Level 3 aerosol products, subject to the following:

(a) The sprinkler system over the aerosol storage area and for a distance of 20 ft (6 m) beyond shall be designed in accordance with Tables 4-3(a) and 4-3(b).

(b) Storage of flammable and combustible liquids shall be separated from the aerosol products storage area by at least 25 ft (8 m).

Such storage shall also meet the requirements of 4-5.2 of NFPA 30, *Flammable and Combustible Liquids Code*.

4-3.4.3 Subject to the approval of the authority having jurisdiction, rack storage of Level 2 and Level 3 aerosol products shall be permitted in a general-purpose warehouse that is protected throughout by an automatic sprinkler system up to a maximum total quantity of 24,000 lb (10,900 kg) combined net weight of Level 2 and Level 3 aerosol products, subject to the following:

(a) The sprinkler system in the Level 2 and Level 3 aerosol products storage area shall be designed in accordance with Tables 4-3(c) through 4-3(e). The ceiling sprinkler system design shall extend for 20 ft (6 m) beyond the aerosol products storage area.

(b) Storage of aerosol products shall be separated from storage of flammable and combustible liquids by at least 25 ft (8 m).

Such storage shall also meet the requirements of 4-5.2 of NFPA 30, *Flammable and Combustible Liquids Code*.

4-3.5 Segregated Aerosol Product Storage Areas in General-Purpose Warehouses.

4-3.5.1 Segregated storage of Level 2 and Level 3 aerosol products in a general-purpose warehouse shall only be in a warehouse that is protected throughout by an automatic sprinkler system that is designed in accordance with NFPA 231, *Standard for General Storage*, or NFPA 231C, *Standard for Rack Storage of Materials*, whichever is applicable.

4-3.5.2 Solid pile, palletized, or rack storage of Level 2 and Level 3 aerosol products in excess of the maximum quantities given in 4-3.4.2 and 4-3.4.3 shall be protected in accordance with the requirements in 4-3.5.3 through 4-3.5.8.

4-3.5.3 Storage of Level 2 and Level 3 aerosol products shall be in a segregated area separated from the rest of the warehouse by interior walls, chain-link fencing, or a separation area, in accordance with the requirements of 4-3.5.3.1 through 4-3.5.3.3.

4-3.5.3.1 Interior walls shall have a fire-resistance rating of 1 or 2 hours and shall be continuous from floor to the underside of the roof deck or ceiling. Openings in these walls shall be protected with self-closing or automatic-closing listed fire door assemblies with fire protection ratings corresponding to the fire-resistance rating of the wall as specified in Table 4-3.5.3.1.

(a) For interior walls having a fire-resistance rating of 2 hours, the total floor area of the segregated Level 2 and Level 3 plfaerosol storage area or areas shall not exceed 25 percent of the total floor area of the warehouse, up to a maximum of 40,000 ft² (3660 m²).

(b) For interior walls having a fire-resistance rating of 1 hour, the total floor area of the segregated Level 2 and Level 3 aerosol storage area or areas shall not exceed 20 percent of the total floor area of the warehouse, up to a maximum of 30,000 ft² (2745 m²).

Table 4-3.5.3.1 Fire Protection Ratings for Fire Doors

Fire-Resistance Rating of Wall (hr)	Fire Protection Rating of Door (hr)
1	$^3/_4$
2	$1^1/_2$
4	3*

*One fire door required on each side of interior openings for attached aerosol warehouses.

4-3.5.3.2 Chain-link fencing shall extend from the floor to the underside of the roof deck or ceiling and shall meet the following requirements:

(a) The total floor area of the segregated Level 2 and Level 3 aerosol storage area or areas shall not exceed 20 percent of the total area of the warehouse, up to a maximum of 20,000 ft² (1830 m²).

(b) Fencing shall not be lighter than 9 gauge (2.9 mm) steel wire woven into a maximum 2 in. (50 mm) diamond mesh.

(c) Storage of commodities whose hazard exceeds that of a Class III commodity, as defined by NFPA 231, *Standard for General Storage*, shall be kept outside of the segregated area and at least 8 ft (2.4 m) from the fence, except as allowed by 4-3.5.8.

(d) The area of the design for the required ceiling sprinkler system shall extend 20 ft (6 m) beyond the segregated area.

(e) A minimum of two personnel exits shall be provided.

(f) All openings in the fencing shall be provided with self-closing or automatic-closing gates or shall be protected with a labyrinth arrangement. Where automatic-closing gates are used, manual closure actuating devices shall be provided adjacent the opening to allow for manual closure of the gates.

4-3.5.3.3 Subject to the approval of the authority having jurisdiction, a separation area shall extend outwards from the periphery of the segregated aerosol product storage area and shall meet the following requirements:

(a) The total floor area of the segregated Level 2 and Level 3 aerosol storage area or areas shall not exceed 15 percent of the total area of the warehouse, up to a maximum of 20,000 ft² (1830 m²).

(b) The limits of the aerosol product storage area shall be clearly marked on the floor.

(c) The separation area shall be a minimum of 25 ft (7.6 m) and shall be maintained clear of all materials that have a commodity classification greater than Class III, according to NFPA 231, *Standard for General Storage*.

(d) The area of the design for the required ceiling sprinkler system shall extend 20 ft (6 m) beyond the segregated area.

4-3.5.4 Sprinkler protection shall be provided for segregated aerosol product storage areas in accordance with Tables 4-3(a) through 4-3(e). Protection shall be provided for the highest level of aerosol products present.

4-3.5.5 Solid pile and palletized storage shall be arranged so that no storage is more than 25 ft (7.6 m) from an aisle. Aisles shall be at least 4 ft (1.2 m) wide.

4-3.5.6 Rack storage shall be arranged so that a minimum aisle width of 8 ft (2.4 m) is maintained between rows of racks and between racks and adjacent solid pile or palletized storage of Level 2 and Level 3 aerosol products.

Exception: Where protection and storage arrangements are in accordance with Table 4-3(c) or 4-3(d), the minimum aisle width shall be 4 ft (1.2 m).

4-3.5.7 An approved fire alarm system, meeting the requirements of Section 2-7, shall be provided throughout buildings used for the warehousing of segregated Level 2 or Level 3 aerosol products.

Activation of the fire alarm system shall cause all fire doors or gates protecting openings in the enclosure surrounding the segregated aerosol product storage area to close automatically.

4-3.5.8 Storage of flammable and combustible liquids shall be separated from the segregated area by a minimum distance of 25 ft (8 m) or by the segregating wall.

4-3.6 Aerosol Warehouses.

4-3.6.1 Storage of Level 2 and Level 3 aerosol products in excess of the amounts permitted in 4-3.4 and 4-3.5 shall be located within an aerosol warehouse.

4-3.6.2 Aerosol warehouses shall be protected by automatic sprinkler systems in accordance with Tables 4-3(a) through 4-3(e). Protection shall be provided for the highest level of aerosol product present.

Exception: Subject to the approval of the authority having jurisdiction, an unprotected aerosol warehouse shall be located a minimum of 100 ft (30 m) from exposed buildings or adjoining property that can be built upon if there is protection for exposures. Where protection for exposures is not provided, a minimum 200-ft (60-m) distance is required.

4-3.6.3 Aerosol warehouses shall be separate, detached buildings or shall be separated from other occupancies by free-standing 4-hour fire walls, with communicating openings protected on each side by automatic-closing, listed 3-hour fire doors.

4-3.6.4 If the aerosol warehouse building is located more than 10 ft (3 m), but less than 50 ft (15 m), from an important building or line of adjoining property that can be built upon, the exposing wall shall have a fire-resistance rating of at least 2 hours with each opening protected with a listed 1 1/2-hour fire door.

4-3.6.5 If the aerosol warehouse building is located 10 ft (3 m) or less from an important building or line of adjoining property that can be built upon, the exposing wall shall have a fire-resistance rating of 4 hours with each opening protected with a listed 3-hour fire door.

4-3.6.6 The total quantity of aerosols within an aerosol warehouse shall not be restricted.

4-3.6.7 Combustible commodities, other than flammable and combustible liquids, shall be permitted to be stored in an aerosol product warehouse, provided the warehouse is protected in accordance with Tables 4-3(a) through 4-3(e), whichever is applicable. Flammable and combustible liquids in metal containers of 1-qt (0.9-L) capacity or less shall be permitted to be stored in an aerosol product warehouse, provided the warehouse is protected in accordance with Table 4-3(e).

4-3.6.8 Solid pile and palletized storage shall be arranged so that no storage is more than 25 ft (7.6 m) from an aisle. Aisles shall be at least 4 ft (1.2 m) wide.

4-3.6.9 Rack storage shall be arranged so that a minimum aisle width of 8 ft (2.4 m) is maintained between rows of racks and between racks and adjacent solid pile or palletized storage of aerosol products.

Exception: Where protection and storage arrangements are in accordance with Table 4-3(c) or Table 4-3(d), the minimum aisle width shall be 4 ft (1.2 m).

4-3.7 Storage of Aerosol Products in Separate, Inside Flammable Liquid Storage Areas.

4-3.7.1 Storage of aerosol products shall be permitted in separate, inside flammable liquid storage areas of 500 ft² (47 m²) or less that meet the requirements of NFPA 30, *Flammable and Combustible Liquids Code*, up to a maximum quantity of 1000 lb (454 kg) net weight of Level 2 aerosol products or 500 lb (227 kg) net weight of Level 3 aerosol products or 1000 lb (454 kg) net weight of combined Level 2 and Level 3 aerosol products.

4-3.7.2 Storage of aerosol products shall be permitted in separate, inside flammable liquid storage areas of greater than 500 ft² (47 m²) that meet the requirements of NFPA 30, *Flammable and Combustible Liquids Code*, up to a maximum quantity of 2500 lb (1135 kg) net weight of Level 2 aerosol products or 1000 lb (454 kg) net weight of Level 3 aerosol products or 2500 lb (1135 kg) net weight of combined Level 2 and Level 3 aerosol products.

Exception: Storage of Level 2 and Level 3 aerosol products shall be permitted in separate inside storage areas up to a maximum of 5000 lb (2270 kg) net weight if the separate inside storage area is protected by an automatic sprinkler system that is designed in accordance with Tables 4-3(a) through 4-3(e), whichever is applicable.

4-3.8 Storage of Aerosol Products in Liquid Warehouses (as defined in NFPA 30, *Flammable and Combustible Liquids Code*).

4-3.8.1 Storage of Level 2 and Level 3 aerosol products in a liquid warehouse, as defined in NFPA 30, *Flammable and Combustible Liquids Code*, shall be within a segregated area.

4-3.8.2 Storage of Level 2 and Level 3 aerosol products shall be in a segregated area that is separated from the rest of the warehouse by either interior walls or chain-link fencing in accordance with the requirements of 4-3.8.2.1 or 4-3.8.2.2.

Exception: Where aerosol products are stored in an unprotected liquid warehouse, as allowed by 4-4.4 of NFPA 30, Flammable and Combustible Liquids Code, the aerosol products are not required to be in a segregated area. Storage configuration shall meet the requirements of 4-3.6.8 and 4-3.6.9 of this code.

4-3.8.2.1 Interior walls shall have a fire-resistance rating of 1 or 2 hours and shall be continuous from floor to the underside of the roof deck. Openings in these walls shall be protected with self-closing or automatic-closing listed fire door assemblies with fire protection ratings corresponding to the fire-resistance rating of the wall as specified in Table 4-3.5.3.1.

(a) For interior walls having a fire-resistance rating of 2 hours, the total floor area of the segregated Level 2 and Level 3 aerosol storage area or areas shall not exceed 25 percent of the total floor area of the warehouse, up to a maximum of 40,000 ft² (3700 m²).

(b) For interior walls having a fire resistance of 1 hour, the total floor area of the segregated Level 2 and Level 3 aerosol storage area or areas shall not exceed 20 percent of the total floor area of the warehouse, up to a maximum of 30,000 ft² (1850 m²).

(c) Spill control or drainage shall be provided to prevent the flow of liquid to within 8 ft (2.4 m) of the segregated area.

4-3.8.2.2 Chain-link fencing shall extend from the floor to the underside of the roof deck and shall meet the following requirements:

(a) The total floor area of the segregated Level 2 and Level 3 aerosol storage area or areas shall not exceed 20 percent of the total floor area of the warehouse, up to a maximum of 20,000 ft² (1850 m²).

(b)*Fencing shall be not lighter than 9 gauge (2.9 mm) steel wire woven into a maximum 2 in. (5 cm) diamond mesh.

(c) All storage outside the segregated storage area shall be kept at least 8 ft (2.4 m) from the fence.

(d) Spill control or drainage shall be provided to prevent the flow of liquid to within 8 ft (2.4 m) of the segregated storage area.

(e) The area that extends for 20 ft (6 m) beyond the segregated storage area shall be protected by an automatic sprinkler system designed in accordance with the requirements for storage of aerosol products, as specified by this code, or in accordance with the requirements for liquid storage, as specified in NFPA 30, *Flammable and Combustible Liquids Code*, whichever is the more restrictive.

(f) All openings in the fencing shall be provided with self-closing or automatic-closing gates or shall be protected with a labyrinth arrangement. Where automatic-closing gates are used, manual closure actuating devices shall be provided adjacent the opening to allow for manual closure of the gates.

(g) A minimum of two personnel exits shall be provided.

4-3.8.3 Sprinkler protection shall be provided for segregated aerosol product storage areas in accordance with Tables 4-3(a) through 4-3(e). Protection shall be provided for the highest level of aerosol products present.

4-3.8.4 Solid pile and palletized storage shall be arranged so that no storage is more than 25 ft (7.6 m) from an aisle. Aisles shall be at least 4 ft (1.2 m) wide.

4-3.8.5 Rack storage shall be arranged so that a minimum aisle width of 8 ft (2.4 m) is maintained between rows of racks and between racks and adjacent solid pile or palletized storage of aerosol products.

Exception: Where protection is provided by ESFR sprinklers, aisle width shall not be less than 4 ft (1.2 m).

4-3.8.6 Fire doors or gates that lead into the segregated storage area shall be either self-closing or provided with automatic-closing devices that are activated by water flow or by an approved fire detection system.

4-3.9 Outdoor Storage.

4-3.9.1* Level 2 and 3 aerosol products that are stored outdoors shall be separated from important buildings or structures.

4-3.9.2 A minimum 50-ft (15-m) separation shall be maintained between Level 2 and Level 3 aerosol products and other combustible yard storage.

4-3.9.3 Temporary storage trailers shall be located a minimum of 50 ft (15 m) from buildings, any property line that can be built upon, and other unprotected or combustible yard storage. A maximum of two such trailers shall be permitted in any one storage group.

4-3.9.4 Storage shall meet all applicable requirements of NFPA 231, *Standard for General Storage*.

Chapter 5 Mercantile Occupancies

5-1 Sales Display Areas — Aerosol Storage Not Exceeding 8 ft (2.4 m) High.

5-1.1 Level 1 aerosol products in sales display areas shall not be limited.

5-1.2 Level 2 and Level 3 aerosol products shall be removed from combustible cartons, or the cartons shall be display-cut, when located in sales display areas.

Exception: Cartoned display of Level 2 and Level 3 aerosol products shall be permitted provided the area is protected in accordance with Tables 4-3(a) through 4-3(e).

5-1.3 Level 2 and Level 3 aerosol products in sales display areas shall not exceed the maximum quantities given in 5-1.3.1 and 5-1.3.2 according to the protection provided.

5-1.3.1 In sales display areas that are unsprinklered or whose sprinkler system does not meet the requirements of 5-1.3.2, the total aggregate quantity of Level 2 and Level 3 aerosol products shall not exceed 2 lb net weight per ft² (9.8 kg/m²) of total sales display area, up to the quantities specified in

Table 5-1.3.1. No single 10-ft by 10-ft (3-m by 3-m) section of sales display area shall contain an aggregate quantity of more than 1000 lb (454 kg) net weight of Level 2 and Level 3 aerosol products.

Table 5-1.3.1 Maximum Quantity per Floor

Floor	Max. Net Weight per Floor, lb (kg)
Basement	Not Permitted
Ground	2500 (1135)
Upper	500 (227)

5-1.3.2 In sales display areas that are sprinklered in accordance with NFPA 13, *Standard for the Installation of Sprinkler Systems*, for at least Ordinary Hazard (Group 2) occupancies, the total aggregate quantity of Level 2 and Level 3 aerosol products shall not exceed 2 lb net weight per ft² (9.8 kg/m²) of total sales display area. No single 10-ft by 10-ft (3-m by 3-m) section of sales display area shall contain an aggregate quantity of more than 1000 lb (454 kg) net weight of Level 2 and Level 3 aerosol products.

5-1.4 Level 2 and Level 3 aerosol products shall be securely stacked to not more than 6 ft (1.8 m) high from base to top of the storage array unless on fixed shelving. Shelving shall be of stable construction and storage shall not exceed 8 ft (2.4 m) in height.

5-2 Sales Display Areas — Aerosol Storage Exceeding 8 ft (2.4 m) High.

5-2.1 Storage and display of Level 1 aerosol products in sales display areas shall not be limited.

5-2.2 Storage and display of Level 2 and Level 3 aerosol products shall be in cartons.

Exception: Containers of Level 2 and Level 3 aerosol products that are stored or displayed no more than 6 ft (1.8 m) above the floor shall be permitted to be uncartoned or in display-cut cartons.

5-2.3 Protection.

5-2.3.1 The storage and display of Level 2 and Level 3 aerosol products shall be protected in accordance with Tables 4-3(a) through 4-3(e), whichever is applicable. Where in-rack sprinklers are required by Table 4-3(e) and where the Level 2 and Level 3 aerosol products are stored in accordance with the Exception to 5-2.2, the first tier of in-rack sprinklers shall be installed above the shelf unit but not more than 6 ft (1.8 m) above the floor level.

5-2.3.2 Noncombustible draft curtains of at least 2 ft (0.61 m) depth shall be installed in the building as follows:

(a) At the interface between design areas utilizing ESFR sprinklers and those utilizing standard response sprinklers

(b) At the interface between design areas utilizing ordinary-temperature sprinklers and those utilizing high-temperature sprinklers

5-2.4 Storage and display of Level 2 and Level 3 aerosol products shall not exceed 10,000 lb (4540 kg) net weight within any 25,000 ft² (2323 m²) of sales display area. Level 2 and Level 3 aerosol product display areas shall be separated from each other by a minimum of 25 ft (7.6 m).

5-2.5 The area of the design for the required ceiling sprinkler system shall extend 20 ft (6 m) beyond the Level 2 and Level 3 aerosol display and storage area.

5-2.6 Storage and display of Level 2 and Level 3 aerosol products shall be separated from the storage of flammable and combustible liquids by a minimum distance of 25 ft (7.6 m) or by a segregating wall or noncombustible barrier. Where Level 2 and Level 3 aerosol products are stored within 25 ft (7.6 m) of flammable and combustible liquids beneath the noncombustible barrier shall be liquid-tight at the floor to prevent spilled liquids from flowing beneath the aerosol products.

5-2.7 The sales display area shall meet the requirements for mercantile occupancies in NFPA *101, Life Safety Code*.

5-3 Back Stock Storage Areas.

5-3.1 Where back stock areas are separated from sales display areas by construction having a minimum 1-hour fire-resistance rating, storage of Level 2 and Level 3 aerosol products shall meet the requirements of Chapter 4.

5-3.2 Where back stock areas are *not* separated from sales display areas by construction having a minimum 1-hour fire-resistance rating, the quantity of Level 2 and Level 3 aerosol products in back stock areas shall be included in the total allowable quantities specified in 5-1.3 or 5-2.4, and protection shall be provided in accordance with 5-3.1.

5-3.3 An additional quantity of Level 2 and Level 3 aerosol products, up to a maximum of 500 lb (227 kg) net weight, shall be permitted in back stock areas, where the additional quantities are stored in flammable liquid storage cabinets that meet the requirements of Section 4-3 of NFPA 30, *Flammable and Combustible Liquids Code*.

5-3.4 Storage of Level 2 and Level 3 aerosol products in separate, inside flammable liquids storage rooms shall meet the requirements of 4-3.7 of this code.

Chapter 6 Operations and Maintenance

6-1 Means of Egress. Means of egress and exits shall be maintained in accordance with NFPA *101, Life Safety Code*.

6-2 Powered Industrial Trucks.

6-2.1 The use and selection of powered industrial trucks shall comply with NFPA 505, *Fire Safety Standard for Powered Industrial Trucks Including Type Designations, Areas of Use, Conversions, Maintenance, and Operation*.

6-2.2 Only trained and authorized operators shall be allowed to operate powered industrial trucks.

6-2.3 Operator training shall be equivalent to that specified by ANSI B56.1, *Safety Standard for Low-Lift and High-Lift Trucks*.

6-2.4 Loads.

6-2.4.1 If the type of load handled presents a hazard of rearward falls, the powered industrial truck shall be equipped with a vertical load backrest extension.

6-2.4.2 For loads that are elevated above the mast of the truck, the backrest extension shall reach at least halfway into the uppermost pallet load.

6-3 Control of Ignition Sources.

6-3.1 Sources of Ignition. In areas where flammable gases or flammable vapors might be present, precautions shall be taken to prevent ignition by eliminating or controlling sources of ignition. Sources of ignition include, but are not limited to the following:

(a) Open flames
(b) Lightning
(c) Hot surfaces
(d) Radiant heat
(e) Smoking
(f) Cutting and welding
(g) Spontaneous ignition
(h) Frictional heat or sparks
(i) Static electricity
(j) Electrical arcs and sparks
(k) Stray currents
(l) Ovens, furnaces, and other heating equipment
(m) Automotive vehicles
(n) Material-handling equipment

6-3.2 Smoking shall be strictly prohibited, except in designated smoking areas.

6-3.3* Welding, cutting, and similar spark-producing operations shall not be permitted in areas that contain aerosol products until a written permit authorizing the work has been issued. The permit shall be issued by a person in authority following an inspection of the area to assure that proper precautions have been taken and will be followed until completion of the work.

6-4 Aisles. Storage in aisles shall be prohibited so as to permit access for fire fighting, salvage, and removal of stored commodities.

6-5 Waste Disposal.

6-5.1 Filled or partly filled aerosol containers shall be separated from all other rubbish and trash and shall be placed in noncombustible waste containers.

6-5.2 Filled or partly filled aerosol containers shall not be disposed of in compactors, balers, or incinerators that crush the container or heat its contents.

Exception: Equipment and facilities that are specifically designed for the disposal of aerosol containers.

6-6 Inspection and Maintenance.

6-6.1 A written and documented preventive maintenance program shall be developed for equipment, machinery, and processes that are critical to fire-safe operation of the facility.

6-6.2 Critical detection systems and their components, emergency trips and interlocks, alarms, and safety shutdown systems shall be inspected on a regularly scheduled basis, and any deficiencies shall be immediately corrected. Items in this inspection schedule include, but are not limited to the following:

(a) Gas detection systems
(b) Deflagration suppression systems
(c) Deflagration vent systems
(d) Ventilation and local exhaust systems
(e) Propellant charging room door interlocks
(f) Process safety devices
(g) Fire alarm systems

6-7* Static Electricity. All process equipment and piping involved in the transfer of flammable liquids or gases shall be connected to a static-dissipating earth ground system to prevent accumulations of static charge.

Chapter 7 Referenced Publications

7-1 The following documents or portions thereof are referenced within this code as mandatory requirements and shall be considered part of the requirements of this code. The edition indicated for each referenced mandatory document is the current edition as of the date of the NFPA issuance of this code. Some of these mandatory documents might also be referenced in this code for specific informational purposes and, therefore, are also listed in Appendix F.

7-1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 10, *Standard for Portable Fire Extinguishers*, 1998 edition.

NFPA 11, *Standard for Low-Expansion Foam*, 1998 edition.

NFPA 11A, *Standard for Medium- and High-Expansion Foam Systems*, 1994 edition.

NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems*, 1998 edition.

NFPA 12A, *Standard on Halon 1301 Fire Extinguishing Systems*, 1997 edition.

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 1996 edition.

NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*, 1996 edition.

NFPA 16, *Standard for the Installation of Deluge Foam-Water Sprinkler and Foam-Water Spray Systems*, 1995 edition.

NFPA 17, *Standard for Dry Chemical Extinguishing Systems*, 1998 edition.

NFPA 20, *Standard for the Installation of Centrifugal Fire Pumps*, 1996 edition.

NFPA 22, *Standard for Water Tanks for Private Fire Protection*, 1998 edition.

NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*, 1995 edition.

NFPA 30, *Flammable and Combustible Liquids Code*, 1996 edition.

NFPA 31, *Standard for the Installation of Oil-Burning Equipment*, 1997 edition.

NFPA 45, *Standard on Fire Protection for Laboratories Using Chemicals*, 1996 edition.

NFPA 54, *National Fuel Gas Code*, 1996 edition.

NFPA 58, *Liquefied Petroleum Gas Code*, 1998 edition.

NFPA 69, *Standard on Explosion Prevention Systems*, 1997 edition.

NFPA 70, *National Electrical Code®*, 1999 edition.

NFPA 72, *National Fire Alarm Code®*, 1996 edition.

NFPA 80, *Standard for Fire Doors and Fire Windows*, 1995 edition.

NFPA 90A, *Standard for the Installation of Air Conditioning and Ventilating Systems*, 1996 edition.

NFPA *101®*, *Life Safety Code®*, 1997 edition.

NFPA 231, *Standard for General Storage*, 1998 edition.

NFPA 231C, *Standard for Rack Storage of Materials*, 1998 edition.

NFPA 505, *Fire Safety Standard for Powered Industrial Trucks Including Type Designations, Areas of Use, Conversions, Maintenance, and Operation*, 1996 edition.

NFPA 2001, *Standard on Clean Agent Fire Extinguishing Systems*, 1996 edition.

NFPA 8501, *Standard for Single Burner Boiler Operation*, 1997 edition.

NFPA 8502, *Standard for the Prevention of Furnace Explosions/ Implosions in Multiple Burner Boiler*, 1995 edition.

7-1.2 Other Publications.

7-1.2.1 ANSI Publication. American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036.

ANSI/ASME B56.1-1993, *Low-Lift and High-Lift Trucks.*

7-1.2.2 ASTM Publications. American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM A 47-90 (1995), *Standard Specification for Ferritic Malleable Iron Castings.*

ASTM A 48-94a, *Standard Specification for Gray Iron Castings.*

ASTM A 395-88 (1993) e1, *Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures.*

ASTM A 536-84 (1993), *Standard Specification for Ductile Iron Castings.*

Appendix A Explanatory Material

Appendix A is not a part of the requirements of this NFPA document but is included for informational purposes only. This appendix contains explanatory material, numbered to correspond with the applicable text paragraphs.

A-1-1.2 An example of an aerosol product that is not flammable and, therefore, not covered by this code is whipped cream: the base product is a water-based material and the propellant is nitrous oxide, which is nonflammable.

A-1-1.3 See NFPA 58, *Liquefied Petroleum Gas Code.*

A-1-2 This code provides minimum acceptable requirements for fire prevention and protection in facilities that manufacture and store aerosol products and in mercantile occupancies where aerosol products are displayed and sold. As explained in A-3-1, the hazards presented by each stage of the manufacturing process will vary, depending on the flammability of the base product and on the flammability of the propellant. Considerable judgment will be required of the designer and of the authority having jurisdiction to provide an adequate level of fire protection. *(See also Appendix B, Mechanism of Fire Growth in Aerosol Containers.)*

A-1-4 This section should not be interpreted as discouraging the upgrading of existing aerosol manufacturing or storage facilities. Improvements to fire protection systems in existing facilities should be allowed without requiring retroactive compliance with all of the requirements of this code. It is the intent of this code, however, that major renovations to such a facility should meet, to the greatest extent practical, the requirements of this code.

A-1-6 Aerosol. The base product can be dispensed from the container in such form as a mist, spray, foam, gel, or aerated powder.

A-1-6 Aerosol Container. Maximum sizes, minimum strengths, and other critical limitations for aerosol containers are set by the U.S. Department of Transportation (Title 49, *Code of Federal Regulations*). These regulations assure that aerosol products can be safely transported in interstate commerce. Aerosol products are generally classified as Other Regulated Materials — Class D (ORM-D). A cutaway drawing of a typical aerosol container is shown in Figure A-1-6. Labeling of aerosol products, including precautionary language for flammability and other hazards, is regulated by a number of federal authorities, including the Consumer Product Safety Commission, the Food and Drug Administration, the Environmental Protection Agency, the Occupational Safety and Health Administration, and the Federal Trade Commission.

Additional information on the labeling of aerosol products is given in Appendix D, Flammability Labeling of Aerosol Products.

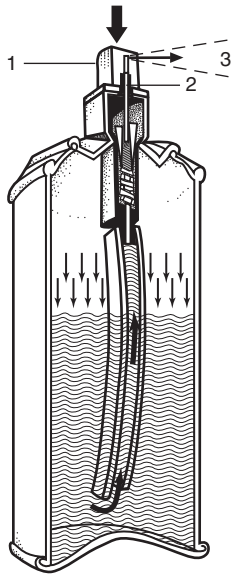


Figure A-1-6 An aerosol can (cutaway view). When the plunger (1) is pressed, a hole in the valve (2) allows a pressurized mixture of product and propellant (3) to flow through the plunger's exit orifice. ***(Source: Fire Protection Handbook, 18th edition)***

A-1-6 Approved. The National Fire Protection Association does not approve, inspect, or certify any installations, procedures, equipment, or materials; nor does it approve or evaluate testing laboratories. In determining the acceptability of installations, procedures, equipment, or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure, or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization that is concerned with product evaluations and is thus in a position to determine compliance with appropriate standards for the current production of listed items.

A-1-6 Authority Having Jurisdiction. The phrase "authority having jurisdiction" is used in NFPA documents in a broad manner, since jurisdictions and approval agencies vary, as do

their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction; at government installations, the commanding officer or departmental official may be the authority having jurisdiction.

A-1-6 Base Product (Concentrate). The base product contains the active ingredient of the aerosol product.

A-1-6 Code. The decision to designate a standard as a "code" is based on such factors as the size and scope of the document, its intended use and form of adoption, and whether it contains substantial enforcement and administrative provisions.

A-1-6 Cold Filling. Reprinted with permission from ASTM D 3064, *Standard Definitions of Terms and Nomenclature Relating to Aerosol Products.*

A-1-6 Combustible Liquid. See NFPA 30, *Flammable and Combustible Liquids Code*, for further information on flash point test procedures.

A-1-6 Flammable Liquid. See NFPA 30, *Flammable and Combustible Liquids Code*, for further information on flash point test procedures.

A-1-6 Net Weight. Label weight should always be used for calculation of total net weight. When dealing with limited quantities of aerosols, the total net weight is the sum of the individual container net weights.

For example, if a small retail display area contains 100 7-oz containers, 140 10-oz containers, and 180 16-oz containers, the total net weight is calculated as follows:

$$100 \text{ cans} \times \frac{7 \text{ oz/can}}{16 \text{ oz/lb}} = \frac{700}{16} = 43.75 \text{ lb}$$

$$140 \text{ cans} \times \frac{10 \text{ oz/can}}{16 \text{ oz/lb}} = \frac{1400}{16} = 87.5 \text{ lb}$$

$$180 \text{ cans} \times \frac{16 \text{ oz/can}}{16 \text{ oz/lb}} = \frac{2880}{16} = 180 \text{ lb}$$

$$\text{Total} = 311 \text{ lb}$$

When dealing with larger quantities of product, the number of cases per pallet and the number of units per case also enter into the calculation.

For example, if a general-purpose warehouse contains 20 pallets of a product with a label weight of 12 oz, and there are 12 units per case, and 75 cases per pallet, the total net weight calculation is as follows:

$$\frac{12 \text{ oz/unit}}{16 \text{ oz/lb}} \times 12 \text{ units/case} \times 75 \text{ cases/pallet} \times 20 \text{ pallets} = 13,500 \text{ lb}$$

A-1-6 Propellant. The flammable propellant is generally a hydrocarbon gas, such as butane, isobutane, propane, and various blends of these gases. Systems that generate a propellant gas are included in this definition.

A-1-6 Rack. For additional information, see NFPA 231C, *Standard for Rack Storage of Materials.*

A-1-7 Test data indicate that the overall fire hazard of an aerosol product is a function of the chemical heat of combustion. The chemical heat of combustion, ΔH_c, in kiloJoules per gram, is the product of the theoretical heat of combustion, ΔH_{comb}, also in kiloJoules per gram, and a combustion efficiency, usually less than 1.0. A typical combustion efficiency is 0.95, or 95 percent.

For a product that consists of a number of components, the chemical heat of combustion is the summation of the weighted heats of combustion for the individual components as follows:

$$\Delta H_c(\text{product}) = \Sigma[I\% \times \Delta H_{c(I)}]$$

where:

ΔH_c = chemical heat of combustion (kJ/g)

$I\%$ = weight fraction of component I in product

$\Delta H_{c(I)}$ = chemical heat of combustion of component I (kJ/g)

Heats of combustion are available from standard chemical and chemical engineering references, such as *Perry's Chemical Engineers' Handbook*, and other standard references, such as the *Fire Protection Handbook* and the *SFPE Handbook of Fire Protection Engineering.*

Heats of combustion can also be determined by calculation or by appropriate test methods, such as ASTM D 240, *Standard Test Method for Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeter.*

Representative values are given in Table A-1-7(a). Where the chemical heat of combustion of a particular material is not readily available, or if the material is a minor component of the product mix, use the theoretical heat of combustion, ΔH_{comb}, or use 19,000 Btu/lb (43.7 kJ/g). This latter value is typical for hydrocarbons.

Some examples of calculation of chemical heat of combustion follow.

Example 1 — Typical Level 1 Aerosol Product

Ingredient	Weight (%)	ΔH_c of Ingredient (kJ)	Weight % $\times \Delta H_c$ (kJ)
Isobutane	30	42.7	12.8
Water	69	0	0
Fragrance, etc.	1	43.7*	0.4
		Total =	13.2 kJ

Note: For U.S. customary units, 1 kJ = 0.95 Btu

*Since the fragrance constitutes a small proportion of the total, 43.7 kJ/g was used instead of actually determining or calculating the heat of combustion. In this example, the resulting classification of the aerosol product was not affected. However, with other products, this might not be the case and actual calculation of or testing for the heat of combustion might have to be done.

Table A-1-7(b) provides a cross-reference between CAS numbers and the materials listed in Table A-1-7(a).

Example 2 — Typical Level 2 Aerosol Product

Ingredient	Weight (%)	ΔH_c of Ingredient (kJ)	Weight % × ΔH_c (kJ)
Isobutane	20	42.7	8.5
Ethanol	60	25.5	15.3
Water	19	0	0
Fragrance, Surfactant, Corrosion Inhibitors, or other minor ingredients	1	43.7*	0.4
		Total =	24.2 kJ

Note: For U.S. customary units, 1 kJ = 0.95 Btu

*Since these minor ingredients constitute a small proportion of the total, 43.7 kJ/g was used instead of actually determining or calculating the heat of combustion. In this example, the resulting classification of the aerosol product was not affected. However, with other products, this might not be the case and actual calculation of or testing for the heat of combustion might have to be done.

Example 3 — Typical Level 3 Aerosol Product

Ingredient	Weight (%)	ΔH_c of Ingredient (kJ)	Weight % × ΔH_c(kJ)
Isobutane	25	42.7	10.7
Propane	10	43.7	4.4
Toluene	25	27.8	7.0
Acetone	15	27.9	4.2
Methyl Ethyl Ketone	15	30.7	4.6
Pigments (Titanium Dioxide), etc.	10	0	0
		Total =	30.9 kJ

Note: For U.S. customary units, 1 kJ = 0.95 Btu

Table A-1-7(a) Chemical Heat of Combustion for Representative Materials

Chemical Name	CAS Number[1]	Chemical Heat of Combustion[2] ΔH_c,kJ/g
Acetone	67-64-1	27.7
Acrylic Resin	—	*
Alkyd Resin	—	*
Aluminum	7429-90-5	*
Asphalt	8052-42-4	22.7
Barium Sulfate	7727-43-7	0.0
Benzidine (Yellow)	92-87-5	*
Butane	106-97-8	43.3
2-Butoxyethanol	111-76-2	29.6
Butyl Benzyl Phthalate	85-68-7	31.5
Calcium Carbonate	1317-65-3	0.0
Carbon Black	1333-86-4	*
Carbon Dioxide	124-38-9	0.0
1-Chloro-1,1-Difluoroethane (HCFC 142b)	75-68-3	3.3
Chromium Hydroxide	1308-14-1	0.0
Corn Oil	8001-30-7	35.3
Diacetone Alcohol	123-42-2	35.1
1,1-Dichloro-1-Fluoroethane	1717-00-6	2.9
Diethylene Glycol Methyl Ether	112-34-5	33.0
1,1-Difluoroethane (HFC 152a)	75-37-6	6.3
1,2-Dimethoxyethane	110-71-4	25.9
Dimethyl Ether	115-10-6	26.5
Dipropylene Glycol Methyl Ether	34590-94-8	32.2
Ethanol	64-17-15	24.7
Ethanol (95.6% Azeotrope)	64-17-15	23.6
2-Ethoxyethanol	110-80-5	25.9
2-Ethoxyethyl Acetate	111-15-9	30.9

Table A-1-7(a) Chemical Heat of Combustion for Representative Materials *(Continued)*

Chemical Name	CAS Number[1]	Chemical Heat of Combustion[2] ΔH_c, kJ/g
Ethyl 3-Ethoxypropionate	763-69-9	32.0
Ethylbenzene	100-41-4	29.0
Ethylene Glycol	107-21-1	16.4
Ethylene Glycol Diacetate	111-55-7	32.0
Graphite	7782-42-5	*
Hexylene Glycol	107-41-5	28.5
Iron Oxide	1309-37-1	0.0
Isobutane, See 2-Methylpropane	—	
Isobutyl Alcohol	78-83-1	29.8
Isopropyl Acetate	108-21-4	25.5
Isopropyl Alcohol	67-63-0	27.4
Isopropyl Myristate	110-27-0	36.2
Isopropyl Palmitate	142-91-6	37.2
Kaolin Clay (Aluminum Silicate Hydroxide)	1332-58-7	0.0
Kerosene	8008-20-6	41.4
d-Limonene	5989-27-5	39.8
Liquids, Noncombustible/Nonflammable	—	0.0
Liquids, Noncontributory	—	*
Magnesium Silicate (Talc)	14807-96-6	0.0
Methanol	67-56-1	19.0
1-Methoxy-2-Propanol Acetate	108-65-6	30.9
Methyl Ethyl Ketone	78-93-3	30.6
Methyl Isopropyl Ketone	563-80-4	31.1
Methyl n-Amyl Ketone	110-43-0	35.0
Methylene Chloride	75-09-2	2.1
2-Methylpropane (Isobutane)	75-28-5	42.8
Mica (Mica Silicate)	12001-26-2	0.0
Mineral Oil	8012-95-1	31.5
Mineral Spirits (Petroleum Distillate)	64742-47-8	41.2
Mineral Spirits (Petroleum Distillate)	64742-88-7	41.2
N,N-Diethyl-m-Toluamide (Deet)	134-62-3	28.2
n-Butyl Acetate	123-86-4	27.6
n-Heptane	142-82-5	41.0
n-Hexane	110-54-3	41.1
n-Octyl Bicycloheptane Dicarboximide	113-48-4	30.0
Naphtha (High Flash)	8052-41-3	41.2
Naphtha (Petroleum Distillate)	8030-30-6	41.2
Naphtha, VM &P (Petroleum Distillate)	64742-95-6	41.2
Naphtha, VM&P (Petroleum Distillate)	64742-48-9	41.2
Naphtha, VM&P (Petroleum Distillate)	64742-94-5	41.2
Nitrogen	7727-37-9	0.0
Paraffin (Wax)	8002-74-2	*
Pentane	109-66-0	41.9
Perchloroethylene (Tetrachloroethylene)	127-18-4	*
Petroleum Distillate	64741-65-7	41.2
Phthalocyanine Blue	147-14-8	*

(continues)

Table A-1-7(a) Chemical Heat of Combustion for Representative Materials *(Continued)*

Chemical Name	CAS Number[1]	Chemical Heat of Combustion[2] ΔH_c,kJ/g
Phthalocyanine Green	1328-53-6	*
Piperonyl Butoxide	51-03-6	32.0
Polyoxyethlene Sorbitan Oleate	9005-65-6	*
Polyoxyethylene (20) Sorbitan Monolaurate	9005-64-5	*
Propane	74-98-6	44.0
Propylene Glycol	57-55-6	20.5
sec-Butyl Alcohol	78-92-2	39.9
Silica (Crystalline)	—	0.0
Silica, Amorphous Hydrated	7631-86-9	0.0
Silicone Oil	63148-58-3	*
Silicone Oil	63148-62-9	*
Solids, Noncombustible/Nonflammable	—	0.0
Solids, Noncontributory	—	*
Sorbitan Monolaurate	1338-39-2	37.9
Sorbitan Monopalmitate	26266-57-9	37.9
Styrene Butadiene Rubber	25038-32-8	*
Tin Oxide (Stannic Oxide)	18252-10-5	0.0
Titanium Dioxide	13463-67-7	0.0
Toluene	108-88-3	28.4
Triacetin	102-76-1	35.4
1,1,1-Trichloroethane	71-55-6	*
Trichloroethylene	79-01-6	*
1,2,4-Trimethylbenzene (Pseudocumene)	95-63-6	27.5
Water	7732-18-5	0.0
Xylene	1330-20-7	27.4
Zinc Oxide	1314-13-2	0.0

*Materials that have either (1) a closed-cup flash point greater than 500°F (260°C), or (2) no fire point when tested in accordance with ASTM D 92, *Test Method for Flash and Fire Points by Cleveland Open Cup*, or (3) are combustible solids. Such materials contribute very little to the overall fire hazard of aerosol products in an actual fire, due to incomplete combustion or inconsistent burning behavior (i.e., the majority of the released material does not burn). Such materials are considered to be "noncontributory" to the overall determination of the product's level of classification. They can be ignored or they can be assigned a chemical heat of combustion (ΔH_c) of 0 kJ/g.

[1]Chemical Abstracts Service Registration Number.

[2]The theoretical heats of combustion and combustion efficiencies used to determine the chemical heats of combustion listed in this table are contained in the supporting documentation on file at NFPA.

Table A-1-7(b) Cross-Reference Table — Chemical Abstract Services (CAS) Numbers for Representative Materials in Table A-1-7(a)

CAS Number	Chemical Name
51-03-6	Piperonyl Butoxide
57-55-6	Propylene Glycol
64-17-15	Ethanol
64-17-15	Ethanol (95.6% Azeotrope)
67-56-1	Methanol
67-63-0	Isopropyl Alcohol
67-64-1	Acetone
71-55-6	1,1,1-Trichloroethane
74-98-6	Propane
75-09-2	Methylene Chloride
75-28-5	2-Methylpropane (Isobutane)

Table A-1-7(b) Cross-Reference Table — Chemical Abstract Services (CAS) Numbers for Representative Materials in Table A-1-7(a) *(Continued)*

CAS Number	Chemical Name
75-37-6	1,1-Difluoroethane (HFC 152a)
75-68-3	1-Chloro-1,1-Difluoroethane (HCFC 142b)
78-83-1	Isobutyl Alcohol
78-92-2	sec-Butyl Alcohol
78-93-3	Methyl Ethyl Ketone
79-01-6	Trichloroethylene
85-68-7	Butyl Benzyl Phthalate
92-87-5	Benzidine (Yellow)
95-63-6	1,2,4-Trimethylbenzene (Pseudocumene)
100-41-4	Ethylbenzene
102-76-1	Triacetin

Table A-1-7(b) Cross-Reference Table — Chemical Abstract Services (CAS) Numbers for Representative Materials in Table A-1-7(a) ***(Continued)***

CAS Number	Chemical Name
106-97-8	Butane
107-21-1	Ethylene Glycol
107-41-5	Hexylene Glycol
108-21-4	Isopropyl Acetate
108-65-6	1-Methoxy-2-Propanol Acetate
108-88-3	Toluene
109-66-0	Pentane
110-27-0	Isopropyl Myristate
110-43-0	Methyl n-Amyl Ketone
110-54-3	n-Hexane
110-71-4	1,2-Dimethoxyethane
110-80-5	2-Ethoxyethanol
111-15-9	2-Ethoxyethyl Acetate
111-55-7	Ethylene Glycol Diacetate
111-76-2	2-Butoxyethanol
112-34-5	Diethylene Glycol Methyl Ether
113-48-4	n-Octyl Bicycloheptane Dicarboximide
115-10-6	Dimethyl Ether
123-42-2	Diacetone Alcohol
123-86-4	n-Butyl Acetate
124-38-9	Carbon Dioxide
127-18-4	Perchloroethylene (Tetrachloroethylene)
134-62-3	N,N-Diethyl-m-Toluamide (Deet)
142-82-5	n-Heptane
142-91-6	Isopropyl Palmitate
147-14-8	Phthalocyanine Blue
563-80-4	Methyl Isopropyl Ketone
763-69-9	Ethyl 3-Ethoxypropionate
1308-14-1	Chromium Hydroxide
1309-37-1	Iron Oxide
1314-13-2	Zinc Oxide
1317-65-3	Calcium Carbonate
1328-53-6	Phthalocyanine Green
1330-20-7	Xylene
1332-58-7	Kaolin Clay (Aluminum Silicate Hydroxide)
1333-86-4	Carbon Black
1338-39-2	Sorbitan Monolaurate
1717-00-6	1,1-Dichloro-1-Fluoroethane
5989-27-5	d-Limonene
7429-90-5	Aluminum
7631-86-9	Silica, Amorphous Hydrated
7727-37-9	Nitrogen
7727-43-7	Barium Sulfate
7732-18-5	Water
7782-42-5	Graphite
8001-30-7	Corn Oil
8002-74-2	Paraffin (Wax)
8008-20-6	Kerosene
8012-95-1	Mineral Oil
8030-30-6	Naphtha (Petroleum Distillate)
8052-41-3	Naphtha (High Flash)
8052-42-4	Asphalt
9005-64-5	Polyoxyethylene (20) Sorbitan Monolaurate
9005-65-6	Polyoxyethlene Sorbitan Oleate
12001-26-2	Mica (Mica Silicate)
13463-67-7	Titanium Dioxide
14807-96-6	Magnesium Silicate (Talc)
18252-10-5	Tin Oxide (Stannic Oxide)
25038-32-8	Styrene Butadiene Rubber
26266-57-9	Sorbitan Monopalmitate
34590-94-8	Dipropylene Glycol Methyl Ether
63148-58-3	Silicone Oil
63148-62-9	Silicone Oil
64741-65-7	Petroleum Distillate
64742-47-8	Mineral Spirits (Petroleum Distillate)
64742-48-9	Naphtha, VM&P (Petroleum Distillate)
64742-88-7	Mineral Spirits (Petroleum Distillate)
64742-94-5	Naphtha, VM&P (Petroleum Distillate)
64742-95-6	Naphtha, VM &P (Petroleum Distillate)

A-3-1 The hazards relative to each manufacturing operation will depend on the flammability of both the base products and the propellant. Information on the properties of liquefied petroleum gases, including safe handling and storage, is found in NFPA 58, *Liquefied Petroleum Gas Code*. Information on the handling and storage of flammable and combustible liquids is found in NFPA 30, *Flammable and Combustible Liquids Code. (See also Appendix A-1-2.)*

A-3-2 Button Tipper (Actuator Placer). This operation sometimes releases small quantities of the container contents to the atmosphere.

A-3-2 Propellant Filler (Gasser, Propellant Charger). Typically, it is one of two types: one adds the propellant through the crimped valve assembly; the other adds the propellant around the uncrimped valve assembly. The propellant is either a liquid, a gas, or both, during this filling operation.

A-3-2 Test Bath (Hot Tank, Water Bath). The test might be required by the U.S. Department of Transportation (Title 49, *Code of Federal Regulations*) to verify container strength and to detect leaks. Usually, the containers are heated to attain a pressure that is equal to the product's pressure at an equilibrium temperature.

A-3-4 It is essential that any flammable propellant charging room be designed by qualified professionals.

A-3-4.5.1 See NFPA 68, *Guide for Venting of Deflagrations,* for additional information on the design and sizing of vents and vent closures.

A-3-4.5.3 Aerosol-filling rooms that utilize flammable propellants have an inherent deflagration hazard. The hazard severity will vary depending on the amount and speed of an accidental flammable gas release. The worst case explosion potential is filling the majority of the room volume with a flammable gas–air mixture. The only currently available protection against this type of event is the use of damage-limiting construction consisting of deflagration venting and pressure-resistant construction as described in NFPA 68, *Guide for Venting of Deflagrations.*

Deflagration suppression systems might only be effective against explosions resulting from small gas releases. These small events might not even require the use of damage-limiting construction. The use of deflagration suppression systems might protect personnel against a deflagration resulting from small flammable gas–air mixtures in these aerosol-filling rooms.

A-3-5.1 For further information, see NFPA 91, *Standard for Exhaust Systems for Air Conveying of Materials.*

A-3-5.2(d) Adequate ventilation of flammable propellant charging and pump rooms is necessary to maintain these rooms at a safe level, well below the lower explosive limit (LEL) of the propellant being used. The internal volume of these rooms should be as small as practical to minimize the capital and operating costs of the ventilation system, as well as the cost of heating and conditioning the required make-up air. The formula given in 3-5.2(d) is used to determine the required ventilation flow rate. In no case should the required ventilation be less than one air change per minute, unless the propellant filler is provided with its own local exhaust ventilation system. The following are some considerations using the formula to take into account when:

(a) The lower explosive limit (LEL) used in the calculation should be that of the most flammable propellant gas used. Normally, this will be isobutane (propellant A-31), which has an LEL of 1.8 percent in air at 70°F (21°C). Butane has the same LEL. All other flammable propellants have LELs that are higher. Thus, the two isomeric butanes are considered the most hazardous propellants and the ventilation system is normally designed based on their use.

(b) The volume of vapor produced by one liter of propellant determines the quantity of saturated vapor that the ventilation system must handle, based on the volumetric flow rate of the propellant through the system. For isobutane, this factor is 0.23 m^3 of vapor per liter (30.77 ft^3 of vapor per gallon), at 70°F (21°C) and sea level conditions.

(c) The LEL design level is an arbitrary decimal fraction. This establishes the maximum amount of vapor concentration that the ventilation system will handle and is, in effect, a percentage of the LEL. Since combustible gas detection systems are set to alarm at 20 percent of the LEL and operational shutdown is set at 40 percent of the LEL, it is recommended that the design level not exceed 10 percent of the LEL. In other words, *DL* in the equation should not exceed 0.10.

(d) *R* as used in the equation represents an estimate of how much propellant is lost from the equipment under normal operating conditions, plus 20 percent for occasional leaks. These losses are due to minor seal and hose leakage and minor loss from the equipment as it is operating. This number is calculated as follows:

$$R = \left(\frac{1 \text{ gal}}{3785 \text{ cc}}\right) \times (\text{cc loss per can}) \times (\text{cans per minute}) \times (\text{safety factor})$$

The following considerations should be taken into account when using the above formula.

(a) *Loss per container.* This is the maximum quantity of propellant that is expected to be lost during the propellant-filling operation and will depend on the type of filling mode used. Some propellant fillers will release 3.0 cubic centimeters (cc) per container per filling station.

Some propellant fillers will fill each container several times from separate filling stations. In this case the loss per container will be the loss per fill multiplied by the number of fills per container.

Some filling operations require the use of two different fillers. An example is aerosol antiperspirant, which is filled using an under-the-cup filler, followed by a through-the-valve filler. The second filler injects a relatively small quantity of propellant, primarily to flush the viscous base product out of the aerosol diptube. For these systems, the combined release amounts to about 4.0 cc per container.

In other systems, different propellants are added at separate filling stations. This eliminates the need for propellant blending equipment or blend holding tanks. The manufacturer of the filling equipment should be consulted for an estimate of the expected losses during filling.

(b) *Cans per minute.* This is the maximum production rate for the entire propellant charging room. The ventilation system needs to be designed to handle the expected losses from the highest number of cans that can foreseeably be filled per minute, based on a 10- to 20-minute reference period. The average rate per shift should not be used, since the average rate will always be lower than the maximum production rate by 10 percent to 25 percent. If there are multiple fill lines, the maximum production rates needs to be added for each. Also, if an additional fill line is later added, the capacity of the ventilation system needs to be increased accordingly.

(c) *Safety factor.* A 20 percent safety factor is generally used to account for minor seal leaks and hose leaks, dead spots, and occasional container ruptures.

The following is an example of the formula's use:

Assumptions:

Under-the-cup filler, 3 cc release per container. A second machine in the propellant charging room is an indexing through-the-valve filler that fills each container three times at three separate stations with a loss per fill of 1 cc times 3 fills per container, which equals 3 cc released per container. Each machine is operating at 150 containers per minute. Propellant is isobutane; LEL is 1.8 percent (30.59 cu ft per gal). Safety factor for leakage is 20 percent. LEL design level is 10 percent.

$$\text{Gal released per min} = \frac{(3.0 \text{ cc/container})(2)(150)(1.2)}{(3785.4 \text{ cc/gal})} = 0.2853 \text{ gal/min}$$

$$\text{Required ft}^3\text{/min} = \frac{(100 - 1.8)(30.59 \text{ cu ft/gal})(0.2853 \text{ gal/min})}{(0.10)(1.8)} = 4761 \text{ ft}^3\text{/min}$$

The equations assume that the released propellant gas and the entering make-up air will quickly mix and the resulting homogeneous mixture will then be exhausted. This is not the case. Thus, the calculations give results that will be on the conservative side in some locations within the propellant charging room and on the improvident side in others. For example, air entering the exhaust registers at points remote from the propellant filler will have a concentration of propellant that is much less than the average value upon which the ventilation system is designed.

Because some of the propellant will be swept into the nearest part of the exhaust system before being fully diluted, the apparent efficiency of the ventilating system is improved, providing an additional safety factor. This efficiency can be mea-

sured using combinations of velocity meters, explosimeters, and gas density plots. For all but a few percent of the volume in the typical propellant charging room, the concentration of propellant will be substantially less than the designed-for 10 percent of the LEL. This means that the gas detection heads might give very different readings if their positions are changed. Care needs to be exercised in determining the optimum location of the detector heads, especially if there are multiple propellant fillers in the room. In such cases, the use of three or four detection heads could be considered, rather than the two that are normally used.

A-3-5.2(f) See NFPA 91, *Standard for Exhaust Systems for Air Conveying of Materials*, for further information.

A-3-5.4 The enclosure required for the test bath provides protection for personnel and improves the efficiency of the local exhaust ventilation.

A-3-6.2 See also NFPA 497, *Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*.

A-3-7 See NFPA 77, *Recommended Practice on Static Electricity,* for further information.

A-3-8 The gas detection system should be provided with detection heads located inside the charging and pump rooms and just inside the conveyor openings into the charging or pump room and into the main production building. Detection heads should also be located within any conveyor enclosure between the charging or pump room and the main production building. Where flammable propellants are stored in a tank farm, the tank farm should be provided with an approved gas detection system and the signal sent to a constantly monitored location.

A-3-9.1 Dry-pipe or preaction systems are not allowed. Tests have shown that control of a fire involving aerosol products requires immediate application of water when the first sprinkler operates. Fire growth is rapid and, once thoroughly established, cannot be controlled by conventional or ESFR systems. Any significant delay in sprinkler discharge will allow the fire to overtax the system. Increasing the design area for a dry-pipe or preaction system is not feasible because the delay will allow too many sprinklers to operate, thus overtaxing any practically designed water supply.

Paragraph 3-9.1 should not be interpreted as discouraging the use of a foam-water sprinkler system. As long as the ceiling density is not reduced, the use of a foam-water system does not introduce any known negative effects and could offer some additional benefits in combatting any spill fire that might result.

A-3-11.1 See Appendix A of NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection,* for further information. Also, see NFPA 30, *Flammable and Combustible Liquids Code*.

A-4-1.2 At the present time there have been no fire retardant packaging systems tested that have demonstrated substantial mitigation of the fire hazards presented by aerosol products.

A-4-2 Fire tests and fire experience show that Level 1 aerosol products present relatively the same fire hazards as Class III commodities, as these are defined and described in NFPA 231, *Standard for General Storage*, and NFPA 231C, *Standard for Rack Storage of Materials*. In some cases, the authority having jurisdiction or applicable fire or building regulations might require storage of such materials to be protected from fire. If fire protection is by means of automatic sprinklers, then the requirements of NFPA 231, *Standard for General Storage*, and NFPA 231C, *Standard for Rack Storage of Materials*, should be used as a design basis.

A-4-3.2.13 The combination of ESFR ceiling sprinklers and in-rack sprinklers was determined in this case to be acceptable based on the review of the original full-scale testing that was used to determine adequate protection using in-rack sprinklers and spray sprinklers at the ceiling. The low number of ceiling sprinklers that operated in the full-scale tests indicates that the substitution of ESFR sprinklers over racks with the same level of in-rack sprinkler protection would not result in a more severe fire. The in-rack sprinklers must be quick-response type and must meet the currently required installation rules provided in Table 4-3(e).

A-4-3.8.2.2(b) The 9-gauge (2.9-mm) chain-link fencing referred to by this paragraph refers to the standard industrial-grade chain link, such as is used for property fencing. Lighter gauge fencing will not restrain rocketing aerosol containers, based on test experience.

A-4-3.9.1 See NFPA 80A, *Recommended Practice for Protection of Buildings from Exterior Fire Exposures*, for recommended separation.

A-6-3.3 See NFPA 51B, *Standard for Fire Prevention in Use of Cutting and Welding Processes*.

A-6-7 See NFPA 77, *Recommended Practice on Static Electricity,* for further information.

Appendix B Mechanism of Fire Growth in Aerosol Containers

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

B-1 Introduction. The automatic fire protection alternatives given in Chapter 4 of this code are derived from more than a dozen aerosol product fire tests conducted by a major insurance company in the late 1970s and early 1980s *[see Tables B-1(a) and B-1(b)]*, and more than 50 small-, medium-, and large-scale tests sponsored by the aerosol products industry in the 1980s *[see Tables B-1(c) through B-1(g)]*. This aerosol fire research represents a significant body of knowledge regarding aerosol fire development and control for various types of aerosol products in various storage and protection scenarios.

A complete and detailed history of these aerosol storage research efforts can be obtained on request from the Chemical Specialities Manufacturers Association, Inc., in the form of a series of articles entitled "An Industry Responds: A Technical History of the CSMA Aerosol Warehouse Storage Fire Protection Research Program." Send requests to the attention of the Director of Scientific Affairs, Chemical Specialities Manufacturers Association, Inc., 1913 I Street N.W., Washington, DC 20006.

Aerosol warehouse storage fires, using standard fire test ignitors, begin as cardboard fires. The fire grows up the flue, burning off the aerosol carton faces, and there is usually a flame 5 ft to 10 ft (1.5 m to 3.0 m) above the top of the array before the first aerosol can ruptures and aerosols become involved in the fire. Depending on the type of aerosol, the first can rupture tends to occur at 30 seconds to 60 seconds after

ignition in rack storage arrays and 90 seconds to 120 seconds in palletized storage arrays.

When aerosol containers begin to rupture, some of the heat from the fuel added by the aerosol goes quickly to the ceiling, while some is absorbed into other aerosol containers, bringing them closer to, or exceeding, their burst pressure. Early application of adequate densities of sprinkler water is the most effective way to control or suppress an aerosol fire, avoiding a chain reaction that can lead to loss of control. For this reason, ESFR protection is especially effective for aerosol products.

Table B-1(a) Spray Sprinkler Tests

1.	Test Location	Factory Mutual Test Center, West Gloucester, Rhode Island, 30 ft (9 m) high test site.						
2.	Ignition	Two cellucotton rolls — 3 in. dia. × 3 in. long, (7.5 cm × 7.5 cm) each soaked in 4 oz (118 ml) of gasoline.						
3.	Protection/Ceiling	$^1/_2$-in. (12.7-mm) standard orifice, 286°F (141°C) [165°F (74°C) in Test No. 6]; 10 ft × 10 ft (2.5 m × 2.5 m) spacing; approx. 0.30 gpm/ft² (12.2 L/min · m²) density.						
4.	Protection/In-Rack	Three $^1/_2$-in. (12.7-mm) standard orifice, 165°F (74°C) rated, upright sprinklers at the first, second, and third tier levels; 30 psi (207 kPa) discharge pressure.						
5.	Test No.	1	2	3	4	5	6	7
6.	Type of Aerosol Base Product	Alcohol	Alcohol	Toluene	Alcohol	Toluene	Alcohol	Toluene
7.	No. of Pallet Loads	8	24	8	12	12	8	1
8.	Storage Configuration	Rack	Rack	Rack	Palletized	Palletized	2 × 2 × 2	Palletized
9.	No. of Ceiling Sprinklers Operated	13	16	43	4	92	64	36
10.	Time of Operation of First Sprinkler (Min:Sec)	1:52	2:06	2:19	3:05	3:03	1:26	9:23
11.	No. of In-Rack Sprinklers Operated	5	6	5	—	—	—	—
12.	Maximum Near-Ceiling Gas Temperature	1292	1334	1493	938	2216	1789	1905
	°F (°C)	(700)	(723)	(812)	(503)	(1213)	(976)	(1040)
13.	Time of Maximum Gas Temperature (Min:Sec)	3:19	5:41	3:48	3:09	4:54	4:26	9:58
14.	Time Above 1000°F (538°C)	—	—	—	—	2:16	3:32	0.52
15.	Maximum Near-Ceiling Steel Temperature	642	815	973	378	1439	—	626
	°F (°C)	(339)	(435)	(503)	(192)	(782)	—	(330)
16.	Aisle Jump	No	No	Yes	No	Yes	—	—
17.	Fire Controlled	Yes	Yes	No	Yes	No	No	No

Table B-1(b) Spray Sprinkler Tests

1.	Test Location	Factory Mutual Test Center, West Gloucester, Rhode Island, 30 ft (9 m) high test site.									
2.	Ignition	Two cellucotton rolls — 3 in. diam × 3 in. long (7.5 cm × 7.5 cm) each soaked in 4 oz (118 ml) of gasoline.									
3.	Protection/Ceiling	$^{17}/_{32}$-in. (13.5-mm) large orifice, 286°F (141°C); 10 ft × 10 ft (2.5 m × 2.5 m) spacing. [Tests 1-3, 5, and 9.] $^{1}/_{2}$-in. (12.7-mm) standard orifice, 286°F (141°C); 10 ft × 10 ft (2.5 m × 2.5 m) spacing. [Tests 4, 6-8, and 10.]									
4.	Protection/ In-Rack	Three $^{1}/_{2}$-in. (12.7-mm) orifice, 165°F (74°C) rated, upright sprinklers per tier; 30 psi (207 kPa) discharge pressure.									
5.	Test No.	1	2	3	4	5	6	7	8	9	10
6.	Ceiling Sprinkler Density (gpm/ft²)	0.6	0.6	0.6	0.3	0.6	0.3	0.3	0.3	0.6	0.3
	(L/min · m²)	(24)	(24)	(24)	(12)	(24)	(12)	(12)	(12)	(24)	(12)
7.	Type of Aerosol Base Product	Toluene	Toluene	Toluene	Toluene	Paint	Alcohol	Perfume	Deodorant	Toluene	Butane
8.	No. of Pallets	8	12	24	24	10	1	1	1	24	1
9.	Storage Configuration (r = rack, p = palletized, 3 × 4 × 1 high)	r	p	r	r	p	—	—	—	p (2 high)	—
10.	No. of Ceiling Sprinklers Operated	12	4	5	5	18	4	0	3	44	—
11.	Time of Operation of First Sprinkler (min:sec)	1:37	2:33	3:37	2:15	2:35	4:21	—	4:13	2:07	—
12.	No. of In-Rack Sprinklers Operated	6	—	5	1	—	—	—	—	—	—
13.	Maximum Near-Ceiling Gas Temperature	1527	1177	790	1410	1343	697	165	520	2162	372
	°F (°C)	(830)	(636)	(421)	(765)	(728)	(369)	(74)	(271)	(189)	(1183)
14.	Time of Maximum Gas Temperature (min:sec)	3:32	2:34	3:32	2:17	4:02	4:27	4:50	3:57	4:03	6:13
15.	Time Above 1000°F (538°C)	2:28	0:04	0:28	0:44	0:06	—	—	—	4:56	—
16.	Maximum Near-Ceiling Steel Temperature	835	417	213	375	323	170	100	177	1557	243
	°F (°C)	(446)	(214)	(101)	(191)	(162)	(77)	(38)	(80)	(117)	(847)
17.	Aisle Jump	Yes	No	Yes	No	Yes	—	—	—	Yes	—
18.	Fire Controlled	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes