NFPA 30B Code for the Manufacture and Storage of Aerosol Products 1994 Edition

National Fire Protection Association, 1 Batterymarch Park, PO Box 9101, Quincy, MA 02269-9101

NOTICE

All questions or other communications relating to this document should be sent only to NFPA headquarters, addressed to the attention of the Committee responsible for the document.

For information on the procedures for requesting Technical Committees to issue Formal Interpretations, proposing Tentative Interim Amendments, proposing amendments for Committee consideration, and appeals on matters relating to the content of the document, write to the Secretary, Standards Council, National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

A statement, written or oral, that is not processed in accordance with Section 16 of the Regulations Governing Committee Projects shall not be considered the official position of NFPA or any of its Committees and shall not be considered to be, nor be relied upon as, a Formal Interpretation.

Users of this document should consult applicable federal, state and local laws and regulations. NFPA does not, by the publication of this document, intend to urge action that is not in compliance with applicable laws, and this document may not be construed as doing so.

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

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

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

---

1. Adoption by Reference—Public authorities and others are urged to reference this document in laws, ordinances, regulations, administrative orders, or similar instruments. Any deletions, additions, and changes desired by the adopting authority must be noted separately. Those using this method are requested to notify the NFPA (Attention: Secretary, Standards Council) in writing of such use. The term "adoption by reference" means the citing of title and publishing information only.

2. Adoption by Transcription—A. Public authorities with lawmaking or rule-making powers only upon written notice to the NFPA (Attention: Secretary, Standards Council), will be granted a royalty-free license to print and republish this document in whole or in part, with changes and additions, if any, noted separately, in laws, ordinances, regulations, administrative orders, or similar instruments having the force of law, provided that: (I) due notice of NFPA's copyright is contained in each law and in each copy thereof; and (2) that such printing and republication is limited to numbers sufficient to satisfy the jurisdiction's lawmaking or rule-making process. **B.** Once this NFPA Code or Standard has been adopted into law, all printings of this document by public authorities with lawmaking or rule-making powers or any other persons desiring to reproduce this document or its contents as adopted by the jurisdiction in whole or in part, in any form, upon written request to NFPA (Attention: Secretary, Standards Council), will be granted a nonexclusive license to print, republish, and vend this document in whole or in part, with changes and additions, if any, noted separately, provided that due notice of NFPA's copyright is contained in each copy. Such license shall be granted only upon agreement to pay NFPA a royalty. This royalty is required to provide funds for the research and development necessary to continue the work of NFPA and its volunteers in continually updating and revising NFPA standards. Under certain circumstances, public authorities with lawmaking or rule-making powers may apply for and may receive a special royalty where the public interest will be served thereby.

3. Scope of License Grant—The terms and conditions set forth above do not extend to the index to this document.

(For further explanation, see the Policy Concerning the Adoption, Printing, and Publication of NFPA Documents, which is available upon request from the NFPA.)

Statement on NFPA Procedures

This material has been developed under the published procedures of the National Fire Protection Association, which are designed to assure the appointment of technically competent Committees having balanced representation. While these procedures assure the highest degree of care, neither the National Fire Protection Association, its members, nor those participating in its activities accept any liability resulting from compliance or noncompliance with the provisions given herein, for any restrictions imposed on materials or processes, or for the completeness of the text.

NFPA has no power or authority to police or enforce compliance with the contents of this document, and any certification of products stating compliance with requirements of this document is made at the peril of the certifier.

99 98 97 96 95 94 5 4 3 2 1 SC-AM-94

Errata

NFPA 30B

Aerosol Products

1994 Edition

Reference: Edition

The Committee on Aerosol Products notes the following error in the 1994 edition of NFPA 30B, *Code for the Manufacture and Storage of Aerosol Products:*

1. On Page 30B-4, upper left hand corner, the edition date in the title for NFPA 30B should read "1994 Edition" *instead of* "1990 Edition" *as shown.*

Issue Date: September 16, 1994

NFPA 30B

Code for the

Manufacture and Storage of Aerosol Products

1994 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 16–18, 1994, in San Francisco, CA. It was issued by the Standards Council on July 14, 1994, with an effective date of August 5, 1994, and supersedes all previous editions.

The 1994 edition of this document has been approved by the American National Standards Institute.

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

Origin and Development of NFPA 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 and this 1994 edition incorporates the following major changes:

- Several definitions have been revised to improve clarity.
- Section 1-7, Classification of Aerosol Products, has been completely revised. Aerosol products are now classified according to the chemical heat of combustion of the contents of the aerosol container.
- Section 1-8 has been revised to require marking of cartons of all aerosol products, regardless of level of classification.
- Subsection 3-5.2 has been rewritten to more clearly set forth the requirements for ventilation of the propellant charging and pump rooms.
- Subsection 3-12.1 has been revised so that an explosion suppression system is no longer required in the propellant pump room.
- The sprinkler design tables in Chapter 4 have been revised to reflect editorial improvements, correction of errors, and new information.
- Chapter 5, Mercantile Occupancies, has been rewritten for editorial improvement and clarity.
- Appendix A-1-7, which provides the user with assistance in classifying aerosol products, has been completely revised to reflect the new classification procedure in Section 1-7.

Technical Committee on Aerosol Products

Byron L. Briese, *Chair*
HSB Professional Loss Control, Inc., TN

Charles B. Barnett, Figgie Fire Protection Systems, OH
Rep. Nat'l Fire Sprinkler Assn.
David L. Fredrickson, S C Johnson & Son Inc., WI
Rep. Chemical Specialties Manufacturers Assn.
Robert O. George, 3M Co., MN
David Grandaw, Fenwal Safety Systems, Inc., IL
William A. Gregg, Precision Valve Corp., SC
Rep. Chemical Specialties Manufacturers Assn.
Richard J. Hild, Verlan Ltd, DC
Edmund M. Kelly, Chubb & Son, Inc., GA
James Koskan, Super Valu Stores, Inc., MN
Thomas J. Kramer, Schirmer Engineering Corp., IL
John A. LeBlanc, Factory Mutual Research Corp., MA
Michael J. Madden, Gage-Babcock & Assoc., CA
Michael J. Nappi, Potomac Electric Power Co., DC
Rep. Electric Light Power Group/Edison Electric Inst.
Donald E. Rowson, Industrial Hydrocarbons, Inc., AZ
Thomas Siciliano Jr., L & F Products Products, NJ
Rodney P. Smith, The Kartridg Pak Co., IA
David C. Tabar, The Sherwin-Williams Co., OH
Jack Thacker, Allan Automatic Sprinkler Corp. of S. CA
Rep. Nat'l Fire Sprinkler Assn.
William P. Thomas Jr., Kemper Nat'l Insurance Cos., IL
James W. Tomes, Tomes, VanRickley & Assoc., CA
Rep. Home Depot
Peter J. Gore Willse, Industrial Risk Insurers, CT
Gene Wolfe, Los Angeles Cnty Fire Dept., CA

Alternates

Jack T. Cranefield, Factory Mutual Research Corp., MA
(Alt. to J. LeBlanc)
John F. Devlin, Schirmer Engineering Corp., VA
(Alt. to T. Kramer)
D. Douglas Fratz, Chemical Specialties Mfgs Assn., DC
(Alt. to W. Gregg)
Rick Glenn, Gage-Babcock & Assn. Inc., IL
(Alt. to M. J. Madden)
W. Lance Hemsarth, L & F Products Products, NJ
(Alt. to T. Siciliano Jr.)
Kenneth E. Isman, Nat'l. Fire Sprinkler Assn., NY
(Alt. to J. Thacker)
Montfort A. Johnsen, Montfort A Johnsen & Assn. Ltd, IL
(Alt. to D. L. Fredrickson)
Kim M. Kihara, Industrial Risk Insurers, CA
(Alt. to P. J. G. Willse)
Donald B. Pounder, Grinnell Corp., RI
(Alt. to C. Barnett)
Thomas K. Terrebonne, Kemper Nat'l. Insurance Cos., KS
(Alt. to W. P. Thomas Jr.)

Robert P. Benedetti, NFPA Staff Liaison

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

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

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

NFPA 30B

Code for the

Manufacture and Storage of Aerosol Products

1994 Edition

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

Information on referenced publications can be found in Chapter 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. (*See NFPA 58, Standard for the Storage and Handling of Liquefied Petroleum Gases.*)

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

Approved. Acceptable to the authority having jurisdiction.

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

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

NOTE: The phrase "authority having jurisdiction" is used in NFPA documents in a broad manner, since jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, 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.

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.

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). Reprinted with permission from ASTM D3064, *Standard Definitions of Terms and Nomenclature Relating to Aerosol Products*.

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

Combustible liquids shall be subdivided as follows:

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

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

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

(See NFPA 321, *Standard on Basic Classification of Flammable and Combustible Liquids*, for further information on flash point test procedures.)

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 containing 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, i.e., 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.

Fire Area. An area of a building separated from the remainder of the building by construction having a fire resistance rating of at least 1 hr and having all communicating openings properly protected by an assembly having a fire protection rating of at least 1 hr.

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:

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).

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).

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

(*See NFPA 321, Standard on Basic Classification of Flammable and Combustible Liquids, for further information on flash point test procedures.*)

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.

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

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. (*For additional information, see NFPA 231C, Standard for Rack Storage of Materials.*)

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:

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

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

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

Fenced Enclosure. A segregated area meeting the requirements of 4-8.2.2.

Shall. Indicates a mandatory requirement.

Shelf Storage. Storage on structures that are less than 30 in. (0.75 m) deep, with shelves usually 24 in. (0.6 m) to 36 in. (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.

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.

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

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

1-7* Classification of Aerosol Products. Aerosol products manufactured after September 1, 1994, shall be classified by means of the calculation of their chemical 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: greater than:	and less than or equal to:	then, aerosol should be classified as 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 (20kJ/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, *Standard for the Storage and Handling of Liquefied Petroleum Gases*; NFPA 85C, *Standard for the Prevention of Furnace Explosions/ Implosions in Multiple Burner Boiler-Furnaces*; 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, *Standard for the Storage and Handling of Liquefied Petroleum Gases*.

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 hr. 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.

2-7.1 Fire alarm systems shall be installed, tested, and maintained in accordance with applicable requirements of NFPA 72, *National Fire Alarm Code.*

2-7.2 Where required by this code, manual fire alarm stations shall be installed in the natural path of escape near each required exit.

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:

(a) open flames
(b) lightning
(c) hot surfaces
(d) radiant heat
(e) smoking
(f) cutting and welding
(g) spontaneous ignition
(h) frictional heat or parks
(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. 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, *Standard for the Storage and Handling of Liquefied Petroleum Gases.* 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.)*

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. This operation sometimes releases small quantities of the container contents to the atmosphere.

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

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.

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, *Standard for the Storage and Handling of Liquefied Petroleum Gases.*

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 can have basements or below-ground level areas provided they are ventilated at a minimum flow rate of 1 cfm per ft² (0.3 m³ per min per 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 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.)*

3-4.4.1 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 psf (4.8 kPa).

3-4.5 Deflagration venting shall be provided for 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.

Exception: In existing facilities where the required deflagration venting cannot be installed, an explosion suppression system that meets the requirements of NFPA 69, Standard on Explosion Prevention Systems, shall be installed.

(See NFPA 68, Guide for Venting of Deflagrations, for information on the design and sizing of vents and vent closures.)

3-4.5.1 Deflagration vents shall relieve to a safe location to avoid injury to personnel and to minimize property damage.

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. *(For further information, see NFPA 91, Standard for Exhaust Systems for Air Conveying of Materials.)*

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 6 in. (0.15 m) above the floor.

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

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

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 = the 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. 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) (See NFPA 91, *Standard for Exhaust Systems for Air Conveying of Materials*, for further information.)

(g) Exhaust ventilation air flow shall be suitably monitored 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 cfm per sq ft (0.3 m^3 per min per m^2) of floor area. Ventilation shall be arranged to uniformly sweep the entire floor area.

Exception: When provided at all of the following areas 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.

3-6.1 Electrical equipment and wiring in flammable propellant charging and pump rooms shall be suitable for Class I, Division 1 locations.

3-6.1.1 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 5-3.5.3 of NFPA 30, *Flammable and Combustible Liquids Code*. [*See also NFPA*

497A, Recommended Practice for Classification of Class I Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas, and NFPA 497M, Manual for Classification of Gases, Vapors, and Dusts for Electrical Equipment in Hazardous (Classified) Locations.]

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. (*See NFPA 77, Recommended Practice on Static Electricity, for further information.*)

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) 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 4-1 through 4-6, 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 on Deluge Foam-Water Sprinkler and Foam-Water Spray Systems.*

3-10 Fixed Extinguishing Systems.

3-10.1 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 12B, *Standard on Halon 1211 Fire Extinguishing Systems.*

NFPA 16, *Standard on Deluge Foam-Water Sprinkler and Foam-Water Spray Systems.*

NFPA 17, *Standard for Dry Chemical 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. (*See Appendix A of NFPA 15, Standard for Water Spray Fixed Systems for Fire Protection, for further information. Also, see 5-3.4 of NFPA 30, Flammable and Combustible Liquids Code.*)

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 Explosion Suppression Systems.

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

3-12.2 Where installed, an engineered explosion suppression system shall meet the requirements of NFPA 69, *Standard for Explosion Prevention Systems*, and shall use detectors that respond to radiant energy or ultraviolet light.

3-13 Equipment Interlocks. Equipment shall be suitably interlocked so that the conditions listed in Table 3-13 result in the associated automatic actions given.

Table 3-13 Equipment Interlocks

Condition	Automatic Action
Detection of 20% of the lower explosive limit.	Alarm activates. General ventilation flow rate increases to that required by 3-5.2(e).
Detection of 40% of the lower explosive limit	Audible alarm activates. Main propellant line shuts down. All equipment in propellant charging room shuts down. Vacuum pump(s) used in conjunction with aerosol can filling shuts down.
Actuation of protective systems within the propellant charging room or product fill area.	Automatic shut-down of entire propellant charging line.

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 pump. Pump discharge pressures shall not be limited.

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):

(a) From any opening in the adjacent wall of the production facility.

(b) From walls or buildings other than the production facility or propellant charging room.

(c) From any area subject to vehicular travel or from 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 A395 or A536, grade 60-40-18 or 65-45-12);

(d) Malleable iron (ASTM A47);

(e) Higher strength grey iron (ASTM A48, 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 nail or punch, making as small a puncture as possible.

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

(e) When more than five containers are to be evacuated at any one 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 this chapter.

4-1.3 Storage of Level 2 and Level 3 aerosol products shall not be permitted in basement areas of warehouses.

Exception: As provided for in Section 4-3.

4-1.4* 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.

4-1.4.1 Level 2 aerosol products in containers whose net weight of flammable contents is less than 1 oz (28 g) shall be considered to be equivalent to Group A plastics, as defined in NFPA 231 and NFPA 231C.

4-1.5 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.

4-1.6 Level 2 and 3 aerosol products whose containers are designed to vent at pressures less than 210 psig (1450 kPa) shall not be stored.

4-1.7 Noncombustible draft curtains shall be installed as follows:

(a) At the interface between the ESFR sprinkler design area and the spray sprinkler design area; and

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

The draft curtains shall extend for a depth of 6 ft (1.8 m) or 20 percent of the ceiling height, whichever is smaller.

4-1.8 Storage of mixed commodities within or adjacent to aerosol product storage areas shall meet all applicable requirements of this chapter.

4-1.9 Storage of idle or empty pallets shall meet all applicable requirements of NFPA 231, *Standard for General Storage*.

4-2 Fire Protection — Basic Requirements.

4-2.1 Where required by this chapter, wet-pipe automatic sprinkler protection shall be provided in accordance with Tables 4-2(a) through 4-2(f). Protection shall be based on the highest level of aerosol product present.

4-2.2 Control valves for in-rack sprinklers shall be provided in accordance with NFPA 231C, *Standard for Rack Storage of Materials*.

4-2.3 Installations of hose connections shall meet the requirements of NFPA 231 or NFPA 231C, whichever is applicable.

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

4-2.4 Storage height and clearance requirements between storage and sprinklers shall comply with Tables 4-2(a) through 4-2(f).

4-2.5 Solid shelving that is installed in racks that contain Level 3 aerosol products shall be protected in accordance with Table 4-2(f). 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 4-2(f). Solid shelving shall not be installed in racks that are protected by a ceiling sprinkler system that utilizes ESFR sprinklers.

4-3 Limited Quantity Storage in Occupancies Other than Warehouses.

4-3.1 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 the following quantities:

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

(b) A maximum of 500 lb (227 kg) 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).

Table 4-2(a) Arrangement and Protection of Palletized and Solid-Pile Level 2 Aerosol Storage*

Max. Ceiling Ht (ft)	30	30	25	25
Maximum Pile Ht (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)
Temp. Rating**	High	Ordinary	Ordinary	Ordinary
Sprinkler Spacing (ft^2)	100 max.	80-100	80-100	80-100
Sprinkler Demand	0.30 gpm/ft^2 over 2500 ft^2	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

*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 $(ft/sec)^{1/2}$ [100 $(meter/sec)^{1/2}$].
**When sprinklers having higher temperature ratings are used, such as near unit heaters, refer to NFPA 13, *Standard for the Installation of Sprinkler Systems*.
For SI Units: 1 ft = 3048 mm; 1 ft^2 = 0.0929 m^2; 1 gpm/ft^2 = 40.743 L/min/m^2; 1 psi = 6.895 kPa; 1 gpm = 3.785 L/min.

Table 4-2(b) Arrangement of Protection for Palletized and Solid-Pile Level 3 Aerosols*

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

*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 sec)$^{1/2}$ [100 (meter/sec)$^{1/2}$].
**When sprinklers having higher temperature ratings are used, such as near unit heaters, refer to NFPA 13, *Standard for the Installation of Sprinkler Systems*.
***Extra-large orifice sprinklers shall have a minimum operating pressure of 10 psi (69 kPa).
For SI Units: 1 ft = 3048 mm; 1 ft^2 = 0.0929 m^2; 1 gpm/ft^2 = 40.743 L/min/m^2; 1 psi = 6.895 kPa; 1 gpm = 3.785 L/min.

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

Max. Ceiling Ht (ft)	30	25
Max. Storage Ht (ft)	15	20
Temp. Rating**	Ordinary	Ordinary
Sprinkler Spacing (ft^2)	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

*Single and double-row racks only.
**When sprinklers having higher temperature ratings are used, such as near unit heaters, refer to NFPA 13, *Standard for the Installation of Sprinkler Systems*.
For SI Units: 1 ft = 3048 mm; 1 ft^2 = 0.0929 m^2; 1 gpm/ft^2 = 40.743 L/min/m^2; 1 psi = 6.895 kPa; 1 gpm = 3.785 L/min.

Table 4-2(d) ESFR (K = 13.5 to 14.5) Arrangement and Protection of Level 3 Rack Storage*

Max. Ceiling Ht (ft)	30	25
Max. Storage Ht (ft)	15	15
Temp. Rating**	Ordinary	Ordinary
Sprinkler Spacing (ft^2)	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

*Single and double-row racks only.
**When sprinklers having higher temperature ratings are used, such as near unit heaters, refer to NFPA 13, *Standard for the Installation of Sprinkler Systems*.
For SI Units: 1 ft = 3048 mm; 1 ft^2 = 0.0929 m^2; 1 gpm/ft^2 = 40.743 L/min/m^2; 1 psi = 6.895 kPa; 1 gpm = 3.785 L/min.

Table 4-2(e) Protection of Rack Storage of Level 2 Aerosols with Spray Sprinklers

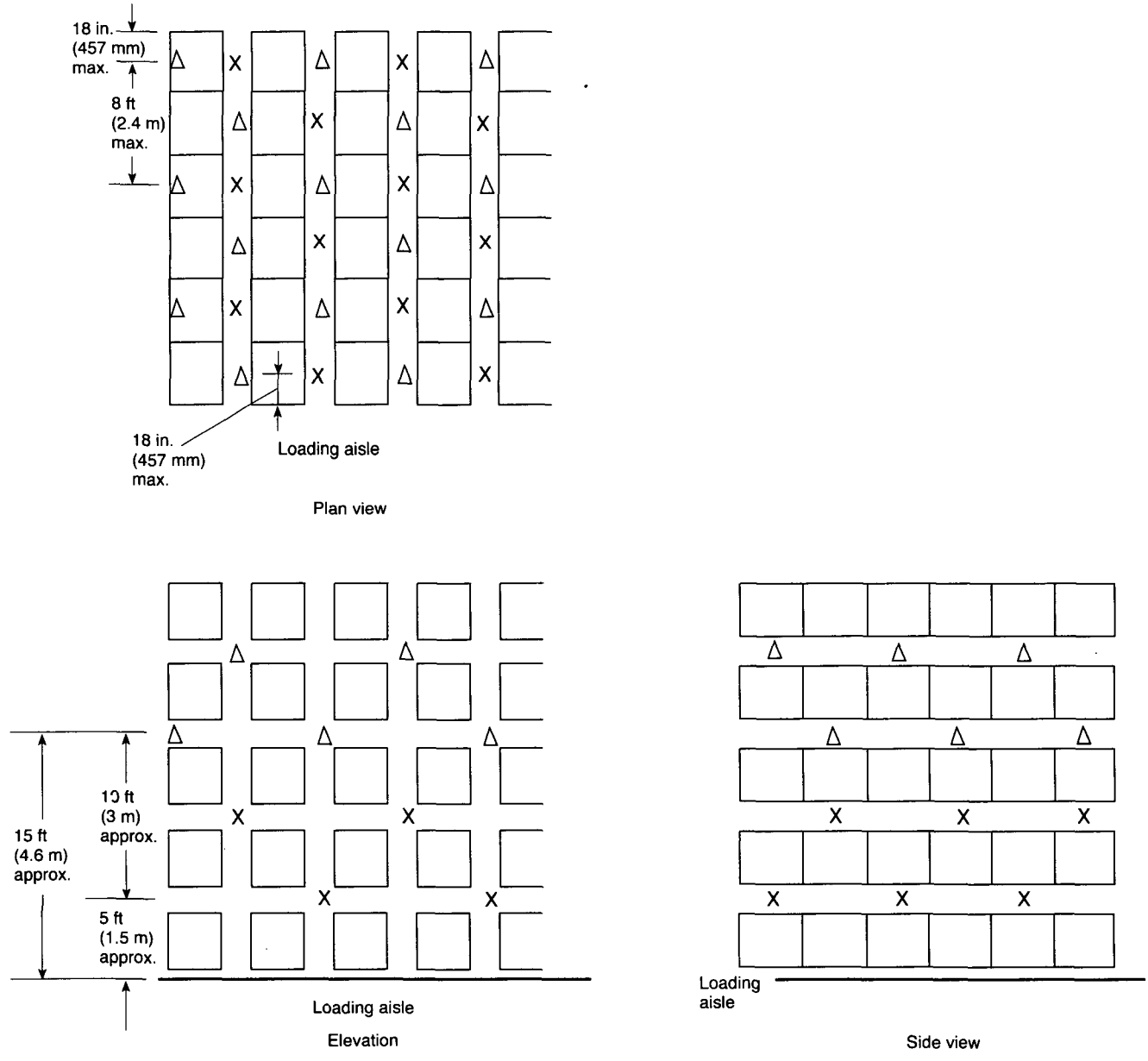
Level	Ceiling Sprinkler Arrangement	In-Rack Sprinkler Arrangement*	Clearances: Storage to Sprinklers**	Ceiling Demand	In-Rack Sprinkler Demand	Duration: Sprinklers and Hose Stream
2	High temperature, 100 ft^2 max. spacing; standard or large orifice	Ordinary temperature sprinklers 8 ft apart max. One line at each tier except top. Locate in longitudinal flue spaces double-row racks.	15 ft max. If clearance exceeds 15 ft (4.6 m), a barrier with face sprinklers below is required.	0.30 gpm/ft^2 over 2500 ft^2	30 gpm per sprinkler minimum. Base on operation of hydraulically most remote: (1) 8 sprinklers if one level. (2) 6 sprinklers each of 2 levels if only 2 levels. (3) 6 sprinklers on top 3 levels if 3 or more levels.	2 hr

*For multiple-row storage, refer to Figure 4-2(a) where distance between transverse flues does not exceed 6 ft (1.8 m); refer to Figure 4-2(b) where distance between transverse flues exceeds 6 ft (1.8 m).
**Provide at least 6 in. (150 mm) between sprinkler deflectors and top of storage in tier. If clearance exceeds 15 ft (4.6 m), a barrier with face sprinklers below is required.
For SI Units: 1 ft = 3048 mm; 1 ft^2 = 0.0929 m^2; 1 gpm/ft^2 = 40.743 L/min/m^2; 1 psi = 6.895 kPa; 1 gpm = 3.785 L/min.

Table 4-2(f) Protection of Rack Storage of Level 3 Aerosols with Spray Sprinklers

Level	Ceiling Sprinkler Arrangement	In-Rack Sprinkler Arrangement	Clearance: Storage to Sprinklers**	Ceiling Demand	In-Rack Sprinkler Demand	Duration Sprinklers and Hose Stream
3	High temperature, Large or Extra-large* orifice, 100 ft^2 max. spacing	Ordinary temperature sprinklers 8 ft apart max. Install in longitudinal flue and on face of each tier except top tier.	5 ft (1.5 m) or less	0.30 gpm/ft^2 over 2500 ft^2	30 gpm per sprinkler minimum. Base on operation of hydraulically most remote: (1) 8 sprinklers if 1 level. (2) 6 sprinklers each of 2 levels if only 2 levels. (3) 6 sprinklers on top 3 levels if 3 or more levels.	2 hr
			More than 5 ft (1.5 m) to 15 ft (4.6 m)	0.60 gpm/ft^2 over 1500 ft^2 to 2500 ft^2. Interpolate for clearances between 5 ft and 15 ft	30 gpm per sprinkler minimum. Base on operation of hydraulically most remote: (1) 8 sprinklers if 1 level. (2) 6 sprinklers each of 2 levels if only 2 levels. (3) 6 sprinklers on top 3 levels if 3 or more levels.	2 hr
			More than 15 ft (4.6 m) or more than 5 ft (1.5 m) where barriers are used	0.30 gpm/ft^2 over 2500 ft^2 plus a barrier above top tier of storage with face sprinklers below	30 gpm per sprinkler minimum. Base on operation of hydraulically most remote: (1) 8 sprinklers if 1 level. (2) 6 sprinklers each of 2 levels if only 2 levels. (3) 6 sprinklers on top 3 levels if 3 or more levels.	2 hr
3 Maximum Ceiling Height: 30 ft (9 m)	High temperature, Large or Extra-large* orifice, 100 ft^2 max. spacing	Ordinary temperature sprinklers 8 ft (2.4 m) apart max. One line at each except top. Locate in longitudinal flue. For multiple-row racks, refer to Figures 4-2(a) and (b).	Up to 15 ft (4.6 m)	0.60 gpm/ft^2 over 2500 ft^2	30 gpm per sprinkler minimum. Base on operation of hydraulically most remote: (1) 8 sprinklers if 1 level. (2) 6 sprinklers each of 2 levels if only 2 levels. (3) 6 sprinklers on top 3 levels if 3 or more levels.	2 hr
			More than 15 ft (4.5 m)	60 gpm/ft^2 over 2500 ft^2 plus a barrier above top tier with face sprinklers below	30 gpm per sprinkler minimum. Base on operation of hydraulically most remote: (1) 8 sprinklers if 1 level. (2) 6 sprinklers each of 2 levels if only 2 levels. (3) 6 sprinklers on top 3 levels if 3 or more levels.	2 hr

*Extra-large orifice sprinklers shall have a minimum operating pressure of 10 psi (69 kPa).
**At least 6 in. (150 mm) shall be provided between sprinkler deflectors and top of storage.
For SI Units: 1 ft = 3048 mm; 1 ft^2 = 0.0929 m^2; 1 gpm/ft^2 = 40.743 L/min/m^2; 1 psi = 6.895 kPa; 1 gpm = 3.785 L/min.



1. Distance between top level of in-rack sprinklers and top of storage shall be no more than 5 ft (1.5 m) when only in-rack sprinklers are provided in addition to ceiling sprinklers.
2. Horizontally staggered face sprinklers shall be provided at 15-ft (4.6-m) vertical intervals.
3. Distance between transverse flues shall be no more than 6 ft (1.8 m).

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

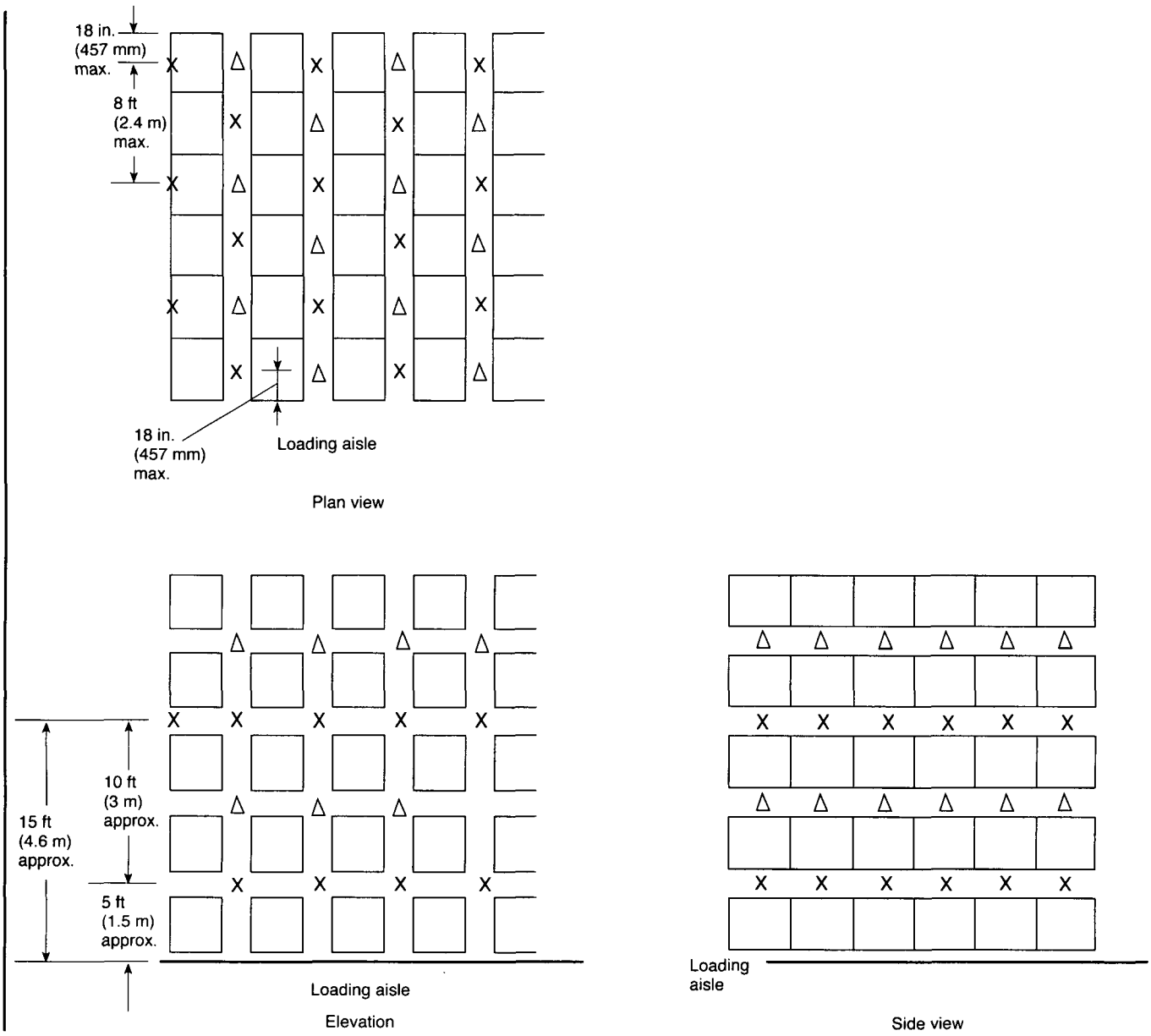
4-3.1.1 These quantities shall be permitted to be doubled if the quantities in excess of those stated in 4-3.1 are stored in storage cabinets that meet the requirements of Section 4-3 of NFPA 30, *Flammable and Combustible Liquids Code*.

4-3.2 Where Level 2 and Level 3 aerosol products are stored in quantities greater than those allowed by 4-3.1, such quantities shall be stored in a separate inside storage area meeting the requirements of Section 4-7.

4-4 Limited Quantity Storage in General Purpose Warehouses.

4-4.1 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 the following quantities:

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



1. Distance between top level of in-rack sprinklers and top of storage shall be no more than 5 ft (1.5 m) when only in-rack sprinklers are provided in addition to ceiling sprinklers.
2. Horizontally staggered face sprinklers shall be provided at 15-ft (4.6-m) vertical intervals.

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

4-4.2 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 4-2(a) and 4-2(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.*

4-4.3 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 ware house 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 4-2(c) through 4-2(f). 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.*

4-5 Segregated Aerosol Product Storage Areas in General Purpose Warehouses.

4-5.1 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.

4-5.2 Solid pile, palletized, or rack storage of Level 2 and Level 3 aerosol products in excess of the maximum quantities given in 4-4.2 and 4-4.3 shall be protected in accordance with the requirements in 4-5.2.1 through 4-5.2.6.

4-5.2.1 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 4-5.2.1.1 through 4-5.2.1.3.

4-5.2.1.1 Interior walls shall have a fire-resistance rating of 1 or 2 hr and shall be continuous from floor to the underside of the roof deck or ceiling.

(a) For interior walls having a fire-resistance rating of 2 hr, the aggregate floor area utilized for Level 2 and Level 3 aerosol product storage shall not exceed 25 percent of the total floor area of the warehouse, up to a maximum of 40,000 sq ft (3660 m^2).

(b) For interior walls having a fire-resistance rating of 1 hr, the aggregate floor area utilized for Level 2 and Level 3 aerosol product storage shall not exceed 20 percent of the total floor area of the warehouse, up to a maximum of 30,000 sq ft (2745 m^2).

4-5.2.1.2 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 aggregate area utilized for Level 2 and Level 3 aerosol product storage shall not exceed 20 percent of the total area of the warehouse, up to a maximum of 20,000 ft^2 (1830 m^2).

(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, shall be kept outside of the segregated area and at least 8 ft (2.4 m) from the fence, except as allowed by 4-5.2.6.

(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.

4-5.2.1.3 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 aggregate area used for aerosol product storage shall not exceed 15 percent of the total area of the warehouse, up to a maximum of 20,000 sq ft (91830 m^2).

(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 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.

4-5.2.2 Sprinkler protection shall be provided for segregated aerosol product storage areas in accordance with Tables 4-1 through 4-6. Protection shall be provided for the highest level of aerosol products present.

4-5.2.3 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.

4-5.2.4 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 is provided by ESFR sprinklers, the minimum aisle width shall be 4 ft (1.2 m).

4-5.2.5 An approved fire alarm system, meeting the requirements of Section 2-7, shall be provided in any general purpose warehouse in which Level 2 and Level 3 aerosol products are stored.

(a) Activation of the fire alarm system shall be by operation of the automatic sprinkler system or by manual pull station.

(b) Activation of the fire alarm system shall cause all fire doors or gates leading to the segregated aerosol product storage area to close automatically.

4-5.2.6 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.

4-6 Aerosol Warehouses.

4-6.1 Storage of Level 2 and Level 3 aerosol products in excess of the amounts permitted in Sections 4-4 and 4-5 shall be located within an aerosol warehouse.

4-6.2 Aerosol warehouses shall be protected by automatic sprinkler systems in accordance with Tables 4-2(a) through 4-2(f). 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.

4-6.3 Aerosol warehouses shall be separate, detached buildings or shall be separated from other occupancies by freestanding 4-hr fire walls, with communicating openings protected on each side by automatic closing, listed 3-hr fire doors.

4-6.4 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 hr with each opening protected with a listed 1½-hr fire door.

4-6.5 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 hr with each opening protected with a listed 3-hr fire door.

4-6.6 The total quantity of aerosols within an aerosol warehouse shall not be restricted.

4-6.7 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 4-2(a) through 4-2(f), 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 4-2(f).

4-6.8 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.

4-6.9 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 is provided by ESFR sprinklers, the minimum aisle width shall be 4 ft (1.2 m).

4-7 Storage of Aerosol Products in Separate Inside Flammable Liquid Storage Areas.

4-7.1 Storage of aerosol products shall be permitted in separate inside flammable liquid storage areas of 500 sq ft (47 m^2) or less that meet the requirements of NFPA 30, *Flammable and Combustible Liquids Code*, up to a maximum quantity of 1000 lb (454 kg) of Level 2 aerosol products or 500 lb (227 kg) of Level 3 aerosol products or 1000 lb (454 kg) of combined Level 2 and Level 3 aerosol products.

4-7.2 Storage of aerosol products shall be permitted in separate inside flammable liquid storage areas of greater than 500 sq ft (47 m^2) that meet the requirements of NFPA 30, *Flammable and Combustible Liquids Code*, up to a maximum quantity of 2500 lb (1135 kg) of Level 2 aerosol products or 1000 lb (454 kg) of Level 3 aerosol products or 2500 lb (1135 kg) 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), if the separate inside storage area is protected by an automatic sprinkler system that is designed in accordance with Tables 4-2(a) through 4-2(f), whichever is applicable.

4-8 Storage of Aerosol Products in Liquid Warehouses (as defined in NFPA 30).

4-8.1 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.

4-8.2 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 4-8.2.1 or 4-8.2.2.

Exception: Where aerosol products are stored in an unprotected liquid warehouse, as allowed by 4-4.4 of NFPA 30, the aerosol products are not required to be in a segregated area. Storage configuration shall meet the requirements of 4-6.8 and 4-6.9 of this code.

4-8.2.1 Interior walls shall have a fire-resistance rating of 1 or 2 hr and shall be continuous from floor to the underside of the roof deck.

(a) For interior walls having a fire-resistance rating of two hours, the aggregate floor area utilized for the storage of Level 2 and Level 3 aerosol products shall not exceed 25 percent of the total floor area of the warehouse, up to a maximum of 40,000 sq ft (3700 m^2).

(b) For interior walls having a fire resistance of 1 hr, the aggregate floor area utilized for the storage of Level 2 and Level 3 aerosol products shall not exceed 20 percent of the total floor area of the warehouse, up to a maximum of 30,000 sq ft (1850 m^2).

(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.

4-8.2.2 Chain link fencing shall extend from the floor to the underside of the roof deck and shall meet the following requirements:

(a) The aggregate floor area utilized for the storage of Level 2 and Level 3 aerosol products shall not exceed 20 percent of the total floor area of the warehouse, up to a maximum of 20,000 sq ft (1850 m^2).

(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.

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

4-8.3 Sprinkler protection shall be provided for segregated aerosol product storage areas in accordance with Tables 4-2(a) through 4-2(f). Protection shall be provided for the highest level of aerosol products present.

4-8.4 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.

4-8.5 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).

4-8.6 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.

4-9 Outdoor Storage.

4-9.1 Level 2 and 3 aerosol products that are stored outdoors shall be separated from important buildings or structures. (*See NFPA 80A, Recommended Practice for Protection of Buildings from Exterior Fire Exposures, for recommended separation*).

4-9.2 A minimum 50-ft (15-m) separation shall be maintained between Level 2 and Level 3 aerosol products and other combustible yard storage.

4-9.3 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.

4-9.4 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 4-2(a) through 4-2(f).

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 the following:

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 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 sq ft (9.8 kg/m^2) of gross sales floor area. However, no single 10-ft by 10-ft (3-m by 3-m) section of sales floor area shall contain more than 1000 lb (454 kg) net weight of 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 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 The storage and display of Level 2 and Level 3 aerosol products shall be protected in accordance with Tables 4-2(a) through 4-2(f), whichever is applicable. Where in-rack sprinklers are required by Table 4-2(e) or Table 4-2(f) and where the 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.

5-2.3.1 Noncombustible draft curtains shall be installed in the building as follows:

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

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

The draft curtains shall extend for a depth of 6 ft (1.8 m) or 20 percent of the ceiling height, whichever is smaller.

5-2.4 Storage and display of Level 2 and Level 3 aerosol products shall not exceed 10,000 lb (4540 kg) within any 25,000 sq ft (2323 m^2) of sales display area. Aerosol products 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 aerosol display and storage area.

5-2.6 Storage and display of flammable and combustible liquids shall be separated from the storage of aerosol products by a minimum distance of 25 ft (7.6 m) or by a segregating wall.

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-hr 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-hr 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), 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 aerosol products in separate inside flammable liquids storage rooms shall meet the requirements of Section 4-7 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, 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 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.

6-2.4.1 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:

(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. (*See NFPA 51B, Standard for Fire Prevention in Use of Cutting and Welding Processes.*)

6-4 Aisles. Aisles shall be maintained free of storage 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. 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.

6-6.1 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:

(a) Gas detection systems;
(b) Explosion 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. (*See NFPA 77, Recommended Practice on Static Electricity, for further information.*)

Chapter 7 Referenced Publications

7-1 The following documents or portions thereof are referenced within this code and shall be considered part of the requirements of this document. The edition indicated for each reference is the current edition as of the date of the NFPA issuance of this document.

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 Extinguisher*, 1994 edition.

NFPA 11, *Standard for Low-Expansion Foam*, 1994 edition.

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

NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems*, 1993 edition.

NFPA 12A, *Standard on Halon 1301 Fire Extinguishing Systems*, 1992 edition.

NFPA 12B, *Standard on Halon 1211 Fire Extinguishing Systems*, 1990 edition.

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 1994 edition.

NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*, 1993 edition.

NFPA 16, *Standard on the Installation of Deluge Foam-Water Sprinkler and Foam-Water Spray Systems*, 1991 edition.

NFPA 17, *Standard for Dry Chemical Extinguishing Systems*, 1994 edition.

NFPA 20, *Standard for the Installation of Centrifugal Fire Pumps*, 1993 edition.

NFPA 22, *Standard for Water Tanks for Private Fire Protection*, 1993 edition.

NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*, 1992 edition.

NFPA 30, *Flammable and Combustible Liquids Code*, 1993 edition.

NFPA 31, *Standard for the Installation of Oil Burning Equipment*, 1992 edition.

NFPA 45, *Standard on Fire Protection for Laboratories Using Chemicals*, 1991 edition.

NFPA 54, *National Fuel Gas Code*, 1992 edition.

NFPA 58, *Standard for the Storage and Handling of Liquefied Petroleum Gases*, 1992 edition.

NFPA 69, *Standard on Explosion Prevention Systems*, 1992 edition.

NFPA 70, *National Electrical Code*, 1993 edition.

NFPA 72, *National Fire Alarm Code*, 1993 edition.

NFPA 80, *Standard for Fire Doors and Fire Windows*, 1992 edition.

NFPA 85C, *Standard for the Prevention of Furnace Explosions/Implosions in Multiple Burner Boiler-Furnaces*, 1991 edition.

NFPA 90A, *Standard for the Installation of Air Conditioning and Ventilating Systems*, 1993 edition.

NFPA *101*, *Life Safety Code*, 1994 edition.

NFPA 231, *Standard for General Storage*, 1990 edition.

NFPA 231C, *Standard for Rack Storage of Materials*, 1991 edition.

NFPA 505, *Fire Safety Standard for Powered Industrial Trucks Including Type Designations, Areas of Use, Maintenance, and Operation*, 1992 edition.

NFPA 1221, *Standard for the Installation, Maintenance, and Use of Public Fire Service Communications Systems*, 1994 edition.

NFPA 8501, *Stand for Single Burner Boiler Operation*, 1992 edition.

7-1.2 Other Publications.

7-1.2.1 ANSI Publication. American National Standards Institute, 1430 Broadway, New York, NY.

ANSI B56.1, *Safety Standard for Low-Lift and High-Lift Trucks*.

7-1.2.2 ASTM Publications. American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

ASTM A47-1984, *Standard Specification for Ferritic Malleable Iron Castings*.

ASTM A48-1983, *Standard Specification for Gray Iron Castings*.

ASTM A395-1988, *Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures*.

ASTM A536-1984, *Standard Specification for Ductile Iron Castings*.

7-1.2.3 U.S. Government Publication. U.S. Government Printing Office, Superintendent of Documents, Washington, DC 20407.

Title 49, *Code of Federal Regulations, Transportation*.

Appendix A Explanatory Material

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

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-1-2 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 Section 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 may 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.

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

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-1-7 Test data indicates 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, $\Delta H_{comb,}$ 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

$$\Delta H_c \text{ (Product)} = \sum (I\% \times \Delta H_{c\,(I)})$$

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 the *Chemical Engineers' Handbook*, and other standard references, such as the *Fire Protection Handbook* and the *Handbook of Fire Protection Engineering*.

Heats of combustion can also be determined by calculation or by appropriate test methods, such as ASTM D240, *Standard Test Method for Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeter*.

Representative values are given in Table A-1-7. 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, $\Delta H_{comb,}$ or use 43.7 kJ/g (19,000 BTU/lb). This latter value is typical for hydrocarbons.

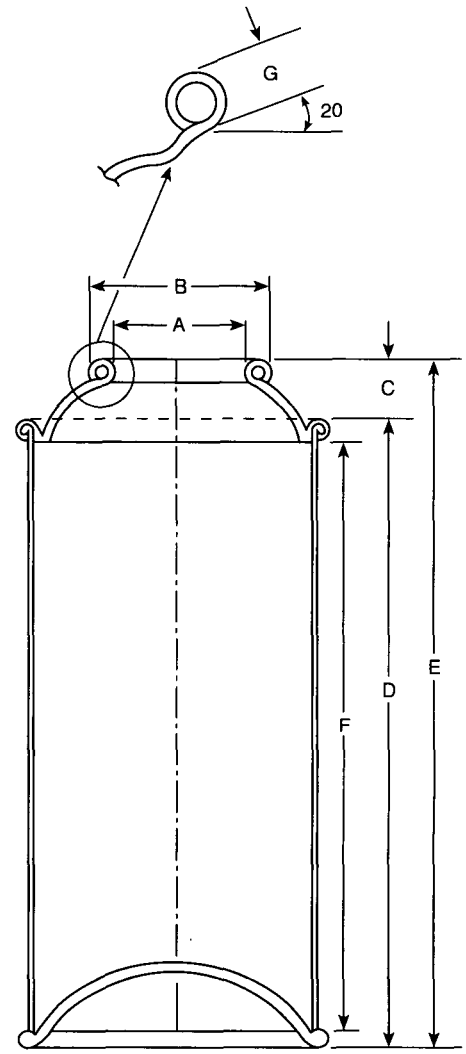


Figure A-1-6 Typical aerosol container.

Some examples of calculation of chemical heat of combustion follow:

Example 1 — Typical Level 1 Aerosol Product

Ingredient	Weight %	ΔH_c of Ingredient	Wt % × ΔH_c
Isobutane	30%	42.7 kJ	12.8 kJ
Water	69%	0 kJ	0 kJ
Fragrance, etc.	1%	43.7 kJ*	0.4 kJ
			Total = 13.2 kJ

*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.

Example 2 — Typical Level 2 Aerosol Product

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

*Since these minor ingredients constitute a small proportion of the total, 43.7 kJ/g was used instead of acutally 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	Wt % × ΔH_c
Isobutane	25%	42.7 kJ	10.7 kJ
Propane	10%	43.7 kJ	4.4 kJ
Toluene	25%	27.8 kJ	7.0 kJ
Acetone	15%	27.9 kJ	4.2 kJ
Methyl Ethyl Ketone	15%	30.7 kJ	4.6 kJ
Pigments, etc.	10%	43.7 kJ*	4.4 kJ
			Total = 35.3 kJ

*Since the pigments 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.

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

Material	CAS #	ΔHcomb, kJ/g*	Combustion Efficiency	ΔHc, kJ/g
Acetone	67-64-1	29.7	0.94	27.9
n-Butane	106-97-8	45.4	0.94	42.6
Corn Oil		36.8	—	—
Dimethyl Ether	115-10-6	28.7	0.95	27.3
Ethanol	64-17-5	27.7	0.92	25.5
Ethanol (95.6% Azeotrope)		26.5	0.92	24.4
Glycerol Triacetate		36.9	0.96	35.4
Glycol Ethers	Various			
Monethyl		26.7	0.97	25.9
Monoethyl Acetate		32.2	0.96	30.9
Monoethyl Diacetate		33.3	0.96	32.0
HCFC 142b (Chlorodifluoroethane)	75-68-3	9.3	0.95	8.8
HFC 152a (1,1,Difluoroethane)	75-37-6	18.1	0.95	17.2
n-Heptane	142-82-5	44.6	0.92	41.0
Inerts		0.0	—	0.0
Isobutane	75-28-5	45.4	0.94	42.7
Isopropanol	67-63-0	31.8	0.91	28.9
Isopropyl Myristate		36.2	—	—
Isopropyl Palmitate		37.2	—	—
Methanol	67-56-1	20.0	0.96	19.2
Methyl Ethyl Ketone	78-93-3	32.7	0.94	30.7
Methyl Isopropyl Ketone	108-10-1	33.1	0.94	31.1
Mineral Oil	Various	41.5	0.76	31.7
n-Propane	74-98-6	46.0	0.95	43.7
Silicone Oil	63148-62-9	25.1	0.78	19.6
Toluene	108-88-3	39.7	0.70	27.8
Water	7732-18-5	0.0	—	0.0
Waxes (Polyolefins)	Various	43.5	0.89	38.7

*Determined by calculation or by Oxygen Bomb Calorimeter.
1kJ/g = 434.5 BTU/lb.
NOTE: Table A-1-7(a) provides a cross-reference between CAS numbers and the materials listed in this table.

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

CAS #	Material
64-17-5	Ethanol
67-56-1	Methanol
67-63-0	Isopropanol
67-64-1	Acetone
74-98-6	n-Propane
75-28-5	Isobutane
75-37-6	HFC-152a
75-68-3	HCFC-142b
78-93-3	Methyl Ethyl Ketone
106-97-8	n-Butane
108-10-1	Methyl Isopropyl Ketone
108-88-3	Toluene
115-10-6	Dimethyl Ether
142-82-5	n-Heptane
7732-18-5	Water
63148-62-9	Silicone Oil

A-3-2 Test Bath (Hot Tank, Water Bath). The test may 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-3-5.2(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 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 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. Some considerations involved in using the formula follow:

(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% in air at 70°F (21°C). Butane has the same an 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 1 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, 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% of the LEL and operational shutdown is set at 40% of the LEL, it is recommended that the design level not exceed 10% of the LEL. In other words, DL in the equation should not exceed 0.10.

(d) "R" in the equation is an estimate of how much propellant is lost from the equipment under normal operating conditions, plus 20% 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:

$$R = \left(\frac{1 \text{ gal}}{3785.4 \text{ cc}}\right) \times (\text{loss per can, cc}) \times (\text{cans per minute}) \times (\text{safety factor})$$

Considerations to be used with the above formula are:

— Loss per Can. 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 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.

— Cans per Minute. This is the maximum production rate for the entire propellant charging room. The ventilation system must be designed to handle the expected losses from the highest number of cans that can foreseeably be filled per min, based on a 10- to 20-min 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 to 25%. If there are multiple fill lines, the maximum production rates must be added for each. Also, if an additional fill line is later added, the capacity of the ventilation system must be increased accordingly.

— 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.

An example of the use of the formula follows:

Assumptions:

Under-the-Cup Filler, 3 cc per min release per filling head. Two fill machines, each operating at 150 containers per min. Propellant is isobutane; LEL is 1.8%. 30.59 cu ft per gal. Safety factor for leakage is 20%. LEL Design Level is 10%.

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

$$= 0.2853 \text{ gallons per minute}$$

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

$$= 4761 \text{ CFM}$$

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 measured 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% of the LEL. This means that the gas detection heads may give very different readings if their positions are changed. Care must 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 may be considered, rather than the two that are normally used.

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-3-8 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 may offer some additional benefits in combatting any spill fire that may result.

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-4-1.4 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-4-8.2.2(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.

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.

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 and B-2*) and more than 50 small, medium, and large-scale tests sponsored by the aerosol products industry in the 1980s (*see Tables B-3 through B-7*). 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., 1913 I Street N.W., Washington, DC 20006, Attn: Director of Scientific Affairs, 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."

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 to 10 ft (1.5 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 30-60 sec after ignition in rack storage arrays and 90-120 sec 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.

I. Rack Storage Arrays.

The rack storage configuration is ideal for promoting fire development. The fuel is supported so that air has access to the fire from all sides and so that the stored com-

Table B-1 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 × 7.5 cm) each soaked in 4 oz (118 ml) of gasoline.						
3.	Protection/Ceiling:	½ 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/ft^2 (12.2 Lpm/m^2) density.						
4.	Protection/In-Rack:	Three ½ 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	2x2x2	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

modity does not topple over, as it would in solid pile storage. A rack also has many areas that are shielded from ceiling sprinkler discharge.

Fire tests of rack storage configurations shows a very consistent development pattern: the fire starts at a point and widens as it moves up the storage array, like a "V." When the fire reaches the second tier of storage, the flames fan out along the bottom of the pallet above and spread laterally to the face of the rack. Fireballs from rupturing aerosol cans, which usually measure 10 ft (3 m) in diameter, also spread fire to the face of the rack. Once the fire is established on the face of the rack, the fire spreads rapidly upward and outward horizontally in the classic "V" pattern, thus exposing more of the commodity. The fire on the face of the rack and within the transverse flue spaces of the rack structure also causes more aerosol containers to rupture. As additional containers rupture, uninvolved containers on the interior of the pallet load are now exposed to the fire.

Fire can jump the aisle space between two rows of racks in several ways. If the fire is severe enough, the radiant energy alone may be sufficient to ignite combustible cartons or commodities in the exposed rack. Fireballs from rupturing aerosol cans are large enough to engulf adjacent racks with flame. Occasionally, burning flammable liquid may be ejected from rupturing containers with enough force to reach the exposed storage.

In-rack sprinklers, located in the longitudinal flue space, are highly effective in preventing the fire from crossing into the other half of a double-row rack. Even in fire tests that were failures (i.e., the fire jumped the aisle to involve the target array), these in-rack sprinklers were successful in stopping the fire at the flue space. Cartons were burned, but no aerosol containers ruptured.

In-rack sprinklers located at the face of the rack structure have been shown to stop the spread of fire up the face of the rack. Their position within the rack structure allows

Table B-2 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 × 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/ft^2) (Lpm/m^2)	0.6 (24)	0.6 (24)	0.6 (24)	0.3 (12)	0.6 (24)	0.3 (12)	0.3 (12)	0.3 (12)	0.6 (24)	0.3 (12)
7.	Type of Aerosol Base Product	Tolu-ene	Tolu-ene	Tolu-ene	Tolu-ene	Paint	Alco-hol	Per-fume	Deodo-rant	Tolu-ene	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 °F (°C)	1527 (830)	1177 (636)	790 (421)	1410 (765)	1343 (728)	697 (369)	165 (74)	520 (271)	2162 (1183)	372 (189)
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 °F (°C)	835 (446)	417 (214)	213 (101)	375 (191)	323 (162)	170 (77)	100 (38)	177 (80)	1557 (847)	243 (117)
17.	Aisle Jump?	Yes	No	Yes	No	Yes	–	–	–	Yes	–
18.	Fire Controlled?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes

them to wet down the face of the storage array that fronts on the aisle. This reduces the demand on the ceiling sprinkler system, which allows a reduction in the design density of the ceiling sprinkler system. Also, the Early Suppression-Fast Response (ESFR) sprinkler head operates fast enough and discharges water at a high enough density that it is capable of preventing fire spread up the face of the rack.

II. Palletized Storage Arrays.

Palletized storage does not offer the same conducive conditions for fast fire growth as rack storage, but can result in persistent fires if sprinklers are not designed for proper protection.

Table B-3 Tests on Product and Packaging Changes

Data Summary Series 1

Test	1	2	3	4	5	6
Aerosol Base Product	Paint	Paint	Paint	Paint	Paint	Paint
Packaging Variable	—	Rim-Vent-Release Cans	Fire Retardant Cartons	Shrink-Wrapped Pallets	Methylene Chloride Solvent	Metal Overcaps
TEST RESULTS						
Sprinklers Operated	4	33	4	30	28	5
Maximum Ceiling Temp.	1010	2141	980	1525	1881	1220
Time of First Can Rupture	1:31	1:20	1:56	1:25	1:18	1:36
1st Sprinkler Activation	2:15	1:40	2:40	2:13	1:45	1:55
Final Sprinkler Activation	2:22	5:09	4:12	5:22	4:55	3:06
Est. Product Damage	60%	70%	40%	80%	70%	75%
Comments	Fire controlled by four sprinklers in 9-10 min.	Fire built rapidly out of control, reaching maximum intensity at 6 min.	Fire controlled by four sprinklers in 6 min, after slow fire development	Increased fire intensity after 4 min required test to be aborted at 5:20.	Increased fire intensity after 3 min required test to be aborted at 4:30.	Fire controlled by five sprinklers in 9-10 min.

All Tests: 20-ft ceiling (tests conducted on 40-ft by 40-ft metal platform); standard orifice sprinklers with 286°F (141°C) links installed 10 ft apart; 29 psi constant water pressure delivering 0.3 gpm per sq ft; 2-pallet array spaced 1 ft apart with ignition between pallets by two half-ignitors (plastic bags containing 4 oz heptane on cotton rolls).
Note: 1 ft = 3048 mm; 1 ft^2 = 0.0929 m^2; 1 gpm/ft^2 = 40.743 L/min/m^2; 1 psi = 6.895 kPa; 1 gpm = 3.785 L/min.

Early aerosol fire tests showed that standard spray sprinkler protection had difficulty controlling Level 2 and Level 3 aerosol products stacked more than 5 ft (1.5 m) high under a 30-ft (9-m) ceiling. A major testing program sponsored by the aerosol industry was therefore begun to seek more cost-effective storage and protection alternatives.

The first series in that program investigated packaging and formulation alternatives in a series of small scale tests on Level 3 aerosol paint products, protected by spray sprinklers (½ in. orifice) under a 20-ft (6.1-m) ceiling. The packaging variables were rim-vent-release cans, shrink-wrap replacing cardboard cartons, metal instead of plastic overcaps, fire-resistant cardboard cartons, and methylene chloride replacing some of the petroleum distillate solvents.

None of these alternatives proved significantly beneficial as compared to the standard "control" aerosol product. The rim-vent release, shrink-wrap, and methylene chloride alternatives resulted in harder-to-control fires. The metal overcap product was essentially equivalent to the control. The fire-resistant cartons primarily resulted only in delaying the fire build-up, but had little benefit once aerosols were involved.

Further aerosol fire testing evaluated higher water densities and larger-orifice sprinkler heads to protect higher stacking in palletized storage arrays of Level 1, 2, and 3 aerosol products under low-to-medium ceiling heights [20 to 25 ft (6.1 to 7.6 m)]. Numerous successful protection alternatives were found. To properly protect each class of aerosol product stored in higher stack height and higher ceiling height scenarios was found to require higher water densities from larger orifice ($^{17}/_{32}$ in. to 0.64 in.) sprinklers fitted with low temperature (160°F) fusible links.

The final improvement in aerosol fire protection was found through the use of an even faster response sprinkler. ESFR sprinklers, which are fitted with extremely fast-responding, low-temperature links (160°F, Response Time Index = 50), were found capable of protecting high-stack palletized aerosol product storage under ceilings up to 30 ft (9 m) high, as well as rack storage without in-rack sprinklers. In virtually all of the successful ESFR tests, the fire was not only controlled, but quickly suppressed and, in some cases, totally extinguished. The success of ESFR protection for aerosol product storage may be due primarily to the ability of these sprinklers to be activated by the cardboard fire and begin to fight the fire before any aerosols are involved.

Table B-4 Intermediate Scale Tests
Data Summary Series 2

Test	1	2	3	4	5	6
Aerosol Base Product	Hairspray	Hairspray	Air Freshener	Furniture Polish	Laundry Pre-Wash	Toluene/ A-70
Pallet Configuration	2×2×2	2×2×3	1×2×1	1×2×1	1×2×1	1×2×1
Sprinkler	1/2 in.	17/32 in.	1/2 in.	1/2 in.	1/2 in.	1/2 in.
Link Temp., °F	160	160	280	280	280	280
Water Pressure, psi	30	30	30	30	30	30
Water Density, gpm/sq ft	0.3	0.43	0.3	0.3	0.3	0.3
TEST RESULTS						
Sprinklers Operated	33	23	1	3	3	16
Maximum Ceiling Temp., °F	1761	1475	659	603	653	1855
Time of First Can Rupture	1:48	1:50	1:45	1:54	1:51	1:50
1st Sprinkler Activation	2:02	2:05	3:05	6:08	4:17	2:16
Final Sprinkler Activation	6:36	4:50	—	6:10	4:20	4:48
Est. Product Damage	50%	75%	20%	50%	75%	65%
Comments	Poor control; intense fire for 15 min.	Intensity of fire required test to be aborted at 8:20.	Fire easily controlled in 5 min by single sprinkler.	Fire controlled in 9 min after slow fire build-up.	Fire reasonably well controlled in 10-12 min.	Intense fire for 8-10 min before any control established.

All Tests: 20-ft ceiling (tests conducted on 40-ft by 40-ft metal platform); ignition by two half-ignitors (plastic bags containing 4 oz heptane on cotton rolls); sprinklers installed on 10-ft grid.
Note: 1 ft = 3048 mm; 1 ft^2 = 0.0929 m^2; 1 gpm/ft^2 = 40.743 L/min/m^2; 1 psi = 6.895 kPa; 1 gpm = 3.785 L/min.

Table B-5 Large-Drop Sprinkler Tests – Intermediate-Scale
Data Summary Series 3

Test	1	2	3	4	5	6	7
Aerosol Base Product	Hairspray	Hairspray	Hairspray	Paint	Furniture Polish	Paint	Paint (RVR/MeCl)*
Pallet Configuration	2×2×3	2×2×3	2×2×3	2×2×3	2×2×3	2×2×2	1×2×1
Sprinklers	17/32 in.	0.64 in.	0.64 in.	0.64 in.	0.64 in.	0.64 in.	1/2 in.
Link Temp., °F	160	160	160	160	160	160	280
Water Pressure, psi	56	50	25	75	50	75	30
Water Density, gpm/ft^2	0.6	0.8	0.56	0.96	0.8	0.96	0.3
TEST RESULTS							
Sprinklers Operated	4	4	18	4	4	4	36
Maximum Ceiling Temp., °F	1080	1645	1439	1350	1068	1111	2163
Time of First Can Rupture	1:48	1:45	1:46	1:35	1:56	1:47	1:20
1st Sprinkler Activation	1:56	1:54	1:53	1:43	2:27	2:01	1:47
Final Sprinkler Activation	2:00	2:01	4:52	1:47	2:28	2:08	3:24
Est. Product Damage	20%	20%	50%	40%	20%	20%	90%
Comments	Fire controlled in 6-8 min and suppressed by 15 min.	Fire fully suppressed in 10 min.	Inadequate control led to 18 sprinkler activations; potential for fire spread.	Fire marginally controlled, but potential for fire spread.	Fire controlled in 5-7 min.	Fire well controlled in 4-5 min.	Very intense fire; test aborted at 3:20.

*Rim-vent-release container; methylene chloride solvent.
Note: 1 ft = 3048 mm; 1 ft^2 = 0.0929 m^2; 1 gpm/ft^2 = 40.743 L/min/m^2; 1 psi = 6.895 kPa; 1 gpm = 3.785 L/min, 160°F = 71°C; 280°F = 138°C.

Table B-6 Large-Drop Sprinkler Tests - Large Scale and Intermediate-Scale Data Summary Series 4

Test	1	2	3	4	5
Aerosol Base Product	Paint	Hairspray	Laundry Pre-Wash	Anti-Perspirant	Paint
Pallet Configuration	2-High	3-High	2×2×2	2×2×3	2×2×3
Sprinkler	0.64	0.64	0.64	0.64	0.64
Link Temp., °F	160	160	160	160	160 (150 RTI*)
Water Pressure, psi	75	50	50	75	75
Water Density, gpm/sq ft	0.96	0.8	0.8	0.96	0.96
TEST RESULTS					
Sprinklers Operated	4	7	4	7	4
Maximum Ceiling Temp., °F	1158	1337	1116	1520	895
Time of First Can Rupture	1:30	1:33	2:24	1:45	1:34
1st Sprinkler Activation	1:49	1:44	2:52	1:49	1:43
Final Sprinkler Activation	1:52	3:42	3:09	6:43	1:48
Est. Product Damage	—	—	15%	50%	25%
Comments	Fire well controlled in 3-4 min; suppressed in 15-20 min. No fire spread.	Fire well controlled in 6-7 min, despite 2 sprinkler malfunctions. No fire spread.	Fire well controlled in 5 min; suppressed within 10-15 min. Fire spread unlikely.	Moderate control, fire persisted 25 min; probability for fire spread.	Fire well controlled in 5 min; suppressed in 15-20 min. Fire spread unlikely.

*Response Time Index of 150
NOTE: 1 ft = 3048 mm; 1 ft^2 = 0.0929 m^2; 1 gpm/ft^2 = 40.743 L/min/m^2; 1 psi = 6.895 kPa; 1 gpm = 3.785 L/min; 160°F = 71°C; 280°F = 138°C.

Table B-7 ESFR Tests

Test	1	2	3	4	5	6	7	8	9
Aerosol Base Product	Hair Spray	Paint	Paint	Paint	Paint	Paint	Hair Spray	Hair Spray	Paint
Aerosol Product Classification	Level 2	Level 3	Level 3	Level 3	Level 3	Level 3	Level 2	Level 2	Level 3
Array	Rack	Rack	Palletized	Rack	Rack	Rack	Rack	Rack	Rack
Stack Ht. (meters)	18'10" (5.7)	13'10" (4.2)	15'6" (4.7)	13'7" (4.1)	13'10" (4.2)	13'10" (4.2)	13'10" (4.2)	18'10" (5.7)	13'10" (4.2)
Ceiling clearance (meters)	6'2" (1.9)	11'2" (3.4)	9'6" (2.9)	4'2" (1.3)	11'2" (3.4)	15'0" (4.5)	15'0" (4.5)	10'0" (3)	15'0" (4.5)
No. of Sprinklers above Ignition Point	4	4	4	2	1	1	1	2	1
Time of First Sprinkler Operation (min:sec)	1:02	0:42	0:49	0:55	0:35	0:36	0:34	0:56	1:15
Time of Last Sprinkler Operation (min:sec)	1:11	1:06	1:36	6:33	0:35	2:06	0:34	3:44	—
Total Sprinklers Operated	4	4	4	5	1	61	1	14	1
Peak Temp., °F (°C)	1045 (563)	565 (296)	713 (378)	1421 (772)	256 (124)	1447 (786)	223 (106)	995 (535)	200 (93)
Time of First Container Rupture	1:03	1:01	1:29	0:52	None	0:44	0:46	1:01	0:10

NOTE: All of the above tests, except for Test 9, were conducted with 50 psi (3.45 bar) operating pressure. Test 9 used 75 psi (5.2 bar).

Appendix C Determining the Classification Level of Aerosol Products

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

Section 1-7 of this code provides formulation-based criteria for classifying aerosol products into three categories requiring different levels of protection. These criteria are based on dozens of fire tests involving sprinklers and other relevant data on current aerosol product formulations. Since exact aerosol formulation data is often proprietary, it will be necessary for aerosol manufacturers to classify each aerosol product and communicate that information to those who require such information, through carton marking, material safety data sheets, or other appropriate means.

There are also standard fire test procedures that may be used to determine the classification levels of aerosol products. Where such data exists, it should be used to identify that product's classification and serve as the basis for further modifications in the formulation-based criteria.

The most reliable test protocol currently available is the 12-pallet aerosol classification test, developed by Factory Mutual Research Corporation. This test consists of a 2-pallet by 2-pallet by 3-pallets high array, with sprinkler protection using upright sprinkler heads having 0.64-in. orifices (K-factor — 11.2), and 160°F (71°C) (RTI = 300) links, spaced 10 ft by 10 ft (3 m × 3 m) on a 25-ft (7.6-m) ceiling, with water pressure at a constant 50 psi (345 kPa) to provide 0.8 gpm/ft^2 (32.6 L/min/m^2).

Classification is determined from considering the "critical performance parameters" in the test, which include the number of sprinklers opened, maximum temperature of a steel beam on the ceiling, maximum plume velocity, maximum plume temperature, maximum heat flux, maximum weight loss rate, and net percent weight loss. The overall consideration in this test is whether control or suppression is achieved and the number of sprinklers that operated. Roughly speaking, fires involving Level 1 aerosol products are well-controlled or suppressed; fires involving Level 2 aerosol products are well to marginally well controlled; and fires involving Level 3 aerosol products are not well controlled.

Appendix D Flammability Labeling of Aerosol Products

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

Precautionary labeling for aerosol products, including that for flammability hazards during use of the product, is regulated by several federal agencies, under a number of federal statutes. Labeling of aerosol pesticide products, including disinfectants and sanitizers as well as insecticides and herbicides, is strictly regulated by the U.S. Environmental Protection Agency (EPA) under the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA). Pesticide labeling regulations may be found in Title 40, *Code of Federal Regulations*, Part 162. Labeling of aerosol food, drug, and cosmetic products is regulated by the U.S. Food and Drug Administration (FDA), under The Federal Food, Drug, and Cosmetic Act (FFDCA). These regulations may be found in various parts of Title 21 of the *Code of Federal Regulations*. The labeling of any consumer (household) aerosol products not already covered by EPA or FDA is regulated by the Consumer Product Safety Commission (CPSC), under the Federal Hazardous Substances Act (FHSA). These labeling regulations may be found in Title 16, *Code of Federal Regulations*, Part 1500.

The labeling of aerosol industrial and institutional products that do not fall under any of the above regulations are covered by the Occupational Safety and Health Administration (OSHA), under its hazard communications rules, in Title 29, *Code of Federal Regulations*, Part 1910.

Although there are many differences between the labeling requirements of the various agencies, there is some degree of consistency in their approach to evaluating and labeling aerosol products for their flammability hazard during use. They generally use the terms "flammable" or "extremely flammable" for aerosol products that meet certain flammability criteria and then mandate related precautionary language.

The principal test procedure for evaluating the in-use flammability of aerosol products is the flame extension test. In this test, the aerosol is sprayed through a flame and the length of the extension of the flame is measured. Any flashback of the flame towards the container valve is also noted. Some authorities also consider the flash point of the base product, although it is the position of the aerosol product industry that this data does not correlate closely with the in-use flammability of the total product.

It is important to understand that the in-use flammability of an aerosol product, as measured by the flame extension test, does not provide an adequate prediction of the fire hazard involved in the storage of the product. Thus, the product label cannot be used to determine whether the aerosol product should be handled as a Level 1, 2, or 3 product.

Appendix E Loss Experience

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

E-1 Fire and Explosion Incidents. Approximately one-third of the incidents involving aerosol products are fires that have occurred in warehouses. These facilities have included manufacturing warehouses, distribution warehouses, and public warehouses. The average loss was $1,220,000, but this does not include the two largest recorded losses, which together totaled $150,000,000. About 15 percent of the losses involved the disposal of aerosol products, either by incineration or by shredding and compacting. These incidents incurred an average $150,000 loss. Fires occur less frequently in this occupancy category. The largest explosion incident resulted in $1,000,000 in damage. Repair facilities account for another 15 percent of the losses, the average loss being $375,000. Eight percent of the losses occurred in aerosol filling operations; these are evenly split between fires and explosions. Fire damage in these cases ranges from negligible to $250,000. Explosions in filling operations also show a wide damage range, although the largest caused $11,000,000 in damage.

The following chart shows the percentage loss by dollar loss category:

Dollar Amount	Percent
Greater than $100,000	68
" " $250,000	52
" " $500,000	27
" " $1,000,000	27

This shows that only 32 percent of the incidents had loss values less than $100,000 and that the median loss was $250,000.

E-2 Causes and Contributing Factors. Electrical equipment was cited as the ignition source in 15 percent of the incidents, except in propellant filling rooms where electrical equipment was involved in almost every case. Smoking was cited in 8 percent of the incidents and incendiarism in 5 percent. Almost half of the losses occurred in inadequately sprinklered or nonsprinklered properties.

E-3 Loss Incidents.

1979 Warehouse Fire. This nonfood supermarket warehouse was one story high, 800 ft by 575 ft, and constructed of concrete block walls and a steel frame roof. Various commodities, including aerosol products, were stored up to 20 ft high, in double-row racks. The building was protected by automatic sprinklers, using 212°F, 17/32 in. orifice heads. Sprinkler heads were spaced 100 sq ft per head, designed for a density of 0.3 gpm per sq ft over the most hydraulically remote 4000 sq ft. In-rack sprinklers were not provided.

An employee first noticed the fire behind a pallet on the first tier of a rack. He attempted extinguishment using a portable extinguisher, but was not successful. The fire spread to the next pallet load above, which held a Level 3 aerosol product, then rapidly up the face of the rack to the ceiling, creating dense black smoke that forced employees to abandon attempts to fight the fire. The roof of the warehouse began to fail as fire fighters arrived on the scene. The fire department was only able to connect to the pumper connection and use aerial snorkels. It took three days to finally extinguish the fire.

All the contents of the building were consumed. The roof and all of the walls collapsed. Property damage and business interruption were estimated at $30,000,000 and $20,000,000, respectively. Incendiarism was suspected.

1982 Warehouse Fire. Levels 1, 2, and 3 aerosol products, as well as a variety of other products, were stored in this 1.2 million sq ft, 30-ft high distribution center. Storage was 15 ft high, in palletized arrays and in single- and double-row racks. The building was sprinklered, using 286°F, 17/32 in. orifice heads, designed for 0.4 gpm per sq ft over 3000 sq ft. In-rack sprinklers were not provided.

An employee was checking paperwork while sitting in his fork-lift truck when he heard a carton fall from a pallet behind him. The carton contained a Level 3 aerosol product (carburetor cleaner). He heard a hissing sound, then saw flames almost immediately. By the time he was able to reach an extinguisher, flames had spread up the face of the stack from which the carton had fallen. Other employees responded, but were forced to evacuate by heavy smoke.

The fire broke through the roof within 13 minutes. Responding fire fighters reported that aerosol containers were rupturing and rocketing, trailing burning contents. The fire burned out of control for 8½ hours. Final extinguishment was not achieved until 8 days later. The warehouse and its contents were totally destroyed.

In addition to the 40 to 50 pallets of carburetor cleaner located immediately adjacent to the ignition point, the warehouse contained an estimated 580,000 containers of Level 3 aerosol products, 480,000 containers of Level 2 aerosol products, as well as high flash point combustible liquids (motor oils), butane lighter refills, and small cylinders of propane for hand-held torches.

Property damage exceeded $100,000,000.

Appendix F Referenced Publications

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

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

NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*, 1990 edition.

NFPA 30, *Flammable and Combustible Liquids Code*, 1993 edition.

NFPA 51B, *Standard for Fire Prevention in Use of Cutting and Welding Processes*, 1994 edition.

NFPA 58, *Standard for the Storage and Handling of Liquefied Petroleum Gases*, 1992 edition.

NFPA 68, *Guide for Venting of Deflagrations*, 1994 edition.

NFPA 77, *Recommended Practice on Static Electricity*, 1993 edition.

NFPA 80A, *Recommended Practice for Protection of Buildings from Exterior Fire Exposures*, 1993 edition.

NFPA 91, *Standard for Exhaust Systems for Air Conveying of Materials*, 1992 edition.

NFPA 231, *Standard for General Storage*, 1990 edition.

NFPA 231C, *Standard for Rack Storage of Materials*, 1991 edition.

NFPA 321, *Standard on Basic Classification of Flammable and Combustible Liquids*, 1991 edition.

NFPA 497A, *Recommended Practice for Classification of Class I Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*, 1992 edition.

NFPA 497M, *Manual for Classification of Gases, Vapors, and Dusts for Electrical Equipment in Hazardous (Classified) Locations*, 1991 edition.

Fire Protection Handbook, 17th edition.

F-1.2 Other Publications.

F-1.2.1 ASTM Publications. American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

ASTM D240-1992, *Standard Test Method for Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeter.*

ASTM D3064-1989, *Standard Definitions of Terms and Nomenclature Relating to Aerosol Products.*

F-1.2.2 Perry, R. H. and Green, D. W., *Perry's Chemical Engineers' Handbook*, 6th edition, McGraw Hill, New York, NY, 1984.

F-1.2.3 DiNenno, P. J., et al, *SFPE Handbook of Fire Protection Engineering*, 1st edition, National Fire Protection Association, Quincy, MA 1988.

F-1.2.4 U.S. Government Publications. U.S. Government Printing Office, Superintendent of Documents, Washington, DC 20407.

Title 16, *Code of Federal Regulations, Commercial Practices.*

Title 21, *Code of Federal Regulations, Food and Drugs.*

Title 29, *Code of Federal Regulations, Labor.*

Title 40, *Code of Federal Regulations, Protection of Environment.*

Title 49, *Code of Federal Regulations, Code of Federal Regulations, Transportation.*

Index

Tentative Interim Amendment

NFPA 30B

Manufacture and Storage of Aerosol Products

1994 Edition

Reference: 1-6 Definitions, Table A-1-7
TIA 94-1 (NFPA 30B)

Pursuant to Section 4 of the NFPA Regulations Governing Committee Projects, the National Fire Protection Association has issued the following Tentative Interim Amendment to NFPA 30B, *Manufacture and Storage of Aerosol Products,* 1994 edition. The TIA was processed by the Aerosol Products Committee and was issued by the Standards Council on July 12, 1994, with an effective date of July 31, 1994.

A Tentative Interim Amendment is tentative because it has not been processed through the entire standards-making procedures. It is interim because it is effective only between editions of the standard. A TIA automatically becomes a proposal of the proponent for the next edition of the standard; as such, it then is subject to all of the procedures of the standards-making process.

1. Add the following definitions to Section 1-6.

Chemical Heat of Combustion (H_c). The amount of heat released, in 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.

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

Theoretical Heat of Combustion. The amount of heat released, in 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 or heat of combustion data, as reported in the literature and assuming all products are in the vapor state.

2. Replace Table A-1-7 with the following.

Chemical Name	CAS Number[1]	Chemical Heat of Combustion[2] ΔH_c,kJ/g
Acetone	67-64-1	27.7
Acrylic Resin	—	a
Alkyd Resin	—	a
Aluminum	7429-90-5a	
Asphalt	8052-42-4	22.7
Barium Sulfate	7727-43-7	0.0
Benzidine (Yellow)	92-87-5	a
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	a
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 (HCFC 152a)	75-37-6	6.3

(Continued)