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NFPA 231

Standard for General Storage

1998 Edition

This edition of NFPA 231, *Standard for General Storage*, was prepared by the Technical Committee on General Storage and acted on by the National Fire Protection Association, Inc., at its Annual Meeting held May 18–21, 1998, in Cincinnati, OH. It was issued by the Standards Council on July 16, 1998, with an effective date of August 5, 1998, and supersedes all previous editions.

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

This edition of NFPA 231 was approved as an American National Standard on August 6, 1998.

Origin and Development of NFPA 231

In 1943, the U.S. War Production Board promulgated *General Storage Specifications for Critical-Strategic Materials*. These specifications were based largely on existing NFPA standards and on generally accepted good practice in fire protection. They were published for reference in NFPA *National Fire Codes for Building Construction and Equipment* in 1944, and an NFPA Committee on General Storage was appointed that same year. On the recommendation of the committee, a general storage standard was adopted at the NFPA Annual Meeting in 1946. The standard covered indoor and outdoor storage. A revision of the standard was tentatively adopted in 1953.

In 1955, the committee submitted the draft of a new document, *Recommended Safe Practices for General Storage*, No. 231-T, which covered indoor storage, outdoor storage, and refrigerated warehouses. The draft was tentatively adopted, while the 1946 general storage standard remained the official document. NFPA 231, *Recommended Safe Practices for General Storage*, was adopted in 1956 and included amendments to the original draft.

In 1965, the document was rewritten as a standard and published under its current title. The sections of the 1965 edition that pertained to outdoor storage and refrigerated warehouses were deleted, and an appendix on pallets and palletized storage was added.

In the 1970 edition, amendments included doubling the maximum recommended area for Type I and Type II storage, placing height limitations on empty wooden pallet storage, and reducing the water requirements for Type II storage.

In 1972, protection requirements for empty combustible pallets and design curves for sprinkler water demands were added.

In 1974, the height of storage to which NFPA 231 applies was increased from 25 ft to 30 ft (7.6 m to 9.1 m).

The standard was partially revised in 1979 and 1985.

The 1987 edition incorporated minor revisions.

The 1990 edition of the standard was modified to include the requirements of early suppression fast response (ESFR) sprinklers. In addition, Chapter 6 was modified to include storage heights for encapsulated commodities up to 15 ft (4.6 m).

The 1995 edition of the standard was revised to include recent developments with regard to miscellaneous storage, extra-large orifice sprinklers, large-drop sprinklers, and ESFR sprinklers. Efforts were made to increase the user friendliness of the document. Chapters 6 and 7 underwent significant modification.

The 1998 edition includes expanded descriptions and examples of storage commodities. Protection criteria has been added for mixed commodity storage, storage on plastic pallets, and storage up to 12 ft in height. Other changes include more options for protecting idle pallets, expanded applications for ESFR and large-drop sprinklers and the application of new types of sprinklers. Additionally, the rules for protecting plastic commodities have been revised, and additional examples illustrating the application of these rules have been included.

Technical Committee on General Storage

Christopher T. Lummus, *Chair*
Insurance Services Office, Inc., TX [I]

Michael T. Kroman, *Secretary*
Fireman's Fund Insurance Co., CA [I]

Hamid R. Bahadori, City of Orlando Fire Dept., FL [U]

Kerry M. Bell, Underwriters Laboratories Inc., IL [RT]

Robert B. Combs, J &H/Marsh & McLennan, WA [I]

Robert C. Everson, Calabash, NC [SE]

James G. Gallup, Rolf Jensen & Assoc., Inc., IL [SE]

James Golinveaux, Central Sprinkler Corp., PA [M]

Rep. Nat'l Fire Sprinkler Assn.

Thomas Goonan, Tom Goonan Assoc., VA [SE]

Richard Greenberg, Carteret Fire Dept., NJ [E]

Richard S. Johnson, Hilton Head, SC [U]

Rep. Owen-Illinois

Rodney A. McPhee, Canadian Wood Council, ON, Canada [M]

Jennifer L. Nelson, AT&T - EH&S, NJ [U]

Michael T. Newman, Johnson & Johnson, NJ [U]

Rep. NFPA Industrial Fire Protection Section

Gerald W. O'Rourke, O'Rourke & Co., CA [SE]

Mark Oliszewicz, Schirmer Engr Corp., IL [SE]

Albert W. Reed, Reed Fire Protection Engr, TX [SE]

Todd E. Schumann, Industrial Risk Insurers, IL [I]

Jerry Shiner, Keepsafe Systems, Inc., ON, Canada [SE]

Peter A. Smith, Int'l Paper Co., TN [U]

Robert D. Spaulding, Factory Mutual Research Corp., MA [I]

Jack Thacker, Allan Automatic Sprinkler Corp. of Southern California, CA [IM]

Rep. Nat'l Fire Sprinkler Assn.

William P. Thomas, Jr., Kemper Nat'l Insurance Cos., IL [I]

F. A. Underwood, The Trinity Co., TX [U]

Terry L. Victor, Tyco Int'l Ltd., MD [IM]

John F. Viola, HFP Sprinkler Inc., MA [IM]

Rep. American Fire Sprinkler Assn., Inc.

Susan J. Weigand, Victory Fire Protection, Inc., PA [IM]

Rep. American Fire Sprinkler Assn., Inc.

Alternates

Donald "Don" D. Becker, Midland Automatic Sprinkler Co., Inc., [IM]

(Alt. to J. F. Viola)

William M. Carey, Underwriters Laboratories Inc., IL [RT]

(Alt. to K. M. Bell)

Stephen A. Clark, Jr., Fireman's Fund Insurance Co., NC [I]

(Alt. to M. T. Kroman)

J. Grayson Gilbert, Industrial Risk Insurers, GA [I]

(Alt. to T. E. Schumann)

Salvatore Gitto, J&H/Marsh & McLennan, NY [I]

(Voting Alt. to M&M Rep.)

Joseph B. Hankins, Jr., Factory Mutual Research Corp., MA [I]

(Alt. to R. D. Spaulding)

Stephen R. Hoover, Kemper Nat'l Insurance Cos., IL [I]

(Alt. to W. P. Thomas, Jr.)

Roland J. Huggins, American Fire Sprinkler Assn., Inc., TX [IM]

(Alt. to S. J. Weigand)

Richard E. Hughey, ISO Commercial Risk Services, NY [I]

(Alt. to C. T. Lummus)

Kenneth E. Isman, Nat'l Fire Sprinkler Assn., NY [IM]

(Alt. to J. Thacker)

Steven G. Krone, Schirmer Engr Corp., TX [SE]

(Alt. to M. Oliszewicz)

Donald C. Moeller, Rolf Jensen & Assoc., Inc., CA [SE]

(Alt. to J. G. Gallup)

Peter Thomas, The Viking Corp., MI [M]

(Alt. to J. Golinveaux)

Nonvoting

Martin M. Brown, Laguna Hills, CA
(Member Emeritus)

Sultan M. Javeri, AXA Global Risks, France

Milosh T. Puchovsky, 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. A key to classifications is found at the back of this document.

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 general warehousing and commodities against fire where stored indoors or outdoors. This Committee does not cover storage that is specifically covered by other NFPA standards.

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

Information on referenced publications can be found in Chapter 11 and Appendix D.

Chapter 1 Introduction

1-1 Scope.

1-1.1 This standard shall apply to the storage of materials that represent the broad range of combustibles, including plastics that are stored palletized, solid-piled, in bin boxes, or on shelves.

Exception: Miscellaneous storage shall be permitted to be protected in accordance with NFPA 13, Standard for the Installation of Sprinkler Systems.

1-1.2 Outdoor Storage of a Broad Range of Combustibles. See Appendix C.

1-1.3 This standard shall not apply to the following:

- (a) Unsprinklered buildings
- (b) Storage of commodities that, with their packaging and storage aids, are classified as noncombustible
- (c) Unpackaged bulk materials such as grain, coal, or similar commodities
- (d) Inside or outside storage of commodities that are covered by other NFPA standards, except where specifically mentioned herein (e.g., pyroxylin plastics). Storage of high hazard materials such as tires, roll paper stored on end, and flammable liquids is outside the scope of this standard. Storage of such commodities shall be protected in accordance with the provisions of NFPA 30, *Flammable and Combustible Liquids Code*; NFPA 30B, *Code for the Manufacture and Storage of Aerosol Products*; NFPA 40, *Standard for the Storage and Handling of Cellulose Nitrate Motion Picture Film*; NFPA 58, *Liquefied Petroleum Gas Code*; NFPA 231C, *Standard for Rack Storage of Materials*; NFPA 231D, *Standard for Storage of Rubber Tires*; NFPA 231F, *Standard for the Storage of Roll Paper*; NFPA 232, *Standard for the Protection of Records*; NFPA 430, *Code for the Storage of Liquid and Solid Oxidizers*; and NFPA 490, *Code for the Storage of Ammonium Nitrate*.

- (e) Storage on racks

1-1.4 Nothing in this standard is intended to restrict new technologies or alternate arrangements, provided the level of safety prescribed by the standard is not reduced.

1-2 Retroactivity Clause. The provisions of this document shall be considered necessary to provide a reasonable level of protection from loss of life and property from fire. The provisions reflect situations and the state of the art at the time the standard was issued.

Unless otherwise noted, it is not intended that the provisions of this document be applied to facilities, equipment,

structures, or installations that were existing or approved for construction or installation prior to the effective date of this document.

Exception: This standard shall apply in cases where it is determined by the authority having jurisdiction that the existing situation involves a distinct hazard to life or property.

1-3 Definitions. Unless expressly stated elsewhere, for the purpose of this standard, the terms in this section shall be defined as follows:

Approved.* Acceptable to the authority having jurisdiction.

Array.

Closed Array. A storage arrangement where air movement through a pile is restricted due to vertical flues 6 in. (152 mm) in width or narrower.

*Open Array.** A storage arrangement where air movement through a pile is enhanced due to vertical flues wider than 6 in. (152 mm).

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

Available Height for Storage.* The maximum height at which commodities can be stored above the floor and still maintain adequate clearance from structural members and the required clearance below sprinklers.

Bin Box Storage.* Storage in five-sided wood, metal, or cardboard boxes with open face on the aisles.

Ceiling Height. The distance between the floor and the underside of the ceiling above, or roof deck within, a storage area.

Clearance. The distance from the top of storage to the ceiling sprinkler deflectors.

Commodity. The combination of products, their packing materials, and their containers.

Compartmented.* The rigid separation of the products in a container by dividers that form a stable unit under fire conditions.

Container (shipping, master, or outer container).* A receptacle that is strong enough, by reason of material, design, and construction, to be shipped safely without further packaging.

Early Suppression Fast Response (ESFR) Sprinkler. A listed ESFR sprinkler is a thermosensitive device that is designed to react at a predetermined temperature by automatically releasing a stream of water and distributing it in a specified pattern and quantity over a designated area to provide early suppression of a fire where installed on the appropriate sprinkler piping.

Encapsulated.* A method of packing that consists of a plastic sheet that completely encloses the sides and top of a pallet load that contains a combustible commodity or combustible packages.

Expanded (foamed or cellular) Plastic. Plastic whose density is reduced by the presence of numerous small interconnecting or noninterconnecting cavities (cells) that are dispersed throughout their mass.

Exposed Group A Plastic Commodity.* A plastic that is not enclosed in packaging or coverings that absorb water or that

otherwise appreciably retard the burning hazard of the commodity.

Free-Flowing Plastic Materials.* Those plastics that fall out of their containers during a fire, fill flue spaces, and create a smothering effect on the fire.

High-Temperature-Rated Sprinkler. A sprinkler that has a temperature rating between 250°F and 300°F (121°C and 149°C).

Intermediate-Temperature-Rated Sprinkler. A sprinkler that has a temperature rating between 175°F and 225°F (79°C and 107°C).

Labeled. Equipment or materials to which has been attached a label, symbol, or other identifying mark of an organization that is acceptable to the authority having jurisdiction and concerned with product evaluation, that maintains periodic inspection of production of labeled equipment or materials, and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

Large-Drop Sprinkler. A listed sprinkler characterized by a K factor between 11.0 and 11.5 and a proven ability to meet the prescribed penetration, cooling, and distribution criteria specified in the large-drop sprinkler examination requirements. The deflector/discharge characteristics of a large-drop sprinkler generate large drops of such size and velocity that they enable effective penetration of a high-velocity fire plume.

Listed.* Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material, or service meets identified standards or has been tested and found suitable for a specified purpose.

Miscellaneous Storage. Storage that does not exceed 12 ft (3.7 m) in height and that is incidental to another occupancy use group as defined in NFPA 13, *Standard for the Installation of Sprinkler Systems*. Such storage shall not constitute more than 10 percent of the building area or 4000 ft² (372 m²) of the sprinklered area, whichever is greater. Such storage shall not exceed 1000 ft² (93 m²) in one pile or area, and each such pile or area shall be separated from other storage areas by at least 25 ft (7.6 m).

Noncombustible. Commodities, packaging, or storage aids that do not ignite, burn, or liberate flammable gases when heated to a temperature of 1380°F (749°C) for 5 minutes.

Ordinary-Temperature-Rated Sprinkler.* A sprinkler that has a temperature rating between 135°F and 170°F (57°C and 77°C).

Packaging. A commodity wrapping, cushioning, or container.

Palletized Storage. Storage of commodities on pallets or other storage aids that form horizontal spaces between tiers of storage.

Pile Stability.*

Stable Piles.* Those arrays where collapse, spillage of contents, or leaning of stacks across flue spaces is not likely to occur soon after initial fire development.

Unstable Piles.* Those arrays where collapse, spillage of contents, or leaning of stacks across flue spaces occurs soon after initial fire development.

Roof Height. The distance between the floor and the underside of the roof deck within a storage area.

Shall. Indicates a mandatory requirement.

Shelf Storage. Storage on structures less than 30 in. (76.2 cm) deep with shelves usually 2 ft (0.6 m) apart vertically and separated by approximately 30-in. (76.2-cm) aisles.

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

Solid Unit Load of a Nonexpanded Plastic (either cartoned or exposed). A load that does not have voids (air) within the load and that burns only on the exterior of the load; water from sprinklers might reach most surfaces available to burn.

Spray Sprinkler. A sprinkler listed for its ability to provide fire control for a wide range of fire hazards.

Storage Aids. Commodity storage devices, such as pallets, dunnage, separators, and skids.

Unit Load. A pallet load or module that is held together and that is normally transported by material-handling equipment.

Chapter 2 Classification of Storage

2-1* Commodity Classification.

2-1.1 General.

2-1.1.1* Commodity classification and the corresponding protection requirements shall be determined based on the makeup of individual storage units (i.e., unit load, pallet load).

2-1.1.2 Mixed Commodities. Protection requirements for mixed commodities shall not be based on the overall commodity mix in a fire area. Mixed commodity storage shall be protected by the requirements for the highest commodity and storage arrangement.

Exception No. 1: Where in accordance with this standard, up to 10 pallet loads of a higher hazard commodity shall be permitted in an area that does not exceed 40,000 ft² (3716 m²). The higher hazard commodity shall be randomly dispersed with no adjacent loads in any direction (including diagonal). If the ceiling protection is based on Class I or II commodities, the permitted number of pallet loads for Class IV or Group A plastics shall be reduced to five.

Exception No. 2: Where the higher hazard materials are confined to a designated area and properly protected for that area.

2-1.2 Pallet Types. Where loads are palletized, the use of wooden or metal pallets shall be assumed in the classification of commodities. Where plastic pallets are used, the classification of the commodity unit shall be increased by one class (e.g., Class III becomes Class IV and Class IV becomes Group A plastics). No increase shall be required for a Group A plastic commodity.

Exception: Where other than wood pallets are used, and where specific commodity classification test data are available from a nationally recognized testing laboratory, the authority having jurisdiction shall be permitted to use such data in determining the classification of a commodity.

2-1.3* Commodity Classes.

2-1.3.1* A Class I commodity shall be defined as a noncombustible product that meets one of the following criteria:

- (a) It is placed directly on wooden pallets.
- (b) It is stored in single-layer corrugated cartons, with or without single-thickness cardboard dividers, with or without pallets.
- (c) It is shrink-wrapped or paper-wrapped as a unit load with or without pallets.

2-1.3.2* A Class II commodity shall be defined as a noncombustible product that is stored in slatted wooden crates, solid wood boxes, multiple-layer corrugated cartons, or equivalent combustible packaging material, with or without pallets.

2-1.3.3* A Class III commodity shall be defined as a product fashioned from wood, paper, natural fibers, or Group C plastic, with or without cartons, boxes, or crates and with or without pallets. Such products shall be permitted to contain a limited amount (5 percent by weight or volume) of Group A or Group B plastic.

2-1.3.4* A Class IV commodity shall be defined as a product, with or without pallets, that meets one of the following criteria:

- (a) It is constructed partially or totally of Group B plastic.
- (b) It consists of free-flowing Group A plastic materials.
- (c) It contains, within itself or its packaging, an appreciable amount (5 percent to 15 percent by weight or 5 percent to 25 percent by volume) of Group A plastic. The remaining materials shall be permitted to be any of the following:
 1. Metal
 2. Wood
 3. Paper
 4. Natural or synthetic fibers
 5. Group B or Group C plastic

2-1.4 Classification of Plastics, Elastomers, and Rubber. Plastics, elastomers, and rubber shall be classified as Group A, Group B, or Group C.

Groups A, B, and C classifications are based on unmodified plastic materials. The use of fire-retarding or flame-retarding modifiers or the physical form of the material can change the standard classification.

2-1.4.1* Group A.

ABS (acrylonitrile-butadiene-styrene copolymer)
 Acetal (polyformaldehyde)
 Acrylic (polymethyl methacrylate)
 Butyl rubber
 EPDM (ethylene-propylene rubber)
 FRP (fiberglass-reinforced polyester)
 Natural rubber (if expanded)
 Nitrile rubber (acrylonitrile-butadiene rubber)
 PET (thermoplastic polyester)
 Polybutadiene
 Polycarbonate

Polyester elastomer

Polyethylene

Polypropylene

Polystyrene

Polyurethane

PVC (polyvinyl chloride — highly plasticized, with plasticizer content greater than 20 percent) (rarely found)

SAN (styrene acrylonitrile)

SBR (styrene-butadiene rubber)

2-1.4.2 Group B.

Cellulosics (cellulose acetate, cellulose acetate butyrate, ethyl cellulose)

Chloroprene rubber

Fluoroplastics (ECTFE — ethylene-chlorotrifluoro-ethylene copolymer; ETFE — ethylene-tetrafluoroethylene copolymer; FEP — fluorinated ethylene-propylene copolymer)

Natural rubber (not expanded)

Nylon (Nylon 6, Nylon 6/6)

Silicone rubber

2-1.4.3 Group C.

Fluoroplastics (PCTFE — polychlorotrifluoroethylene; PTFE — polytetrafluoroethylene)

Melamine (melamine formaldehyde)

Phenolic

PVC (polyvinyl chloride — flexible — PVCs with plasticizer content up to 20 percent)

PVDC (polyvinylidene chloride)

PVDF (polyvinylidene fluoride)

PVF (polyvinyl fluoride)

Urea (urea formaldehyde)

Chapter 3 Building Construction**3-1 Construction.**

3-1.1* Buildings used for storage of materials that are stored and protected in accordance with this standard shall be of any of the types described in NFPA 220, *Standard on Types of Building Construction*.

3-1.2 Adequate access shall be provided to all portions of the premises for fire-fighting purposes.

3-2* Emergency Smoke and Heat Venting. The protection outlined in this standard shall apply to buildings with or without roof vents and draft curtains.

Exception: Where local codes require heat and smoke vents in buildings that are protected by ESFR sprinklers, the vents shall be manually operated or shall have an operating mechanism with a standard-response fusible element that is rated no less than 360°F (182°C). Drop-out vents shall not be permitted.

Chapter 4 Storage Arrangement

4-1 Piling Procedures and Precautions.

4-1.1 Any commodities that are hazardous in combination with each other shall be stored so they cannot come into contact with each other.

4-1.2* Safe floor loads shall not be exceeded. Where water-absorbent commodities are stored, normal floor loads shall be reduced to take into account the added weight of water that can be absorbed during fire-fighting operations.

4-2 Commodity Clearance.

4-2.1 The clearance between the top of storage and the sprinkler deflectors shall be in accordance with NFPA 13, *Standard for the Installation of Sprinkler Systems*.

Exception: Where modified by this standard.

4-2.2* Where a commodity is stored above the lower chord of roof trusses, at least 1 ft (30.5 cm) of clear space shall be maintained to allow the truss to be wetted.

Exception: The truss is protected with 1-hour fireproofing.

4-2.3 Storage clearance from ducts shall be maintained in accordance with NFPA 91, *Standard for Exhaust Systems for Air Conveying of Materials*, Section 2-6.

4-2.4 The clearance between stored materials and unit heaters, radiant space heaters, duct furnaces, and flues shall not be less than 3 ft (0.9 m) in all directions, or clearances shall be in accordance with those specified on the approval agency label.

4-2.5* Clearance shall be maintained to lights and light fixtures to prevent possible ignition.

4-2.6 Sufficient clearance shall be maintained around the path of fire door travel to ensure proper operation and inspection.

4-3 Aisles.

4-3.1 Wall aisles shall be at least 24 in. (61 cm) wide in warehouses used for the storage of commodities that expand with the absorption of water.

4-3.2* Aisles shall be maintained to retard the transfer of fire from one pile to another and to allow convenient access for fire fighting, salvage, and removal of storage.

4-4* Storage of Idle Pallets.

4-4.1 Wood Pallets.

4-4.1.1* Pallets shall be stored outside or in a detached structure.

Exception: Indoor pallet storage shall be permitted in accordance with 4-4.1.2.

4-4.1.2* Pallets that are stored indoors shall be protected as specified in Table 4-4.1.2, Table 8-1, or Table 9-1.1.

Exception: Where the following conditions are met:

- Pallets shall be stored no higher than 6 ft (1.8 m).*
- Each pallet pile of no more than four stacks shall be separated from other pallet piles by at least 8 ft (2.4 m) of clear space or 25 ft (7.6 m) of commodity.*

4-4.2 Plastic Pallets.

4-4.2.1 Plastic pallets shall be stored outside or in a detached structure.

Exception No. 1: Indoor storage of plastic pallets shall be permitted in accordance with 4-4.2.2.

Exception No. 2: Indoor storage of nonexpanded polyethylene solid deck pallets shall be permitted to be protected in accordance with 4-4.1.2.

Exception No. 3: Indoor storage of plastic pallets shall be permitted to be protected in accordance with Table 9-1.1.

Exception No. 4: Indoor storage of nonwood pallets that have been demonstrated to present a fire hazard equal to or less than that of idle wood pallets and that are listed for such equivalency shall be permitted to be protected in accordance with 4-4.1.2.

4-4.2.2 Plastic pallets that are stored indoors shall be protected as follows:

- Where plastic pallets are stored in cutoff rooms, the following shall apply:
 - The cutoff rooms shall have at least one exterior wall.
 - The plastic pallet storage shall be separated from the remainder of the building by 3-hour-rated fire walls.
 - The storage shall be protected by sprinklers that are designed to deliver 0.60 gpm/ft² [(24.5 L/min)/m²] for the entire room or by high-expansion foam and sprinklers as specified in Section 5-2.
 - The storage shall be piled no higher than 12 ft (3.7 m).
 - Any steel columns shall be protected by 1-hour fireproofing or a sidewall sprinkler directed to one side of the column at the top or at the 15-ft (4.6-m) level, whichever is lower. Flow from these sprinklers used to protect columns shall be permitted to be omitted from the sprinkler system demand for hydraulic calculations.
- Where plastic pallets are stored without cutoffs from other storage, the following shall apply:
 - Plastic pallet storage shall be piled no higher than 4 ft (1.2 m).
 - Sprinkler protection shall employ high-temperature-rated sprinklers.
 - Each pallet pile of no more than two stacks shall be separated from other pallet piles by at least 8 ft (2.4 m) of clear space or 25 ft (7.6 m) of stored commodity.

Table 4-4.1.2 Protection for Indoor Storage of Wood Idle Pallets

Storage Height		Sprinkler Density Requirements		Area of Sprinkler Demand			
				High-Temperature-Rated Sprinklers		Ordinary-Temperature-Rated Sprinklers	
				ft ²	m ²	ft ²	m ²
ft	m	gpm/ft ²	L/min/m ²				
Up to 6	Up to 1.8	0.20	8.2	2000	186	3000	279
6 to 8	1.8 to 2.4	0.30	12.2	2500	232	4000	372
8 to 12	2.4 to 3.7	0.60	24.5	3500	325	6000	557
12 to 20	3.7 to 6.1	0.60	24.5	4500	418	—	—

4-5* Flammable and Combustible Liquids. Only limited quantities of flammable and combustible liquids shall be permitted in general storage warehouses. Any such storage shall be segregated from other stored combustible material.

Chapter 5 Fire Protection — General

5-1 Automatic Sprinkler Systems.

5-1.1 Sprinkler systems that are installed in buildings used for solid pile, bin box, shelf, or palletized storage shall be in accordance with NFPA 13, *Standard for the Installation of Sprinkler Systems*.

Exception: Where modified by this standard.

5-1.2 The minimum temperature rating of ceiling sprinklers shall be 150°F (66°C).

5-1.3 The design density shall not be less than 0.15 gpm/ft² [(6.1 L/min)/m²], and the design area shall not be less than 2000 ft² (186 m²) for wet systems or 2600 ft² (242 m²) for dry systems for any commodity, class, or group.

5-1.3.1 The sprinkler design density for any given area of operation for a Class III or a Class IV commodity, calculated in accordance with Chapter 6, shall not be less than the density for the corresponding area of operation for Ordinary Hazard Group 2 in NFPA 13, *Standard for the Installation of Sprinkler Systems*.

5-1.3.2 The water supply requirements for sprinklers only shall be based on the actual calculated demand for the hazard in accordance with Chapter 6, Chapter 7, Chapter 8, or Chapter 9, depending on the type of sprinkler that is selected and the commodity that is to be protected.

5-1.4 Where palletized or solid pile storage is placed on top of racks, the provisions of NFPA 231C, *Standard for Rack Storage of Materials*, shall apply to the entire height of the storage with regard to sprinkler requirements and water supplies for ceiling and rack sprinklers.

5-1.5 In warehouses with areas that contain rack storage and other areas that contain palletized, solid pile, bin box, or shelf storage, the standard that pertains to the particular storage configuration shall apply.

5-1.6* Standard response 1/2-in. (12.7-mm) orifice or 17/32-in. (13.5-mm) orifice spray sprinklers shall be used in applying Figures 6-2.2.2, 6-2.2.3, and 6-2.2.4 and the tables in Chapters 6 and 7. (See Chapters 8 and 9 for large-drop and ESFR sprinklers.)

Exception No. 1: Use of Figures 6-2.2.2, 6-2.2.3, and 6-2.2.4 and the tables in Chapters 6 and 7 with quick response spray sprinklers shall be permitted when listed for such use.

Exception No. 2: The use of 5/8-in. (15.9-mm) or larger orifice spray sprinklers shall be permitted where listed for such use.

5-1.7 Where buildings are occupied, in part, for storage within the scope of this standard, the required sprinkler protection shall extend 15 ft (4.6 m) beyond the perimeter of the storage area.

Exception: This requirement shall not apply where separated by a barrier partition that is capable of preventing heat from a fire in the storage area from fusing sprinklers in the nonstorage area.

5-1.8 Where nonstorage spaces have lower ceilings than the storage portion of the building, the space above the drop ceiling shall be sprinklered. Where the area above a drop ceiling is sprinklered, the sprinkler system shall conform to 5-1.7 or its exception.

Exception: The space above the drop ceiling shall not be required to be sprinklered where it complies with the provisions of NFPA 13, Standard for the Installation of Sprinkler Systems, for allowable unsprinklered, concealed spaces.

5-2 High-Expansion Foam.

5-2.1 High-expansion foam systems that are installed in addition to automatic sprinklers shall be installed in accordance with NFPA 11A, *Standard for Medium- and High-Expansion Foam Systems*.

Exception: This requirement shall not apply where modified by this standard.

5-2.2 High-expansion foam used to protect the idle pallets shall have a maximum fill time of 4 minutes.

5-2.3 High-expansion foam systems shall be automatic in operation.

5-2.4 Detectors for high-expansion foam systems shall be listed and shall be installed at no more than one-half the listed spacing.

5-2.5 Detection systems, concentrate pumps, generators, and other system components that are essential to the operation of the system shall have an approved standby power source.

5-2.6 A reduction in ceiling density to one-half that required for Class I through Class IV commodities, idle pallets, or plastics (using the secondary demand point) shall be permitted without revising the design area, but the density shall be not less than 0.15 gpm/ft² [(6.1 L/min)/m²].

5-3 Manual Inside Protection.

5-3.1 Small Hose Systems. Small hose lines [1 1/2 in. (38 mm)] shall be available to reach all portions of the storage area; due consideration shall be given to access aisle configuration with maximum anticipated storage in place. Such small hose shall be supplied from one of the following:

- (a) Outside hydrants
- (b) A separate piping system for small hose stations
- (c) Valved hose connections on sprinkler risers where such connections are made upstream of sprinkler control valves
- (d)*Adjacent sprinkler systems

5-3.2 Portable Fire Extinguishers. Portable fire extinguishers shall be provided in accordance with NFPA 10, *Standard for Portable Fire Extinguishers*. Up to one-half of the required complement of portable fire extinguishers for Class A fires shall be permitted to be omitted in storage areas where fixed small hose lines [1 1/2 in. (38 mm)] are available to reach all portions of the storage area.

5-4* Hydrants. At locations without public hydrants, or where hydrants are not within 250 ft (76.2 m), private hydrants shall be installed in accordance with NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*.

5-5* Fire Organization.

5-5.1 Arrangements shall be made to allow the municipal fire department, police department, or other authorized personnel to enter the premises rapidly in case of fire or other emergency.

5-5.2 Plant emergency organizations, where provided, shall be instructed and trained in the following procedures:

- Maintenance of the security of the premises
- Means of summoning outside aid immediately in an emergency
- Use of hand extinguishers and hose lines on small fires and mop-up operations
- Operation of the sprinkler system and water supply equipment
- Use of material-handling equipment while sprinklers are operating to effect final extinguishment
- Supervision of sprinkler valves after system is turned off so that system can be reactivated if rekindling occurs
- Need for breathing apparatus
- Proper operation of emergency smoke venting and heat venting systems where such systems are provided

5-5.3 A fire watch shall be maintained when the sprinkler system is not in service.

5-6* Alarm Service. A central station, remote station, auxiliary, or proprietary sprinkler waterflow alarm shall be provided. A local waterflow alarm shall be permitted where recorded guard service is provided.

Chapter 6 Fire Protection for Commodity Classes I through IV — Spray Sprinklers

6-1* General.

6-1.1 Protection for Class I through Class IV commodities in the following configurations shall be provided in accordance with this chapter:

- Nonencapsulated commodities that are solid pile, palletized, or bin box storage up to 30 ft (9.1 m) in height
- Nonencapsulated commodities on shelf storage up to 15 ft (4.6 m) in height
- * Encapsulated commodities that are solid pile, palletized, bin box, or shelf storage up to 15 ft (4.6 m) in height

6-1.2 Bin box and shelf storage that is over 12 ft (3.7 m) but not in excess of the height limits of 6-1.1 and that is provided with walkways at vertical intervals of not over 12 ft (3.7 m) shall be protected with automatic sprinklers under the walkway(s). Protection shall be as follows:

(a) Ceiling design density shall be based on the total height of storage within the building.

(b) Automatic sprinklers under walkways shall be designed to maintain a minimum discharge pressure of 15 psi (0.72 kPa) for the most hydraulically demanding six sprinklers on each level. Walkway sprinkler demand shall not be required to be added to the ceiling sprinkler demand. Sprinklers under walkways shall not be spaced more than 8 ft (2.4 m) apart horizontally.

6-2 Protection Criteria.

6-2.1 The water supply shall be capable of providing the sprinkler system demand that is determined in accordance with 6-2.3, including the hose stream demand specified in 6-2.4 for the duration requirements specified in 6-2.5.

6-2.2 The area and density for the hydraulically remote area shall be determined as specified in 6-2.2.1 through 6-2.2.7.

6-2.2.1 Sprinkler protection criteria for storage 12 ft (3.7 m) or less in height shall be in accordance with Table 6-2.2.1. All other requirements of this standard shall apply to such storage.

Table 6-2.2.1 Sprinkler Protection of Class I through IV Commodities Stored Up to 12 ft (3.7 m) in Height

Commodity	Storage Height		Sprinkler Protection Criteria
	ft	m	
Class I	Up to 12	3.7	NFPA 13 — Ordinary Hazard Group 1
Class II	Up to 8	2.4	NFPA 13 — Ordinary Hazard Group 1
Class II	Over 8 to 12	3.7	NFPA 13 — Ordinary Hazard Group 2
Class III	Up to 12	3.7	NFPA 13 — Ordinary Hazard Group 2
Class IV	Up to 12	3.7	NFPA 13 — Ordinary Hazard Group 2

6-2.2.2 Where using ordinary-temperature-rated sprinklers, a single point shall be selected from the appropriate commodity curve in Figure 6-2.2.2.

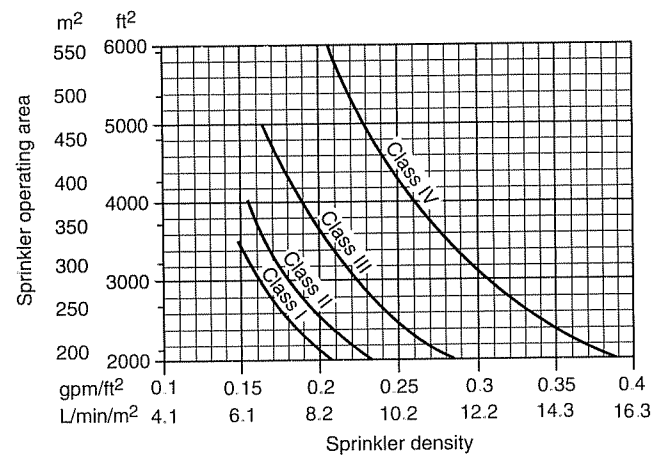


Figure 6-2.2.2 Sprinkler system design curves, 20-ft (6.1-m) high storage — ordinary-temperature-rated sprinklers.

6-2.2.3 Where using high-temperature-rated sprinklers, a single point shall be selected from the appropriate commodity curve in Figure 6-2.2.3.

6-2.2.4 The density selected in accordance with Figure 6-2.2.2 or Figure 6-2.2.3 shall be modified in accordance with Figure 6-2.2.4 without revising the design area.

6-2.2.5 Where dry-pipe systems are used, the areas of operation indicated in the design curves in Figures 6-2.2.2 and 6-2.2.3 shall be increased by 30 percent.

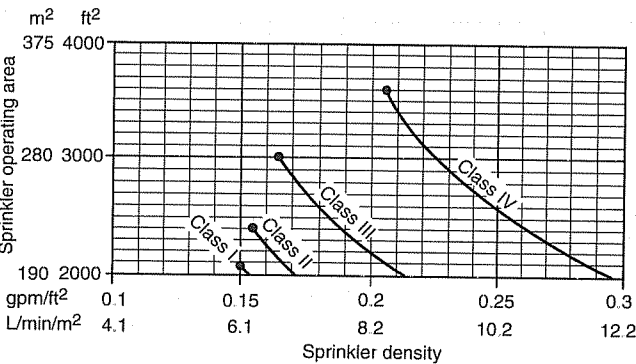


Figure 6-2.2.3 Sprinkler system design curves, 20-ft (6.1-m) high storage — high-temperature-rated sprinklers.

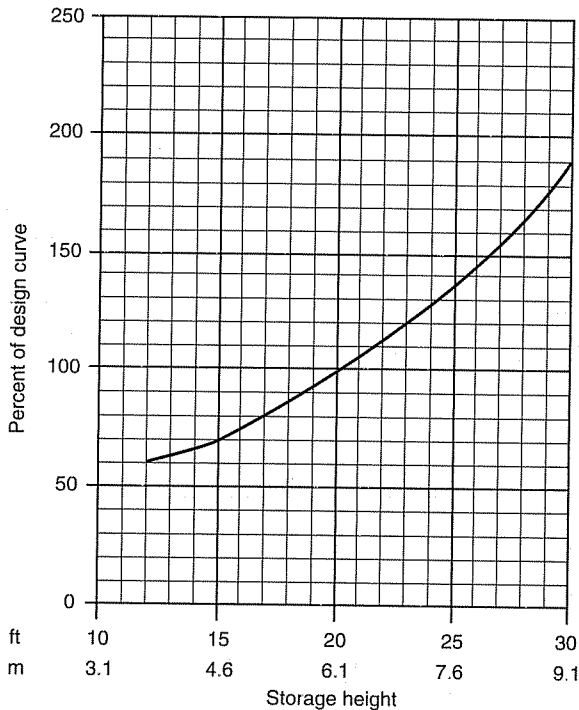


Figure 6-2.2.4 Ceiling sprinkler density versus storage height.

6-2.2.6 In the case of metal bin boxes with face areas not exceeding 16 ft² (1.5 m²) and metal closed shelves with face areas not exceeding 16 ft² (1.5 m²), the area of application shall be permitted to be reduced by 50 percent, provided the minimum requirements of Chapter 5 are met.

6-2.2.7 The final area and density shall not be less than the minimum specified in Chapter 5.

6-2.3 Given the area and density determined in accordance with 6-2.2, the fire sprinkler system shall be hydraulically calculated in accordance with NFPA 13, *Standard for the Installation of Sprinkler Systems*.

6-2.4* A minimum of 500 gpm (32 L/sec) shall be added to the sprinkler demand for combined large and small hose stream demand.

6-2.5 Water supply duration shall be in accordance with Table 6-2.5.

6-3 High-Expansion Foam. 6-3.1 See Section 5-2.

Table 6-2.5 Water Supply Duration in Hours

Storage Height				Commodity Class	
ft	m	ft	m	Classes I, II, and III	Class IV
Over 12	3.7	Up to 20	6.1	1½	2
Over 20	6.1	Up to 30	9.1	2	2½

Chapter 7 Fire Protection for Plastic and Rubber Commodities — Spray Sprinklers

7-1* General. See Appendix B.

7-1.1* Plastics that are stored up to 25 ft (7.62 m) in height and protected by spray sprinklers shall be in accordance with this chapter. The decision tree (see Figure 7-1.1) shown in Figure 7-1.1 shall be used to determine the protection in each situation.

7-1.2* Factors that affect protection requirements such as closed/open array, clearance between storage and sprinklers, and stable/unstable piles, shall apply only to the storage of Group A plastics. The factors contained in 7-2.1, A-7-2.1, and Appendix B shall be given serious consideration prior to determining the final protection requirements. Figure 7-1.1 also shall be used to determine protection for commodities that do not entirely consist of Group A plastics but that contain such quantities and arrangements of Group A plastics that they are deemed more hazardous than Class IV commodities.

7-1.3 Group B plastics and free-flowing Group A plastics shall be protected in the same manner as a Class IV commodity. See Chapter 6 for requirements for the protection of these storage commodities using spray sprinklers.

7-1.4 Group C plastics shall be protected in the same manner as a Class III commodity. See Chapter 6 for requirements for the protection of these storage commodities using spray sprinklers.

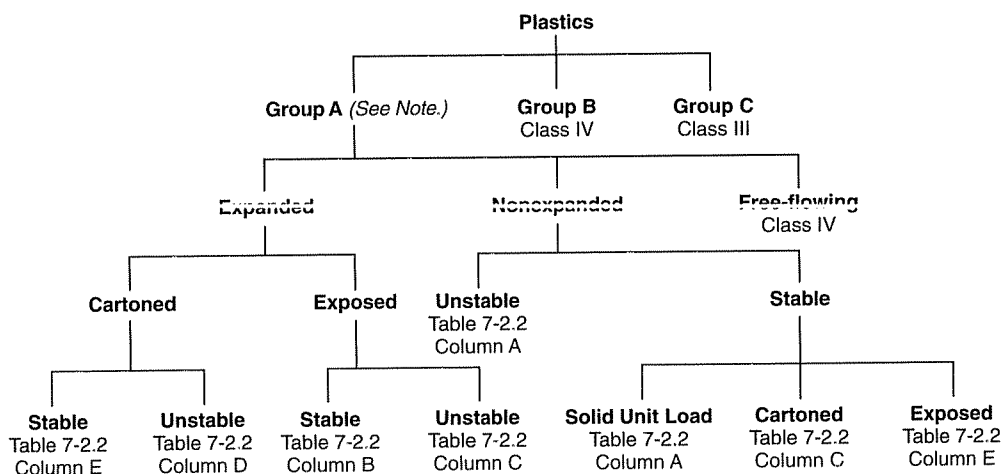
7-2 Protection Criteria.

7-2.1* The design of the sprinkler system shall be based on the existence of routine or periodic building conditions that create the greatest water demand. These conditions include the following:

- (a) Pile height
- (b) Clearance
- (c) Pile stability
- (d) Array

Where the distance between the ceiling/roof height and the top of the storage exceeds 20 ft (6.1 m), protection shall be provided for the storage height that would result in a 20-ft (6.1-m) distance between the ceiling/roof height and the top of the storage.

7-2.2* Design areas and densities for the appropriate storage configuration shall be selected from Table 7-2.2. Columns A, B, C, D, and E correspond to the protection required by the decision tree shown in Figure 7-1.1.



Note: Cartons that contain Group A plastic material shall be permitted to be treated as Class IV commodities under the following conditions:

- There shall be multiple layers of corrugation or equivalent outer material that would significantly delay fire involvement of the Group A plastic, and
- The amount and arrangement of Group A plastic material within an ordinary carton would not be expected to significantly increase the fire hazard.

Figure 7-1.1 Decision tree.

Table 7-2.2 Design Densities for Plastic and Rubber Commodities Sprinkler Systems

Storage Height		Ceiling/Roof Height		Density gpm/ft ² [(L/min)/m ²]				
ft	m	ft	m	A	B	C	D	E
5	1.5	Up to 25	7.6	OH-2	OH-2	OH-2	OH-2	OH-2
12	3.7	Up to 15	4.6	0.2 [8.2]	0.2 [8.2]	0.3 [12.2]	EH-1	EH-2
		>15 to 20	4.6 to 6.1	0.3 [12.2]	0.6 [24.5]	0.5 [20.4]	EH-2	EH-2
		>20 to 32	6.1 to 9.8	0.4 [16.3]	0.8 [32.6]	0.6 [24.5]	0.45 [18.3]	0.7 [28.5]
15	4.6	Up to 20	6.1	0.25 [10.2]	0.5 [20.4]	0.4 [16.3]	0.3 [12.2]	0.45 [18.3]
		>20 to 25	6.1 to 7.6	0.4 [16.3]	0.8 [32.6]	0.6 [24.5]	0.45 [18.3]	0.7 [28.5]
		>25 to 35	7.6 to 10.7	0.45 [18.3]	0.9 [36.7]	0.7 [28.5]	0.55 [22.4]	0.85 [34.6]
20	6.1	Up to 25	7.6	0.3 [12.2]	0.6 [24.5]	0.45 [18.3]	0.35 [14.3]	0.55 [22.4]
		>25 to 30	7.6 to 9.1	0.45 [18.3]	0.9 [36.7]	0.7 [28.5]	0.55 [22.4]	0.85 [34.6]
		>30 to 35	9.1 to 10.7	0.6 [24.5]	1.2 [48.9]	0.85 [34.6]	0.7 [28.5]	1.1 [44.8]
25	7.6	Up to 30	9.1	0.4 [16.3]	0.75 [30.6]	0.55 [22.4]	0.45 [18.3]	0.7 [28.5]
		>30 to 35	9.1 to 10.7	0.6 [24.5]	1.2 [48.9]	0.85 [34.6]	0.7 [28.5]	1.1 [44.8]

Notes:

- The minimum clearance between the sprinkler deflector and the top of the storage shall be maintained as required.
- Column headings correspond to the configuration of plastics storage as follows:
 - (1) Nonexpanded, unstable
 - (2) Nonexpanded, stable, solid unit load
- Column subheadings correspond to required densities for the following:
 - Expanded, exposed, stable
 - Expanded, exposed, unstable
 - (1) Expanded, stable, cartoned
 - Expanded, cartoned, unstable
 - (1) Expanded, cartoned, stable
 - (2) Nonexpanded, stable, exposed
- Column subheadings correspond to required densities for the following:
 - OH-2 = Density required for Ordinary Hazard Group 2 occupancies.
 - EH-1 = Density required for Extra Hazard Group 1 occupancies.
 - EH-2 = Density required for Extra Hazard Group 2 occupancies as specified in NFPA 13, *Standard for the Installation of Sprinkler Systems*.
- Hose streams shall be provided in accordance with 7-2.3.

7-2.2.1 The design areas for Table 7-2.2 shall be a minimum of 2500 ft² (232 m²).

Exception No. 1: Where Table 7-2.2 permits densities and areas to be selected in accordance with NFPA 13, Standard for the Installation of Sprinkler Systems, Ordinary Hazard Group 2, any area/density obtained that curve shall be permitted.

Exception No. 2: The design area for closed arrays shall be permitted to be reduced to 2000 ft² (186 m²).

7-2.2.2 Interpolation of densities between storage heights shall be permitted. Densities shall be based on the 2500 ft² (232 m²) design area. The use of "up to" in Table 7-2.2 is intended to aid in the interpolation of storage height densities. Interpolation of ceiling/roof heights shall not be permitted.

7-2.2.3 Where Table 7-2.2 requires densities of 0.4 gpm/ft² [(16.3 L/min)/m²] or greater, 1/2-in. (12.7-mm) orifice sprinklers shall not be permitted.

7-2.3 Where sprinkler protection has been designed for Group A plastics, at least 500 gpm (32 L/sec) shall be added to the density/area demand for hose streams.

7-2.4 Water supply duration (sprinkler demand plus hose streams) shall be 2 hours where storage heights are 5 ft to 20 ft (1.5 m to 6.1 m) and 2 1/2 hours where storage heights are over 20 ft up to 25 ft (6.1 m up to 7.6 m).

7-2.5* Where dry-pipe systems are used for Group A plastics, the operating area shall be increased by 30 percent without revising the density.

Chapter 8 Fire Protection — Large-Drop Sprinklers

8-1 General. Large-drop sprinklers shall be permitted for use with the hazards specified in Table 8-1.

8-2 Protection Criteria.

8-2.1 Sprinkler water demand for large-drop sprinklers shall be in accordance with Table 8-1.

8-2.2 A minimum of 500 gpm (1900 L/min) shall be added to the sprinkler demand for combined large and small hose stream demand.

Table 8-1 Large-Drop Sprinkler Data Pressure and Number of Design Sprinklers Required for Various Hazards for Large-Drop Sprinklers

Configuration	Commodity Class	Maximum Storage Height		Maximum Building Height		Type of System	Number of Design Sprinklers by Minimum Operating Pressure [psi (bar)] (See 8-2.4.)			Hose Stream Demand		Water Supply Duration
		ft	m	ft	m		25 (1.7)	50 (3.4)	75 (5.2)	gpm	L/min	
Palletized	I, II, or III	25	7.6	35	10.7	Wet	15	15	15	500	1900	2
						Dry	25	25	25	—	—	—
Palletized	IV	20	6.1	30	9.1	Wet	20	15	15	500	1900	2
						Dry	NA	NA	NA	—	—	—
Palletized	Cartoned or exposed unexpanded plastics	20	6.1	30	9.1	Wet	25	15	15	500	1900	2
						Dry	NA	NA	NA	—	—	—
Palletized	Cartoned or exposed expanded plastics	18	5.5	26	7.9	Wet	NA	15	15	500	1900	2
						Dry	NA	NA	NA	—	—	—
Palletized	Idle wood pallets	20	6.1	30	9.1	Wet	15	15	15	500	1900	1 1/2
						Dry	25	25	25	—	—	—
Solid Pile	I, II, or III	20	6.1	30	9.1	Wet	15	15	15	500	1900	1 1/2
						Dry	25	25	25	—	—	—
Solid Pile	IV	20	6.1	30	9.1	Wet	NA	15	15	500	1900	1 1/2
						Dry	NA	NA	NA	—	—	—
Solid Pile	Cartoned or exposed unexpanded plastics	20	6.1	30	9.1	Wet	NA	15	15	500	1900	1 1/2
						Dry	NA	NA	NA	—	—	—

Note: NA — Not Allowed.

8-2.3 Water supply duration shall be as specified in Table 8-1.

8-2.4 Where large-drop sprinklers are installed under open wood-joint construction, their minimum operating pressure shall be 50 psi (3.4 bar).

8-2.5 The requirements of NFPA 13, *Standard for the Installation of Sprinkler Systems*, that pertain to large-drop sprinklers shall apply.

Exception: Where modified by this standard.

8-2.6 For the purpose of applying Table 8-1, preaction systems shall be classified as dry-pipe systems.

Exception: Where it can be demonstrated that the detection system activating the preaction system will cause water to be discharged from sprinklers as quickly as wet systems.

8-2.7 For wet-pipe systems, ordinary-temperature, intermediate-temperature, or high-temperature sprinklers shall be used. For dry-pipe systems, high-temperature sprinklers shall be used.

Chapter 9 Fire Protection — Early Suppression Fast Response (ESFR) Sprinklers

9-1* General.

9-1.1 ESFR sprinklers shall be permitted to be used for the protection of commodities in accordance with Table 9-1.1.

9-1.2 The maximum ceiling/roof height of a building shall be measured to the underside of the roof deck or ceiling.

9-1.3* ESFR sprinklers shall be permitted for use in buildings with the following types of roof construction:

- (a) Smooth ceiling
- (b) Bar joist
- (c) Beam and girder
- (d) Panel

9-1.4 Roof slope shall not exceed 2 in. per foot (51 mm per meter).

9-2* Water Supplies.

9-2.1 The design area shall consist of the most hydraulically demanding area, which shall be protected by 12 sprinklers, consisting of 4 sprinklers on each of 3 branch lines. The design shall include a minimum of 960 ft² (89.2 m²).

9-2.2 A minimum of 250 gpm (946 L/min) shall be added to the sprinkler demand for combined large and small hose streams.

9-2.3 Water supply duration shall be at least 1 hour.

9-2.4 ESFR sprinklers shall be limited to wet-pipe systems.

9-3 Sprinkler System Design.

9-3.1 The requirements of NFPA 13, *Standard for the Installation of Sprinkler Systems*, shall apply.

Exception: Where modified by this standard.

Table 9-1.1 ESFR Sprinkler Data

Type of Storage	Commodity	Maximum Height of Storage		Maximum Ceiling/Roof Height of Building		Nominal K Factor	Sprinkler Design Pressure	
		ft	m	ft	m		psi	bar
Palletized and solid pile storage (no open-top containers or solid shelves)	1. Cartoned unexpanded plastic 2. Cartoned expanded plastic 3. Uncartoned unexpanded plastic 4. Class I, Class II, Class III, or Class IV commodities, encapsulated or unencapsulated 5. Idle wood or plastic pallets	25	7.6	30	9.1	13.5–14.5	50	3.4
	1. Cartoned or uncartoned unexpanded plastic 2. Class I, Class II, Class III, or Class IV commodities, encapsulated or unencapsulated 3. Idle wood or plastic pallets	35	10.7	40	12.2	13.5–14.5	75	5.2
	1. Cartoned or uncartoned unexpanded plastic 2. Class I, Class II, Class III, or Class IV commodities, encapsulated or unencapsulated	35	10.7	45	13.7	13.5–14.5	90	27.4
	1. Cartoned unexpanded plastic 2. Class I, Class II, Class III, or Class IV commodities, encapsulated or unencapsulated	20	6.1	25	7.6	11.0–11.5	50	3.4

Chapter 10 Building Equipment, Maintenance, and Operations

10-1* Mechanical Handling Equipment — Industrial Trucks. Power-operated industrial trucks shall comply with NFPA 505, *Fire Safety Standard for Powered Industrial Trucks Including Type Designations, Areas of Use, Conversions, Maintenance, and Operation*.

10-2 Building Service Equipment — Electrical Equipment. Electrical equipment shall be installed in accordance with the provisions of NFPA 70, *National Electrical Code®*.

10-3 Cutting and Welding Operations.

10-3.1* Where welding or cutting operations are necessary, the requirements of NFPA 51B, *Standard for Fire Prevention in Use of Cutting and Welding Processes*, shall apply. Where possible, work shall be removed to a safe area.

10-3.2 Welding, soldering, brazing, and cutting shall be permitted to be performed on building components that cannot be removed, provided no storage is located below and within 25 ft (7.6 m) of the working area and provided flameproof tarpaulins enclose the working area. During any welding, soldering, brazing, and cutting operations, the sprinkler system shall be in service. Extinguishers that are suitable for Class A fires with a minimum rating of 2A and charged and attended inside hose lines, where provided, shall be located in the working area. A fire watch shall be maintained during welding, soldering, brazing, and cutting operations and shall continue to be maintained for not less than 30 minutes following completion of open-flame operation.

10-4 Waste Disposal. The disposal of rubbish, trash, and other waste material shall be performed at regular intervals.

10-5 Smoking. Smoking shall be strictly prohibited. Signs that read *no smoking* shall be posted in prohibited areas.

Exception: Smoking shall be permitted in locations that are prominently designated as smoking areas.

10-6 Maintenance and Inspection.

10-6.1 Fire walls, fire doors, and floors shall be maintained in good repair at all times.

10-6.2 The sprinkler system and the water supplies shall be inspected, tested, and maintained in accordance with NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*.

10-7 Refrigeration Systems. Refrigeration systems shall conform to ASHRAE 15, *Safety Code for Mechanical Refrigeration*.

Chapter 11 Referenced Publications

11-1 The following documents or portions thereof are referenced within this standard as mandatory requirements and shall be considered part of the requirements of this standard. The edition indicated for each referenced mandatory document is the current edition as of the date of the NFPA issuance of this standard. Some of these mandatory documents might also be referenced in this standard for specific informational purposes and, therefore, are also listed in Appendix D.

11-1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

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

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

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

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

NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*, 1998 edition.

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

NFPA 30B, *Code for the Manufacture and Storage of Aerosol Products*, 1998 edition.

NFPA 40, *Standard for the Storage and Handling of Cellulose Nitrate Motion Picture Film*, 1997 edition.

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

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

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

NFPA 91, *Standard for Exhaust Systems for Air Conveying of Materials*, 1995 edition.

NFPA 220, *Standard on Types of Building Construction*, 1995 edition.

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

NFPA 231D, *Standard for Storage of Rubber Tires*, 1998 edition.

NFPA 231F, *Standard for the Storage of Roll Paper*, 1996 edition.

NFPA 232, *Standard for the Protection of Records*, 1995 edition.

NFPA 430, *Code for the Storage of Liquid and Solid Oxidizers*, 1995 edition.

NFPA 490, *Code for the Storage of Ammonium Nitrate*, 1998 edition.

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

11-1.2 ASHRAE Publication. American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc., 1791 Tullie Circle, N.E., Atlanta, GA 30329-2305.

ASHRAE 15, *Safety Code for Mechanical Refrigeration*, 1992.

Appendix A Explanatory Material

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

A-1-3 Approved. The National Fire Protection Association does not approve, inspect, or certify any installations, procedures, equipment, or materials nor does it approve or evaluate testing laboratories. In determining the acceptability of installations or procedures, equipment, or materials, the "authority having jurisdiction" may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure, or use. The "authority having jurisdiction" may also refer to the listings or labeling practices of an organization that is concerned with product evaluations and is thus in a position to determine compliance with appropriate standards for the current production of listed items.

A-1-3 Open Array. Fire tests that were conducted to represent a closed array used 6-in. (152-mm) longitudinal flues and no transverse flues. Fire tests that were conducted to represent an open array used 12-in. (305-mm) longitudinal flues.

A-1-3 Authority Having Jurisdiction. The phrase "authority having jurisdiction" is used in NFPA documents in a broad manner, since jurisdictions and approval agencies vary as do their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction; at government installations, the commanding officer or departmental official may be the authority having jurisdiction.

A-1-3 Available Height for Storage. The maximum height of storage for new sprinkler installations is the height at which commodities can be stored above the floor where the minimum required unobstructed space below sprinklers is maintained. For the purpose of evaluating existing situations, the maximum height of storage for new sprinkler installations is the maximum existing height, provided the space between sprinklers and storage is equal to or greater than that required.

A-1-3 Bin Box Storage. Boxes are self-supporting or supported by a structure so designed that little or no horizontal or vertical space exists around boxes.

A-1-3 Compartmented. The cartons that were used in most of the Factory Mutual-sponsored plastic tests involved an ordinary 200-lb (90.7-kg) test of outside corrugated cartons with five layers of vertical pieces of corrugated carton that were used as dividers on the inside. Single horizontal pieces of corrugated carton were also used between each layer. Other tests sponsored by the Society of Plastics Industry, Industrial Risk Insurers, Factory Mutual, and Kemper used two vertical pieces of carton (not corrugated) to form an X within the carton to separate the product. Such an arrangement is not considered compartmented, since the pieces of carton that were used for separations were flexible (not rigid), and only two pieces were used in each carton.

A-1-3 Container. The term *container* includes items such as cartons and wrappings. Fire-retardant containers or tote boxes do not themselves create a need for automatic sprinklers unless they are coated with oil or grease. Containers can lose their fire-retardant properties if washed and should not be exposed to rainfall.

A-1-3 Encapsulated. Where a pallet load is banded (i.e., stretch-wrapping) around only the sides, it is not considered to be encapsulated.

A-1-3 Exposed Group A Plastic Commodity. Paper-wrapped or encapsulated commodities, or both, should be considered exposed.

A-1-3 Free-Flowing Plastic Materials. Examples are powder, pellets, flakes, or random-packed small objects [e.g., razor blade dispensers, 1-oz to 2-oz (28-g to 57-g) bottles].

A-1-3 Listed. The means for identifying listed equipment may vary for each organization concerned with product evaluation; some organizations do not recognize equipment as listed unless it is also labeled. The authority having jurisdiction should utilize the system employed by the listing organization to identify a listed product.

A-1-3 Ordinary-Temperature-Rated Sprinkler. Paragraph 5-1.2 places a minimum temperature rating on sprinklers that can be used in storage occupancies.

A-1-3 Pile Stability. Pile stability performance has been shown to be a difficult factor to judge prior to the subjection of a given pile to an actual fire. In the tests that were completed, compartmented cartons (*see A-1-3, Compartmented*) have been shown to be stable under fire conditions. Tests on cartons that were not compartmented tended to be unstable under fire conditions.

A-1-3 Stable Piles. Storage on pallets, compartmented storage, and plastic components that are held in place by materials that do not deform readily under fire conditions are examples of stable pile storage.

A-1-3 Unstable Piles. Leaning stacks, crushed-bottom cartons, and reliance on combustible bands for stability are examples of potential pile instability under a fire condition. An increase in pile height tends to increase instability.

A-2-1 Specification of the type, amount, and arrangement of combustibles for any commodity classification is essentially an attempt to define the potential fire severity, based on its burning characteristics, so the fire can be successfully controlled by the prescribed sprinkler protection for the commodity class. In actual storage situations, however, many storage arrays do not fit precisely into one of the fundamental classifications; therefore, the user needs to make judgments after comparing each classification to the existing storage conditions. Storage arrays consist of thousands of possible products, which makes it impossible to specify all the acceptable variations for any class. As an alternative, the Technical Committee on General Storage has classified a variety of common products in this appendix, based on judgment, loss experience, and fire test results.

Table A-2-1 provides examples of commodities that are outside the scope of this standard.

Table A-2-1.3 is an alphabetized list of commodities with corresponding classifications.

Tables A-2-1.3.1, A-2-1.3.2, A-2-1.3.3, A-2-1.3.4 and A-2-1.4.1 provide examples of commodities within a specific class.

Table A-2-1 Examples of Commodities Outside the Scope of NFPA 231

Boxes, Crates
– Empty, wood, slatted*
Lighters (butane)
– Loose in large containers (Level 3 aerosol)

*Should be treated as idle pallets.

A-2-1.1.1 Commodity classification is governed by the types and amounts of materials (e.g., metal, paper, wood, plastics) that are part of a product and its primary packaging. However, in a storage or warehouse situation, classification is also affected by such factors as the primary storage or shipping

container material, the amount of air space, and the location of the more hazardous materials within the container. For example, a Group A plastic product enclosed in a five-sided or six-sided metal container can be considered Class II; while a ceramic product heavily wrapped in tissue paper and placed in a corrugated carton can be considered Class III.

A-2-1.3 See Table A-2-1.3.

Table A-2-1.3 Alphabetized Listing of Commodity Classes

Commodity	Commodity Class
Aerosols	
Cartoned or uncartoned	
– Level 1	Class III
Alcoholic Beverages	
Cartoned or uncartoned	
– Up to 20 percent alcohol in metal, glass, or ceramic containers	Class I
– Up to 20 percent alcohol in wood containers	Class II
Ammunition	
Small arms, shotgun	
– Packaged, cartoned	Class IV
Appliances, Major (e.g., stoves, refrigerators)	
– Not packaged, no appreciable plastic exterior trim	Class I
– Corrugated, cartoned, (no appreciable plastic trim)	Class II
Baked Goods	
Cookies, cakes, pies	
– Frozen, packaged in cartons ¹	Class II
– Packaged in cartons	Class III
Batteries	
Dry cells (nonlithium or similar exotic metals)	
– Packaged in cartons	Class I
– Blister-packed, cartoned	Class II
Automobile	
– Filled ²	Class I
Truck or larger	
– Empty or filled ²	Group A plastics
Beans	
Dried	
– Packaged, cartoned	Class III
Bottles, Jars	
Empty, cartoned	
– Glass	Class I
– Plastic PET (polyethylene terephthalate)	Class IV
Filled noncombustible powders	
– Glass, cartoned	Class I
– Plastic, cartoned [less than 1 gal (3.8 L)]	Class IV
– Plastic, uncartoned (other than PET) (any size)	Group A plastics

Table A-2-1.3 Alphabetized Listing of Commodity Classes

Commodity	Commodity Class
– Plastic, cartoned or uncartoned [less than 1 gal (3.8 L)]	Group A plastics
– Plastic, solid plastic crates	Group A plastics
– Plastic, open plastic crates	Group A plastics
Filled noncombustible liquids	
– Glass, cartoned	Class I
– Plastic, cartoned [less than 5 gal (18.9 L)]	Class I
– Plastic, open or solid plastic crates ³	Group A plastics
Boxes, Crates	
– Empty, wood, solid walls	Class II
– Empty, wood, slatted ⁴	Outside of scope
Bread	
Wrapped, cartoned	Class III
Butter	
– Whipped, spread	Class III
Candles	
Packaged, cartoned	
– Treat as expanded plastic	Group A plastics
Candy	
Packaged, cartoned	Class III
Canned Foods	
In ordinary cartons	Class I
Cans	
Metal	
– Empty	Class I
Carpet Tiles	
Cartoned	Group A plastics
Cartons	
Corrugated	
– Unassembled (neat piles)	Class III
– Partially assembled	Class IV
Wax coated, single walled	Group A plastics
Cement	
Bagged	Class I
Cereals	
Packaged, cartoned	Class III
Charcoal	
Bagged	
– Standard	Class III
Cheese	
– Packaged, cartoned	Class III
– Wheels, cartoned	Class III
Chewing Gum	
Packaged, cartoned	Class III
Chocolate	
Packaged, cartoned	Class III
Cloth	
Cartoned and not cartoned	
– Natural fiber, viscose	Class III
– Synthetic ⁵	Class IV
Cocoa Products	
Packaged, cartoned	Class III

Table A-2-1.3 Alphabetized Listing of Commodity Classes

Commodity	Commodity Class
Coffee	
– Canned, cartoned	Class I
– Packaged, cartoned	Class III
Coffee Beans	
Bagged	Class III
Cotton	
– Packaged, cartoned	Class III
Diapers	
– Cotton, linen	Class III
– Disposable with plastics and non-woven fabric (in cartons)	Class IV
– Disposable with plastics and non-woven fabric (uncartoned), plastic wrapped	Group A plastics
Dried Foods	
Packaged, cartoned	Class III
Fertilizers	
Bagged	
– Phosphates	Class I
– Nitrates	Class II
Fiberglass Insulation	
– Paper-backed rolls, bagged or unbagged	Class IV
File Cabinets	
Metal	
– Cardboard box or shroud	Class I
Fish or Fish Products	
Frozen	
– Nonwaxed, nonplastic packaging	Class I
– Waxed-paper containers, cartoned	Class II
– Boxed or barreled	Class II
– Plastic trays, cartoned	Class III
Canned	
– Cartoned	Class I
Frozen Foods	
– Nonwaxed, nonplastic packaging	Class I
– Waxed-paper containers, cartoned	Class II
– Plastic trays	Class III
Fruit	
Fresh	
– Nonplastic trays or containers	Class I
– With wood spacers	Class I
Furniture	
Wood	
– No plastic coverings or foam plastic cushioning	Class III
– With plastic coverings	Class IV
– With foam plastic cushioning	Group A plastics
Grains	
Packaged in cartons	
– Barley	Class III
– Rice	Class III
– Oats	Class III

Table A-2-1.3 Alphabetized Listing of Commodity Classes

Commodity	Commodity Class
Ice Cream	Class I
Leather Goods	Class III
Leather Hides	
Baled	Class II
Light Fixtures	
Nonplastic	
– Cartoned	Class II
Lighters	
Butane	
– Blister-packed, cartoned	Group A plastics
– Loose in large containers (Level 3 aerosol)	Outside of scope
Liquor	
100 proof or less; 1 gal (3.8 L) or less, cartoned	
– Glass (palletized) ⁶	Class IV
– Plastic bottles	Class IV
Marble	
Artificial sinks, countertops	
– Cartoned, crated	Class II
Margarine	
– Up to 50 percent oil (in paper or plastic containers)	Class III
– Between 50 percent and 80 percent oil (in any packaging)	Group A plastics
Matches	
Packaged, cartoned	
– Paper	Class IV
– Wood	Group A plastics
Mattresses	
– Standard (box spring)	Class III
– Foam (in finished form)	Group A plastics
Meat, Meat Products	
– Bulk	Class I
– Canned, cartoned	Class I
– Frozen, nonwaxed, nonplastic containers	Class I
– Frozen, waxed-paper containers	Class II
– Frozen, expanded plastic trays	Class II
Metal Desks	
– With plastic tops and trim	Class I
Milk	
– Nonwaxed paper containers	Class I
– Waxed-paper containers	Class I
– Plastic containers	Class I
– Containers in plastic crates	Group A plastics
Motors	
– Electrical	Class I
Nail Polish	
– 1-oz to 2-oz (0.5-kg to 0.9-kg) glass, cartoned	Class IV
– 1-oz to 2-oz (0.5-kg to 0.9-kg) plastic bottles, cartoned	Group A plastics

(continues)

Table A-2-1.3 Alphabetized Listing of Commodity Classes

Commodity	Commodity Class
Nuts	
– Canned, cartoned	Class I
– Packaged, cartoned	Class III
– Bagged	Class III
Paints	
Friction-top cans, cartoned	
– Water based (latex)	Class I
– Oil based	Class IV
Paper Products	
– Books, magazines, stationery, plastic-coated paper food containers, newspapers, cardboard games, or cartoned tissue products	Class III
– Tissue products, uncartoned and plastic wrapped	Group A plastics
Paper, Rolled	
In racks or on side	
– Medium or heavyweight	
Paper, Waxed	
Packaged in cartons	Class IV
Pharmaceuticals	
Pills, powders	
– Glass bottles, cartoned	Class II
– Plastic bottles, cartoned	Class IV
Nonflammable liquids	
– Glass bottles, cartoned	Class II
Photographic Film	
– Motion picture or bulk rolls in polycarbonate, polyethylene, or metal cans; polyethylene bagged in cardboard boxes	Class II
– 35-mm in metal film cartridges in polyethylene cans in cardboard boxes	Class III
– Paper, in sheets, bagged in polyethylene, in cardboard boxes	Class III
– Rolls in polycarbonate plastic cassettes, bulk wrapped in cardboard boxes	Class IV
Plastic Containers	
– Noncombustible liquids or semi-liquids in plastic containers of less than 5 gal (18.9 L) capacity	Class I
– Noncombustible liquids or semi-liquids (such as ketchup) in plastic containers with nominal wall thickness of 1/4 in. (6.4 mm) or less and larger than 5 gal (18.9 L)	Class II
– Noncombustible liquids or semi-liquids (such as ketchup) in plastic containers with nominal wall thickness greater than 1/4 in. (6.4 mm) and larger than 5 gal (18.9 L)	Group A plastics

Table A-2-1.3 Alphabetized Listing of Commodity Classes

Commodity	Commodity Class
Polyurethane	
– Cartoned or uncartoned expanded	Group A plastics
Poultry Products	
– Canned, cartoned	Class I
– Frozen, nonwaxed, nonplastic containers	Class I
– Frozen (on paper or expanded plastic trays)	Class II
Powders (ordinary combustibles — free flowing)	
– In paper bags (e.g., flour, sugar)	Class II
PVA (polyvinyl alcohol) Resins	
– Bagged	Class IV
PVC (polyvinyl chloride)	
– Flexible (e.g., cable jackets, plasticized sheets)	Class III
– Rigid (e.g., pipe, pipe fittings)	Class III
– Bagged resins	Class III
Rags	
Baled	
– Natural fibers	Class III
– Synthetic fibers	Class IV
Rubber	
– Natural, blocks in cartons	Class IV
– Synthetic	Group A plastics
Salt	
– Bagged	Class I
– Packaged, cartoned	Class II
Shingles	
– Asphalt-coated fiberglass	Class III
– Asphalt-impregnated felt	Class IV
Shock Absorbers	
– Metal dust cover	Class II
– Plastic dust cover	Class III
Signatures	
Books, magazines	
– Solid array on pallet	Class II
Skis	
– Wood	Class III
– Foam core	Class IV
Stuffed Toys	
Foam or synthetic	Group A plastics
Syrup	
– Drummed (metal containers)	Class I
– Barreled, wood	Class II
Textiles	
Natural fiber clothing or textile products	Class III
Synthetics (except rayon and nylon) — 50/50 blend or less	
– Thread, yarn on wood or paper spools	Class III
– Fabrics	Class III
– Thread, yarn on plastic spools	Class IV

Table A-2-1.3 Alphabetized Listing of Commodity Classes

Commodity	Commodity Class
– Baled fiber	Group A plastics
Synthetics (except rayon and nylon)	
– greater than 50/50 blend	
– Thread, yarn on wood or paper spools	Class IV
– Fabrics	Class IV
– Baled fiber	Group A plastics
– Thread, yarn on plastic spools	Group A plastics
Rayon and nylon	
– Baled fiber	Class IV
– Thread, yarn on wood or paper spools	Class IV
– Fabrics	Class IV
– Thread, yarn on plastic spools	Group A plastics
Tobacco Products	
– In paperboard cartons	Class III
Transformers	
– Dry and oil filled	Class I
Vinyl-Coated Fabric	
– Cartoned	Group A plastics
Vinyl Floor Coverings	
– Tiles in cartons	Class IV
– Rolled	Group A plastics
Wax-Coated Paper	
– Cups, plates	
– Boxed or packaged inside cartons (emphasis on packaging)	Class IV
– Loose inside large cartons	Group A plastics
Wax	
– Paraffin, blocks, cartoned	Group A plastics
Wire	
– Bare wire on metal spools on wood skids	Class I
– Bare wire on wood or cardboard spools on wood skids	Class II
– Bare wire on metal, wood, or cardboard spools in cardboard boxes on wood skids	Class II
– Single- or multiple-layer PVC-covered wire on metal spools on wood skids	Class II
– Insulated (PVC) cable on large wood or metal spools on wood skids	Class II
– Bare wire on plastic spools in cardboard boxes on wood skids	Class IV
– Single- or multiple-layer PVC-covered wire on plastic spools in cardboard boxes on wood skids	Class IV
– Single, multiple, or power cables (PVC) on large plastic spools	Class IV
– Bulk storage of empty plastic spools	Group A plastics

Table A-2-1.3 Alphabetized Listing of Commodity Classes

Commodity	Commodity Class
Wood Products	
– Solid piles — lumber, plywood, particleboard, pressboard (smooth ends and edges)	Class II
– Spools (empty)	Class III
– Toothpicks, clothespins, hangers in cartons	Class III
– Doors, windows, wood cabinets, and furniture	Class III
– Patterns	Class IV

¹The product is presumed to be in a plastic-coated package in a corrugated carton. If packaged in a metal foil, it can be considered Class I.

²Most batteries have a polypropylene case and, if stored empty, should be treated as a Group A plastic. Truck batteries, even where filled, should be considered a Group A plastic because of their thicker walls.

³As the openings in plastic crates become larger, the product behaves more like a Class III commodity. Conversely, as the openings become smaller, the product behaves more like a plastic.

⁴These items should be treated as idle pallets.

⁵Tests clearly indicate that a synthetics or synthetic blend is considered greater than Class III.

⁶Where liquor is stored in glass containers in racks, it should be considered a Class III commodity; where it is palletized, it should be considered a Class IV commodity.

A-2-1.3.1 See Table A-2-1.3.1.

Table A-2-1.3.1 Examples of Class I Commodities

Alcoholic Beverages
– Cartoned or uncartoned
– Up to 20 percent alcohol in metal, glass, or ceramic containers
Appliances, Major (e.g., stoves, refrigerators)
– Not packaged, no appreciable plastic exterior trim
Batteries
– Dry cells (nonlithium or similar exotic metals), packaged in cartons
– Automobile — filled*
Bottles, Jars
– Empty, cartoned
– Glass
– Filled noncombustible liquids
– Glass, cartoned
– Plastic, cartoned [less than 5 gal (18.9 L)]
– Filled noncombustible powders
– Glass, cartoned
Canned Foods
– In ordinary cartons
Cans
– Metal
– Empty
Cement
– Bagged

(continued)

Table A-2-1.3.1 Examples of Class I Commodities

Coffee
– Canned, cartoned
Fertilizers
Bagged
– Phosphates
File Cabinets
Metal
– Cardboard box or shroud
Fish or Fish Products
Frozen
– Nonwaxed, nonplastic packaging
Canned
– Cartoned
Frozen Foods
– Nonwaxed, nonplastic packaging
Fruit
Fresh
– Nonplastic trays or containers
– With wood spacers
Ice Cream
Meat, Meat Products
– Bulk
– Canned, cartoned
– Frozen, nonwaxed, nonplastic containers
Metal Desks
– With plastic tops and trim
Milk
– Nonwaxed-paper containers
– Waxed-paper containers
– Plastic containers
Motors
– Electrical
Nuts
– Canned, cartoned
Paints
Friction-top cans, cartoned
– Water based (latex)
Plastic Containers
– Noncombustible liquids or semiliquids (such as ketchup) in plastic containers with nominal wall thickness of $\frac{1}{4}$ in. (6.4 mm) or less and larger than 5 gal (18.9 L)
Poultry Products
– Canned, cartoned
– Frozen, nonwaxed, nonplastic containers
Salt
– Bagged
Syrup
– Drummed (metal containers)
Transformers
Dry and oil filled
Wire
– Bare wire on metal spools on wood skids

*Most batteries have a polypropylene case, and if stored empty, should be treated as a Group A plastic. Truck batteries, even where filled, should be considered a Group A plastic of their thicker walls.

A-2-1.3.2 See Table A-2-1.3.2.

Table A-2-1.3.2 Examples of Class II Commodities

Alcoholic Beverages
– Up to 20 percent alcohol in wood containers
Appliances, Major (e.g., stoves, refrigerators)
– Corrugated, cartoned (no appreciable plastic trim)
Baked Goods
Cookies, cakes, pies
– Frozen, packaged in cartons*
Batteries
Dry cells (nonlithium or similar exotic metals), blister-packed in cartons
Boxes, Crates
– Empty, wood, solid walls
Fertilizers
Bagged
– Nitrates
Fish or Fish Products
Frozen
– Waxed-paper containers, cartoned
– Boxed or barreled
Frozen Foods
– Waxed-paper containers, cartoned
Leather Hides
Baled
Light Fixtures
Nonplastic
– Cartoned
Marble
Artificial sinks, countertops
– Cartoned, crated
Meat, Meat Products
– Frozen, waxed-paper containers
– Frozen, expanded plastic trays
Pharmaceuticals
Pills, powders
– Glass bottles, cartoned
Nonflammable liquids
– Glass bottles, cartoned
Photographic Film
– Motion picture or bulk rolls in polycarbonate, polyethylene, or metal cans; polyethylene bagged in cardboard boxes
Plastic Containers
– Noncombustible liquids or semiliquids in plastic containers of larger than 5 gal (18.9 L) capacity
Poultry Products
– Frozen (on paper or expanded plastic trays)
Powders (ordinary combustibles — free flowing)
– In paper bags (e.g., flour, sugar)
Salt
– Packaged, cartoned
Shock Absorbers
– Metal dust cover
Signatures
Books, magazines
– Solid array on pallet

Table A-2-1.3.2 Examples of Class II Commodities

Syrup
– Barreled, wood
Wire
– Bare wire on wood or cardboard spools on wood skids
– Bare wire on metal, wood, or cardboard spools in cardboard boxes on wood skids
– Single- or multiple-layer PVC-covered wire on metal spools on wood skids
– Insulated (PVC) cable on large wood or metal spools on wood skids
Wood Products
Solid piles
– Lumber, plywood, particleboard, pressboard (smooth ends and edges)

*The product is presumed to be in a plastic-coated package in a corrugated carton. If packaged in a metal foil, it can be considered Class I.

A-2-1.3.3 See Table A-2-1.3.3.

Table A-2-1.3.3 Examples of Class III Commodities

Aerosols
Cartoned or uncartoned
– Level 1
Baked Goods
Cookies, cakes, pies
– Packaged in cartons
Beans
Dried
– Packaged, cartoned
Bread
Wrapped, cartoned
Butter
– Whipped spread
Candy
Packaged, cartoned
Cartons
Corrugated
– Unassembled (neat piles)
Cereals
Packaged, cartoned
Charcoal
Bagged
– Standard
Cheese
– Packaged, cartoned
– Wheels, cartoned
Chewing Gum
Packaged, cartoned
Chocolate
Packaged, cartoned
Cloth
Cartoned and not cartoned
– Natural fiber, viscose
Cocoa Products
Packaged, cartoned

Table A-2-1.3.3 Examples of Class III Commodities

Coffee
– Packaged, cartoned
Coffee Beans
Bagged
Cotton
– Packaged, cartoned
Diapers
– Cotton, linen
Dried Foods
Packaged, cartoned
Fish or Fish Products
Frozen
– Plastic trays, cartoned
Frozen Foods
– Plastic trays
Furniture
Wood
– No plastic coverings or foam plastic cushioning
Grains
Packaged in cartons
– Barley
– Rice
– Oats
Leather Goods
Margarine
– Up to 50 percent oil (in paper or plastic containers)
Mattresses
– Standard (box spring)
Nuts
– Packaged, cartoned
– Bagged
Paper Products
– Books, magazines, stationery, plastic-coated paper food containers, newspapers, cardboard games, or cartoned tissue products
Paper, Rolled
In racks or on side
– Medium or heavyweight
Photographic Film
– 35-mm in metal film cartridges in polyethylene cans in cardboard boxes
– Paper, in sheets, bagged in polyethylene, in cardboard boxes
PVC (polyvinyl chloride)
– Flexible (e.g., cable jackets, plasticized sheets)
– Rigid (e.g., pipe, pipe fittings)
– Bagged resins
Rags
Baled
– Natural fibers
Shingles
– Asphalt-coated fiberglass
Shock Absorbers
– Plastic dust cover
Skis
– Wood

(continues)

Table A-2-1.3.3 Examples of Class III Commodities

Textiles
Natural fiber clothing or textile products
Synthetics (except rayon and nylon) — 50/50 blend or less
– Thread, yarn on wood or paper spools
– Fabrics
Tobacco Products
– In paperboard cartons
Wood Products
– Spools (empty)
– Toothpicks, clothespins, hangers in cartons
– Doors, windows, wood cabinets, and furniture

A-2-1.3.4 See Table A-2-1.3.4.

Table A-2-1.3.4 Examples of Class IV Commodities

Ammunition
Small arms, shotgun
– Packaged, cartoned
Bottles, Jars
Empty, cartoned
– Plastic PET (polyethylene terephthalate)
Filled noncombustible powders
– Plastic, cartoned [less than 1 gal (3.8 L)]
Cartons
Corrugated
– Partially assembled
Cloth
Cartoned or not
– Synthetic ¹
Diapers
– Disposable with plastics and nonwoven fabric (in cartons)
Fiber Glass Insulation
– Paper-backed rolls, bagged or unbagged
Furniture
Wood
– With plastic coverings
Liquor 100 proof or less, one gallon or less, cartoned
– Glass (palletized) ²
– Plastic bottles
Matches
Packaged, cartoned
– Paper
Nail Polish
– 1-oz to 2-oz (0.5-kg to 0.9-kg) glass, cartoned
Paints
Friction-top cans, cartoned
– Oil-based
Paper, Waxed
Packaged in cartons
Pharmaceuticals
Pills, powders
– Plastic bottles, cartoned
Photographic Film
– Rolls in polycarbonate plastic cassettes, bulk wrapped in cardboard boxes
PVA (polyvinyl alcohol) Resins

Table A-2-1.3.4 Examples of Class IV Commodities

– Bagged
Rags
Baled
– Synthetic fibers
Rubber
– Natural, blocks in cartons
Shingles
– Asphalt-impregnated felt
Skis
– Foam core
Textiles
Synthetics (except rayon and nylon) — 50/50 blend or less
– Thread, yarn on plastic spools
Synthetics (except rayon and nylon) — greater than 50/50 blend
– Thread, yarn on wood or paper spools
– Fabrics
Rayon and nylon
– Baled fiber
– Thread, yarn on wood or paper spools
– Fabrics
Vinyl Floor Coverings
– Tiles in cartons
Wax-Coated Paper
Cups, plates
– Boxed or packaged inside cartons (emphasis on packaging)
Wire
– Bare wire on plastic spools in cardboard boxes on wood skids
– Single- or multiple-layer PVC-covered wire on plastic spools in cardboard boxes on wood skids
– Single, multiple, or power cables (PVC) on large plastic spools
Wood Products
– Patterns

¹Tests clearly indicate that a synthetic blend is considered greater than Class III.²Where liquor is stored in glass containers in racks, it should be considered a Class III commodity; where it is palletized, it should be considered a Class IV commodity.

A-2-1.4.1 See Table A-2-1.4.1.

Table A-2-1.4.1 Examples of Group A Plastic Commodities

Batteries
Truck or larger
– Empty or filled ¹
Bottles, Jars
Empty, cartoned
– Plastic (other than PET) (any size)
Filled noncombustible liquids
– Plastic, open or solid plastic crates ²
Filled noncombustible powders
– Plastic, cartoned or uncartoned [greater than 1 gal (3.8 L)]

Table A-2-1.4.1 Examples of Group A Plastic Commodities

– Plastic, solid plastic crates
– Plastic, open plastic crates
Candles
Packaged, cartoned
– Treat as expanded plastic
Carpet Tiles
Cartoned
Cartons
Wax coated, single walled
Diapers
– Disposable with plastics and nonwoven fabric (uncartoned), plastic wrapped
Furniture
Wood
– With foam plastic cushioning
Lighters
Butane
– Blister-packed, cartoned
Margarine
– Between 50 percent and 80 percent oil (in any packaging)
Matches
Packaged, cartoned
– Wood
Mattresses
– Foam (in finished form)
Milk
– Containers in plastic crates
Nail Polish
– 1-oz to 2-oz (0.5-kg to 0.9-kg) plastic bottles, cartoned
Paper Products
– Tissue products, uncartoned and plastic wrapped
Plastic Containers
– Combustible or noncombustible solids in plastic containers and empty plastic containers
– Noncombustible liquids or semiliquids (such as ketchup) in plastic containers with nominal wall thickness greater than 1/4 in. (6.4 mm) and larger than 5 gal (18.9 L)
Polyurethane
– Cartoned or uncartoned expanded
Rubber
– Synthetic
Stuffed Toys
Foam or synthetic
Textiles
Synthetics (except rayon and nylon) — 50/50 blend or less
– Baled fiber
Synthetics — (except rayon and nylon) greater than 50/50 blend
– Baled fiber
– Thread, yarn on plastic spools
Rayon and nylon
– Thread, yarn on plastic spools
Vinyl-Coated Fabric
– Cartoned
Vinyl Floor Coverings
– Rolled

Table A-2-1.4.1 Examples of Group A Plastic Commodities

Wax-Coated Paper
Cups, plates
– Loose inside large cartons
Wax
Paraffin, blocks, cartoned
Wire
– Bulk storage of empty plastic spools

¹Most batteries have a polypropylene case and, if stored empty, should be treated as a Group A plastic. Truck batteries, even when filled, should be considered a Group A plastic because of their thicker walls.

²As the openings in plastic crates become larger, the product behaves more like a Class III Commodity. Conversely, as the openings become smaller, the product behaves more like a plastic.

A-3-1.1 Where protection is installed in accordance with this standard, it is possible that fire protection of overhead steel and steel columns is unnecessary.

Consideration should be given to subdividing large-area warehouses in order to reduce the amount of merchandise that can be affected by a single fire.

Walls or partitions should be provided to separate the storage area from mercantile, manufacturing, or other occupancies to prevent the possibility of transmission of fire or smoke between the two occupancies. Door openings should be equipped with automatic-closing fire doors that are appropriate for the fire resistance rating of the wall or partition.

A-3-2 Smoke removal is important to manual fire fighting and overhaul. Since most fire tests were conducted without smoke and heat venting, the protection specified in Sections 5-1, 6-1, and 7-1 was developed without the use of such venting. However, venting through eave-line windows, doors, monitors, or gravity or mechanical exhaust systems is essential to smoke removal after control of the fire is achieved. (*See NFPA 204, Guide for Smoke and Heat Venting.*)

A-4-1.2 Commodities that are particularly susceptible to water damage should be stored on skids, dunnage, pallets, or elevated platforms in order to maintain at least 4 in. (101.6 mm) of clearance from the floor.

A-4-2.2 Protection for exposed steel structural roof members can be necessary and should be provided as specified by the authority having jurisdiction.

A-4-2.5 Incandescent light fixtures should have shades or guards to prevent the ignition of the commodity from hot bulbs where the possibility of contact with storage exists.

A-4-3.2 Storage should be separated by aisles so that piles are not more than 50 ft (15.2 m) wide or 25 ft (7.6 m) wide if they abut a wall. Main aisles and cross aisles should be located opposite window or door openings in exterior walls. Such location is of particular importance in buildings where few exterior openings exist. Aisle width should be at least 8 ft (2.4 m). Aisle spacing and frequency should be given consideration where judging the adequacy of existing sprinkler protection.

A-4-4 Idle pallet storage presents a severe fire condition. The stacking of idle pallets in piles presents the ideal arrangement of combustibles for promoting rapid spread of fire, heat release, and complete combustion. Pallets dry out, and their edges become frayed and splintered after only short use in warehouses. This condition makes them subject to easy igni-

tion from a small ignition source. High piling substantially increases the challenge to sprinklers and the probability of involving a large number of pallets when fire occurs. Therefore, pallets should be stored outdoors where possible.

A fire in stacks of idle plastic or wooden pallets is one of the greatest challenges to sprinklers. The undersides of the pallets create a dry area on which a fire can grow and spread to other dry or partially wet areas. The process of spreading to other dry, closely located, parallel, combustible surfaces continues until the fire bursts through the top of the stack. Once this happens, very little water is able to reach the base of the fire. The only practical method of stopping a fire in a large concentration of pallets using ceiling sprinklers is by prewetting. In high stacks, prewetting is not possible without abnormally high water supplies. The storage of empty wood pallets should not be permitted in an unsprinklered warehouse that contains other storage.

A-4.4.1.1 See Table A-4.4.1.1.

A-4.4.1.2 No additional protection is necessary, provided the requirements of 4.4.1.2(a) and (b) are met.

A-4.5 For further information, see Chapter 4 of NFPA 30, *Flammable and Combustible Liquids Code*.

A-5-1.6 The densities and areas provided in Chapters 6 and 7 are based on fire tests using standard response 1/2-in. (12.7-mm) and 17/32-in. (13.5-mm) orifice spray sprinklers.

A-5-3.1(d) For further information on adjacent sprinkler systems, see NFPA 13, *Standard for the Installation of Sprinkler Systems*.

A-5-4 At windowless warehouses and where windows are scant, hydrants should be located at, or in the vicinity of, entrances.

A-5-5 Manual fire-fighting operations in a storage warehouse are not a substitute for sprinkler operation. The sprinkler sys-

tem should be kept in operation during manual fire-fighting operations until visibility has cleared so that the fire can be seen clearly and until the extent of fire is reduced to the mop-up stage. It is essential that charged hose lines are available before venting is necessary because of a possible increase in fire intensity. Where a sprinkler valve has been closed, a responsible person should remain at the valve so it can be opened promptly if necessary. The water supply for the sprinkler system should be augmented where possible, and care should be exercised so that the water supply for the sprinkler system is not rendered ineffective by the use of excessive hose streams.

Where a private fire brigade is provided, sufficient large hose [2 1/2 in. (64 mm)] and related equipment should be available.

Information on emergency organization and preincident planning is provided in the following publications:

- (a) NFPA *Industrial Fire Brigades Training Manual*
- (b) NFPA 600, *Standard on Industrial Fire Brigades*
- (c) NFPA 1620, *Recommended Practice for Pre-Incident Planning*

A-5-6 For further information, see NFPA 72, *National Fire Alarm Code*®.

A-6.1 The following procedure should be followed in determining the proper density and area as specified in Chapter 6:

- (a) Determine the commodity class.
- (b) Select the density and area of application from Figure 6-2.2.2 or Figure 6-2.2.3.
- (c) Adjust the required density for storage height in accordance with Figure 6-2.2.4.
- (d) Increase the operating area by 30 percent in accordance with 6-2.2.5 where a dry-pipe system is used.

Table A-4.4.1.1 Recommended Clearance Between Outside Idle Pallet Storage and Building

Wall Construction		Minimum Distance of Wall from Storage					
Wall Type	Openings	Under 50 Pallets		50 to 200 Pallets		Over 200 Pallets	
		ft	m	ft	m	ft	m
Masonry	None	0	0	0	0	0	0
	Wired glass with outside sprinklers and 1-hour doors	0	0	10	3.0	20	6.1
	Wired or plain glass with outside sprinklers and 3/4-hour doors	10	3.0	20	6.1	30	9.1
Wood or metal with outside sprinklers							
Wood, metal, or other		20	6.1	30	9.1	50	15.2

Notes:

1. Fire-resistive protection comparable to that of the wall also should be provided for combustible eave lines, vent openings, and so forth.
2. Where pallets are stored close to a building, the height of storage should be restricted to prevent burning pallets from falling on the building.
3. Manual outside open sprinklers generally are not a reliable means of protection, unless the property is constantly attended by plant emergency personnel.
4. Open sprinklers that are controlled by a deluge valve are recommended.

- (e) Satisfy the minimum densities and areas as indicated in 5-1.3 and 5-1.3.1.

Example:

Storage — greeting cards in boxes in cartons on pallets

Height — 22 ft (6.7 m)

Clearance — 6 ft (1.8 m)

Sprinklers — ordinary temperature

System type — dry

1. Classification — Class III
2. Selection of density/area — 0.225 gpm/ft² over 3000 ft² [(9.2 L/min)/m² over 276 m²] from Figure 6-2.2.2
3. Adjustment for height of storage using Figure 6-2.2.4 — $1.15 \times 0.225 = 0.259$ gpm/ft² [(10.553 L/min)/m²]; rounded up to 0.26 gpm/ft² [(10.6 L/min)/m²]
4. Adjustment of area of operation for dry system — 1.3×3000 ft² = 3900 ft² (363 m²)
5. Confirmation that minimum densities and areas have been achieved

In 5-1.3, the minimum design density for a dry sprinkler system is 0.15 gpm/ft² over 2600 ft² [(6.1 L/min)/m² over 242 m²] [satisfied in A-6(e)2] for Class III.

Paragraph 5-1.3.1 refers to Ordinary Hazard Group 2 in NFPA 13, *Standard for the Installation of Sprinkler Systems*. The corresponding minimum density at 3000 ft² (279 m²) is 0.17 gpm/ft² [(6.9 L/min)/m²] (satisfied); 3000 ft² \times $1.3 = 3900$ ft² (363 m²), 0.17 gpm/ft² over 3900 ft² [(6.9 L/min)/m² over 363 m²].

The design density and area of application equals 0.26 gpm/ft² over 3900 ft² [(10.6 L/min)/m² over 363 m²].

A-6-1.1(c) Full-scale tests show no appreciable difference in the number of sprinkler heads that open for either nonencapsulated or encapsulated products up to 15 ft (4.6 m) high. Test data are not available for encapsulated products that are stored higher than 15 ft (4.6 m). However, in rack storage tests that involve encapsulated storage 20 ft (6 m) high, protection greater than that needed for nonencapsulated storage is necessary.

The protection specified in Chapter 6 contemplates a maximum 10-ft (3-m) clearance from the top of storage to the sprinkler deflectors for storage 15 ft (4.6 m) and higher.

A-6-2.4 Recommended water supplies anticipate successful sprinkler operation. Because of the small but still significant number of uncontrolled fires in sprinklered properties, which have various causes, an adequate water supply should be available for fire department use.

A-7-1 The densities and area of application have been developed from fire test data. Most of these tests were conducted with $1^{17}/_{32}$ -in. (13.5-mm) orifice sprinklers and 80-ft² or 100-ft² (7.4-ft² or 9.3-m²) sprinkler spacing. These tests and other tests indicate that, with densities of 0.40 gpm/ft² [(0.27 L/sec)/m²] and higher, better results are obtained using $1^{17}/_{32}$ -in. (13.5-mm) orifice sprinklers at 70-ft² to 100-ft² (7.4-m² to 9.3-m²) sprinkler spacing than where using $1^{1}/_{2}$ -in. (12.7-mm) orifice sprinklers at 50-ft² (4.6-m²) sprinkler spacing. A discharge pressure of 100 psi (689 kPa) was used as a starting point in one of the fire tests. It was successful but had a $1^{1}/_{2}$ -ft (0.5-m) clearance between the top of storage and the ceiling sprinklers. A clearance of 10 ft (3.0 m) can produce a different result due to the tendency of the higher pressure to

atomize the water and the greater distance that the fine water droplets have to travel to the burning fuel.

A-7-1.1 Two direct comparisons between ordinary-temperature-rated and high-temperature-rated sprinklers are possible as follows.

(a) Using nonexpanded polyethylene 1-gal (3.8-L) bottles in corrugated cartons, a 3-ft (0.9-m) clearance, and the same density for both types of sprinklers, approximately the same number of sprinklers operated (nine at high temperature versus seven at ordinary temperature).

(b) Using exposed, expanded polystyrene meat trays, a 9.5-ft (1.9-m) clearance, and the same density for both types of sprinklers, three times as many ordinary-temperature-rated sprinklers operated as did high-temperature-rated sprinklers (11 at high temperature versus 33 at ordinary temperature).

The cartoned plastics requirements in this standard are based to a great extent on tests that used a specific commodity — 16-oz (0.473-L) polystyrene plastic jars individually separated by thin carton stock within a large corrugated carton [$3^{1}/_{2}$ ft² (0.32 m²)]. [See Figure A-7-1.1(a).]

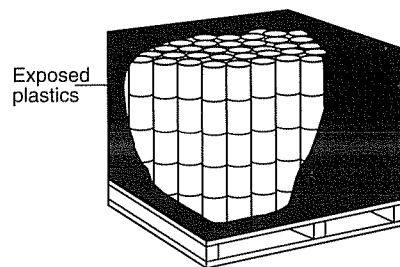


Figure A-7-1.1(a) Corrugated carton containing individually separated plastic jars.

Other Group A plastic commodities can be arranged in cartons so that they are separated by multiple thicknesses of carton material. In such arrangements, less plastic becomes involved in a fire at any one time. The result can be a less vigorous fire that can be controlled by Class IV commodity protection.

Other situations exist in which the plastic component is surrounded by several layers of less hazardous material and is therefore temporarily protected or insulated from a fire that involves adjacent plastic products. Such conditions also can produce a less vigorous fire and can be successfully handled by Class IV protection. [See Figure A-7-1.1(b).]

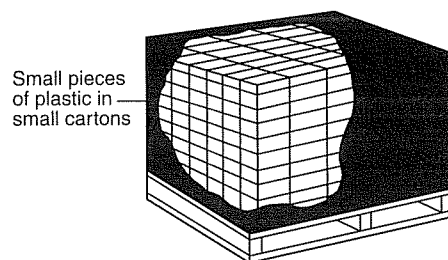


Figure A-7-1.1(b) Corrugated carton containing plastic pieces individually separated by carton material.

The decision to protect as a Class IV commodity, however, should be made based on experience only and with an understanding of the consequences of underprotecting the storage segment.

A-7-1.2 There are few storage facilities in which the commodity mix or storage arrangement remains constant, and a designer should be aware that the introduction of different materials can substantially change protection requirements. The design should be based on higher densities and areas of application, and the various reductions allowed should be applied cautiously. Where evaluating existing situations, however, the allowances can be helpful.

A-7-2.1 An evaluation for each field situation should be made to determine the worst applicable height-clearance relationship that can be expected to appear in a particular case. Fire tests have shown that considerably greater demands occur where clearance is 10 ft (3.0 m), compared to 3 ft (0.9 m), and where a pile is stable, compared to an unstable pile. Since a system is designed for a particular clearance, it can be inadequate where significant areas do not have piling to the design height and where larger clearances exist between the stock and the sprinklers. The system can also be inadequate where the packaging or arrangement is changed so that stable piling is created instead of unstable piling. Recognition of these conditions is essential to avoid installation of protection that is inadequate or that can become inadequate because of changes.

No tests were conducted to simulate a peaked roof configuration. However, it is expected that the principles of Chapter 7 still apply. The worst applicable height-clearance relationship that can be expected to occur should be identified, and appropriate protection should be designed. If all storage is at the same height, the worst height-clearance relationship that creates the greatest water demand occurs under the peak. If commodities are stored higher under the peak, the various height-clearance relationships should be evaluated, and the clearance that creates the greatest water demand should be used for designing protection.

A-7-2.2 Test data is not available for all combinations of commodities, storage heights, and clearances. Some of the protection criteria in this standard are based on extrapolations of test data for other commodities and storage configurations, as well as on available loss data.

For example, there is very limited test data for the storage of expanded plastics higher than 20 ft (6 m). The protection criteria in this standard for expanded plastics higher than 20 ft (6 m) are extrapolated from test data for expanded plastics storage 20 ft (6 m) and less in height and test data for unexpanded plastics above 20 ft (6 m).

Additional examples can be found in the protection criteria for clearances up to 15 ft (4.6 m). Test data is limited for clearances greater than 10 ft (3.0 m). It should be assumed that, if protection is adequate for a given storage height in a building of a given height, the same protection can protect storage of any lesser height in the same building. For example,

protection that is adequate for 20-ft (6.1-m) storage in a 30-ft (10-m) building [10-ft (3.0-m) clearance] can also protect 15-ft (4.6-m) storage in a 30-ft (10-m) building [15-ft (4.6-m) clearance]. Therefore, the protection criteria in Table 7-2.2 for 15-ft (4.6-m) clearance are based on the protection criteria for storage that is 5 ft (1.5 m) higher than the specified height with 10-ft (3.0-m) clearance.

Table 7-2.2 is based on tests that were conducted primarily with high-temperature-rated, $17/32$ -in. (13.5-mm) orifice sprinklers. Other tests have demonstrated that where sprinklers are used with orifices greater than $17/32$ in. (13.5 mm), ordinary temperature sprinklers are acceptable.

A-7-2.5 Wet systems are recommended for storage occupancies. Dry-pipe systems should be permitted only where it is impractical to provide heat.

A-9-1 ESFR sprinklers are designed to respond quickly to growing fires and deliver heavy discharge to suppress fires rather than to control them. ESFR sprinklers should not be relied on to provide suppression if they are used outside the design parameters.

A-9-1.3 Storage in single-story or multistory buildings can be permitted, provided the maximum ceiling/roof height as specified in Table 9-1.1 is satisfied for each storage area.

A-9-2 Design parameters were determined from a series of full-scale fire tests that were conducted as a joint effort between Factory Mutual Research Corporation and the National Fire Protection Research Foundation. (Copies of the test reports are available from the NFPRF.)

A-10-1 Locomotives should not be allowed to enter storage areas. Industrial trucks using gas or liquid fuel should be refueled outside of the storage building at a location designated for the purpose.

A-10-3.1 The use of welding, cutting, soldering, or brazing torches in storage areas introduces a severe fire hazard. The use of mechanical fastenings and mechanical saws or cutting wheels is recommended.

Appendix B Example for Determining Protection Criteria for Plastic and Rubber Commodities

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

B-1 General. This appendix provides and explains an example of the method and procedure to follow for using this standard to determine proper protection for Group A plastics. (See Chapter 7.)

Table B-1 Metric Conversion Factors for Examples

To convert from	to	Multiply by
feet (ft)	meters (m)	0.3048
square feet (ft ²)	square meters (m ²)	0.0929
gallons per minute (gpm)	liters per minute (L/min)	40.746
gallons per minute per square foot (gpm/ft ²)	liters per minute per square meter [(L/min)/m ²]	0.679

Example 1. Expanded, cartoned, stable storage, 15 ft (4.6 m) high in a 20-ft (6.1-m) building

Answer 1. Column E, Table 7-2.2 — design density is 0.45 gpm/ft² [(18.3 L/min)/m²].

Example 2. Nonexpanded, unstable storage, 15 ft (4.6 m) high in a 20-ft (6.1-m) building

Answer 2. Column A, Table 7-2.2 — design density is 0.25 gpm/ft² [(10.2 L/min)/m²]; however, it is also possible that the storage can be 12 ft (3.7 m) in this 20-ft (6.1-m) building, which would require 0.3 gpm/ft² [(12.2 L/min)/m²]. Unless the owner can guarantee that the storage will always be 15 ft (4.6 m), the design density = 0.3 gpm/ft² [(12.2 L/min)/m²]

Example 3. Nonexpanded, stable storage, 15-ft (4.6-m) fixed-height unit load, one unit high, in an 18-ft (5.5-m) building

Answer 3. Column A, Table 7-2.2 — design density is 0.25 gpm/ft² [(10.2 L/min)/m²]. Note that the density does not increase to 0.3 gpm/ft² [(12.2 L/min)/m²] as in Example 2 because of the use of a fixed-height unit load. In this example, the storage height will always be 15 ft (4.6 m) or there will be no storage.

Example 4. Expanded, exposed, unstable storage, 20-ft (6.1-m) high in a 27-ft (8.2-m) building

Answer 4. Column C, Table 7-2.2 — design density is 0.7 gpm/ft² [(28.5 L/min)/m²]. Other lower storage heights should also be checked, but they require the same, or lower, densities (0.7 gpm/ft² and 0.6 gpm/ft²) [(28.5 L/min)/m² and (24.5 L/min)/m²], so the design density remains 0.7 gpm/ft² [(28.5 L/min)/m²].

Example 5. Expanded, cartoned, unstable storage, 17 ft (5.2 m) high in a 32-ft (9.7-m) building

Answer 5. Column D, Table 7-2.2 — design density for 15-ft (4.6 m) storage in a 32-ft (9.7-m) building is 0.55 gpm/ft² [(22.4 L/min)/m²]; design density for 20-ft (6.1-m) storage in a 32-ft (9.7-m) building is 0.7 gpm/ft² [(28.5 L/min)/m²]. Interpolation for 17-ft (5.2-m) storage is as follows:

$$0.7 - 0.55 = 0.15$$

$$0.15 / (20 - 15) = 0.03$$

$$0.03 \times (17 - 15) = 0.06$$

$$0.55 + 0.06 = 0.61$$

$$\text{Design density} = 0.6 \text{ gpm/ft}^2 [(24.5 \text{ L/min})/\text{m}^2]$$

Example 6. Expanded, exposed, stable storage, 22-ft (6.7-m) storage in 23.5-ft (7.2-m) building

Answer 6. Column B, Table 7-2.2 — possible to interpolate between 0.6 gpm/ft² and 0.75 gpm/ft² [(24.5 L/min)/m² and 30.6 (L/min)/m²]; however, it is unnecessary to do so, since the density for 15-ft (4.6-m) storage in a 23.5-ft (7.2-m) building is 0.8 gpm/ft² [(32.6 L/min)/m²]. Unless the owner can guarantee 22-ft (6.7-m) storage, the design density is 0.8 gpm/ft² [(32.6 L/min)/m²]. If the owner can guarantee 22-ft (6.7-m) storage in a manner acceptable to the authority having jurisdiction, the interpolation can be used to yield a design density of 0.66 gpm/ft² [(26.9 L/min)/m²]

Example 7. Nonexpanded, stable, exposed, storage, 13.5 ft (4.1 m) high in a 15-ft (4.5-m) building

Answer 7. Column E, Table 7-2.2 — design density for 12-ft (3.7-m) storage in a 15-ft (4.6-m) building is EH-2 (0.4 gpm/ft² over 2500 ft²) [(16.3 L/min)/m² over 230 m²].

Design density for 15-ft (4.6-m) storage in a 15-ft (4.6-m) building is 0.45 gpm/ft² [(18.3 L/min)/m²]. Interpolation for 13.5-ft (4.1-m) storage is as follows:

$$0.45 - 0.4 = 0.05$$

$$0.05 / (15 - 12) = 0.017$$

$$0.017 \times (13.5 - 12) = 0.026$$

$$0.4 + 0.026 = 0.426$$

$$\text{Design density} = 0.426 \text{ gpm/ft}^2 [(17.4 \text{ L/min})/\text{m}^2]$$

See Table B-1 for conversion factors.

Appendix C Protection of Outdoor Storage

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

C-1 General.

C-1.1 The hazards of exposure to outdoor storage from ignition sources and exposing fires and the infinite variety of conditions under which such exposures can occur render impossible the formulation of any single table, formulae, or set of rules that can cover all conditions adequately.

C-1.2 The recommendations contained in this appendix are for the protection of outdoor storage of commodities covered by the standard. (See Section 1-1.)

C-1.3 In general, the provision of automatic fire protection is impractical for outdoor storage. As a result, emphasis should be placed on the following:

- Control of potential ignition sources, such as from exposing buildings, transformers, yard equipment, refuse burners, overhead power lines, and vandals
- Elimination of adverse factors such as trash accumulations, weeds, and brush
- Provision of favorable physical conditions, such as limited pile sizes, low storage heights, wide aisles, and possible use of fire-retardant covers (e.g., tarpaulins)
- Rapid and effective application of manual fire-fighting efforts by the provision of fire alarms, strategically located hydrants, and adequate hose houses or hose reels

C-1.4 Outdoor storage should be avoided in most cases but is recognized as a necessity in many industries.

C-1.4.1 Outdoor storage is acceptable for materials that are characterized by the following:

- Low fire hazard, not requiring protection, even where located indoors
- Sufficiently low in value that a potential loss does not justify the use of building space
- Fire hazard severe enough that indoor protection is impractical when balanced against potential loss
- Large volume and bulk, making it impractical to construct and protect a building to house the storage

C-1.4.2 Where materials that normally are stored in buildings are stored outdoors in temporary emergencies, special precautions should be taken for their safeguard and they should be moved to a storage warehouse as soon as possible.

C-1.5 Standards that address outdoor storage of specific commodities are referenced in Chapter 11.

C-2 Responsibility of Management.

C-2.1 It is the responsibility of management to consider the hazards of the various materials that are handled. Protection requirements and storage arrangements vary with the combustibility of materials. Management should determine any special precautions that should be followed for the types of material that are stored. The care, cleanliness, and maintenance

nance exercised by management determine to a large extent the relative fire safety in the storage area.

C-2.2 Management should give consideration to the proper storage of materials to prevent storage of excess quantities of materials in a single location, making them subject to a catastrophe that could destroy them all at once. The criteria used to determine the quantity of a material that should be stored in a single location are not only dependent on the dollar value of the commodity but also on the total supply and availability of the material. The impact of the loss of the stored material on the ability to continue production should be considered.

C-3 Site.

C-3.1 In selecting a site for outdoor storage, preference should be given to a location that can provide the following:

- Adequate municipal fire and police protection
- Adequate public water system with hydrants suitably located for protection of the storage
- Adequate all-weather roads for fire department apparatus response
- Sufficient clear space from buildings or from other combustible storage that constitutes an exposure hazard
- Absence of flood hazard
- Adequate clearance space between storage piles and any highways, bridges, railroads, and woodlands
- Topography as level as possible to provide storage stability

C-3.2 The entire site should be surrounded by a fence or other suitable means to prevent access of unauthorized persons. An adequate number of gates should be provided in the surrounding fence or other barriers to allow ready access of fire apparatus.

C-4 Material Piling.

C-4.1 Materials should be stored in unit piles as low in height and as small in area as is consistent with good practice for the materials stored. The maximum height should be determined by the stability of the pile, effective reach of the hose streams, combustibility of the commodity, and ease of the pile breakdown under fire or mop-up conditions. Long, narrow piles are recommended over large, square piles to facilitate manual fire fighting. (The short dimension increases the effectiveness of hose streams and eases pile breakdown.)

C-4.2 Aisles should be maintained between individual piles, between piles and buildings, and between piles and the boundary line of the storage site. Sufficient driveways that have a width of at least 15 ft (4.6 m) should be provided to allow fire equipment to travel to all portions of the storage area. Aisles should be at least twice the pile height to reduce the spread of fire from pile to pile and to allow ready access for fire fighting, emergency removal of material, or salvage purposes.

C-4.3 As the commodity class increases in combustibility, or where storage can be easily ignited due to radiation, wider aisles should be provided. Smaller unit piles can be an alternative to wider aisles if yard space is limited.

C-4.4 Information on outdoor idle pallet storage is provided in Section 4-4 and A-4-4.1.1. Separation between piles of idle pallets and other yard storage should be as specified in Table C-4.4.

Table C-4.4 Pile Separation

Pile Size	Minimum Distance	
	ft	m
Fewer than 50 pallets	20	6
50-200 pallets	30	9.1
More than 200 pallets	50	15.2

C-4.5 Boundary posts with signs that designate piling limits should be provided to indicate yard area, roadway, and aisle limits.

C-5 Buildings and Other Structures.

C-5.1 Yard storage, particularly storage of commodities in the higher heat release category, should have as much separation from important buildings and structures as is practical, but separation should not be less than that specified by NFPA 80A, *Recommended Practice for Protection of Buildings from Exterior Fire Exposures*.

C-5.2 Where using NFPA 80A, *Recommended Practice for Protection of Buildings from Exterior Fire Exposures*, to establish clear spaces, the following severity classifications with the corresponding commodity classes of this standard should be used based on 100 percent openings that represent yard storage:

- Light Severity*. Commodity Class I
- Moderate Severity*. Commodity Class II
- Severity for Class III*. Interpolate between moderate and severe severity for Commodity Class III
- Severe Severity*. Commodity Class IV and Class A plastics

These guidelines apply to the equivalent commodity classes of this standard. The severity of the exposing building or structure also should be a consideration where establishing a clear space.

C-6 Yard Maintenance and Operations.

C-6.1 The entire storage site should be kept free from the accumulation of unnecessary combustible materials. Vegetation should be kept cut low. Procedures should be provided for weed control and periodic cleanup of the yard area.

C-6.2 Adequate lighting should be provided to allow supervision of all parts of the storage area at night.

C-6.3 All electric equipment and installations should conform to the provisions of NFPA 70, *National Electrical Code*.

C-6.4 No heating equipment should be located or used within the storage area. Salamanders, braziers, portable heaters, and other open fires should not be used.

C-6.5 Smoking should be prohibited, except in locations prominently designated as smoking areas. Signs that read *no smoking* should be posted in prohibited areas.

C-6.6 Welding and cutting operations should be prohibited in the storage area, unless in compliance with NFPA 51B, *Standard for Fire Prevention in Use of Cutting and Welding Processes*.

C-6.7 Tarpaulins that are used for the protection of storage against weather should be of fire-retardant fabric.

C-6.8 Locomotives from which glowing particles can be emitted from exhaust stacks should not be permitted in the yard.

C-6.9 Motorized vehicles that use gasoline, diesel fuel, or LP-Gas as fuel should be garaged in a separate, detached building.

C-6.9.1 The storage and handling of fuel should conform with NFPA 30, *Flammable and Combustible Liquids Code*, and NFPA 58, *Liquefied Petroleum Gas Code*.

C-6.9.2 Repair operations should be conducted outside the yard, unless a separate masonry wall building is provided. Vehicles should not be greased, repaired, painted, or otherwise serviced in the yard. Such work should be conducted in compliance with NFPA 88B, *Standard for Repair Garages*.

C-7 Fire Protection.

C-7.1 Provisions should be made for promptly notifying the public fire department and private fire brigade (if available) in case of fire or other emergency.

C-7.2 Hydrants should be spaced to provide a sufficient number of hose streams. (See NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*.)

C-7.2.1 Provisions should be made to allow the direction of an adequate number of hose streams on any pile or portion of the storage area that can be involved in fire. It is recommended that, unless adequate protection is provided by the municipal fire department, sufficient hose and other equipment that are suitably housed should be available at the storage property. Provision also should be made for the availability of trained personnel to operate such equipment.

C-7.2.2 Hydrants and all fire-fighting equipment should be accessible for use at all times. No temporary storage should be allowed to obstruct access to fire-fighting equipment, and any accumulation of snow or obstructing material should be removed promptly.

C-7.3 Monitor nozzles should be provided at strategic points where large quantities of highly combustible materials are stored or where average amounts of combustible materials are stored in inaccessible locations.

C-7.4 Fire extinguishers of an appropriate type should be placed at well-marked, strategic points throughout the storage area so that one or more portable fire extinguisher units is readily available for use at any point. Where the climate is such that there is a danger of freezing, extinguishers suitable for freezing temperatures should be used. For information on the types and uses of extinguishers, refer to NFPA 10, *Standard for Portable Fire Extinguishers*.

C-8 Guard Service.

C-8.1 Guard service should be provided and continuously maintained throughout the yard and storage area while the

yard is otherwise unoccupied. The responsibilities and the training of guards should be as specified in NFPA 601, *Standard for Security Services in Fire Loss Prevention*. A suitable means of supervising guard activities should be provided to ensure that the required rounds are made.

C-8.2 The value of strategically placed watchtowers in large yards where a guard can maintain observation of the entire property should be considered. It is recommended that such watchtowers be connected to the alarm system for prompt notification of fire.

Appendix D Referenced Publications

D-1 The following documents or portions thereof are referenced within this standard for informational purposes only and are thus not considered part of the requirements of this standard unless also listed in Chapter 11. The edition indicated here for each reference is the current edition as of the date of the NFPA issuance of this standard.

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

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

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

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

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

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

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

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

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

NFPA 80A, *Recommended Practice for Protection of Buildings from Exterior Fire Exposures*, 1996 edition.

NFPA 88B, *Standard for Repair Garages*, 1997 edition.

NFPA 204, *Guide for Smoke and Heat Venting*, 1998 edition.

NFPA 600, *Standard on Industrial Fire Brigades*, 1996 edition.

NFPA 601, *Standard for Security Services in Fire Loss Prevention*, 1996 edition.

NFPA 1620, *Recommended Practice for Pre-Incident Planning*, 1998 edition.

NFPA *Industrial Fire Brigades Training Manual*, National Fire Protection Research Foundation test reports.

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NFPA 231**Standard for General Storage****1998 Edition****Reference: Table 9-1.1
TIA 98-1 (NFPA 231)**

Pursuant to Section 5 of the NFPA Regulations Governing Committee Projects, the National Fire Protection Association has issued the following Tentative Interim Amendment to NFPA 231, *Standard for General Storage*, 1998 edition. The TIA was processed by the General Storage Committee, and was issued by the Standards Council on January 14, 1999, with an effective date of February 3, 1999.

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. *Revise Table 9-1.1 to read as follows:***Table 9-1.1 Table 2: ESFR Sprinkler Data**

Type of Storage	Commodity	Maximum Height of Storage		Maximum Ceiling/Roof Height of Building		Nominal K Factor	Sprinkler Design Pressure	
		ft	m	ft	m		psi	bar
Palletized and solid pile storage (no open-top containers or solid shelves)	1. Cartoned unexpanded plastic	25	7.6	30	9.1	13.5-14.5	50	3.4
	2. Cartoned expanded plastic							
	3. Uncartoned unexpanded plastic							
	4. Class I, Class II, Class III, or Class IV commodities, encapsulated or unencapsulated							
	5. Idle wood or plastic pallets							
	1. Cartoned or uncartoned unexpanded plastic	35	10.7	40	12.2	13.5-14.5	75	5.2
	2. Class I, Class II, Class III, or Class IV commodities, encapsulated or unencapsulated							
	3. Idle wood or plastic pallets							
	1. Cartoned or uncartoned unexpanded plastic	35	10.7	45	13.7	13.5-14.5	90	27.4
	2. Class I, Class II, Class III, or Class IV commodities, encapsulated or unencapsulated							
	1. Cartoned unexpanded plastic 2. Class I, Class II, Class III, or Class IV commodities, encapsulated or unencapsulated	20	6.1	25	7.6	11.0-11.5	50	3.4
		25	7.6	30	9.1	23.9-26.5	20	1.4
		30	9.1	35	10.7	23.9-26.5	30	2.1
		35	10.7	40	12.2	23.9-26.5	40	2.7
		40	12.2	45	13.7	23.9-26.5	50	3.4

VERBODEN TOEGANG
(A-11-11)