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NFPA 231 General Storage 1985

National Fire Protection Association Batterymarch Park, Quincy, MA 02269

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

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

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

Statement on NFPA Procedures

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NFPA 231

Standard for

General Storage

1985 Edition

This edition of NFPA 231, *Standard for General Storage*, was prepared by the Technical Committee on General Storage, released by the Correlating Committee on Storage, and acted on by the National Fire Protection Association, Inc. at its Fall Meeting held November 12-15, 1984 in San Diego, California. It was issued by the Standards Council on December 7, 1984, with an effective date of December 27, 1984, and supersedes all previous editions.

The 1985 edition of this standard has been approved by the American National Standards Institute.

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

Origin and Development of NFPA 231

The U.S. War Production Board promulgated in 1943 General Storage Specifications for Critical-Strategic Materials. These were largely based on existing NFPA standards and upon generally accepted good practice in fire protection. They were published for convenient 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 recommendation of that Committee, a General Storage Standard was adopted by the NFPA Annual Meeting in 1946. This covered both indoor and outdoor storage. A revision of the Standard was tentatively adopted in 1953.

In 1955 the Committee presented a draft of a new document, Recommended Safe Practices for General Storage, No. 231-T, covering Indoor Storage, Outdoor Storage and Refrigerated Warehouses. This was tentatively adopted, leaving the 1946 General Storage Standard still official. With a few amendments, NFPA 231, Recommended Safe Practices for General Storage, was adopted in 1956.

In 1965 this was changed from a recommended practice to a standard, and the present title was introduced. The sections of the 1965 edition pertaining 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 this Standard applies was increased from 25 feet to 30 feet.

In 1979 the Standard was partially revised. This 1985 edition supersedes the 1979 edition.

Committee on Storage

Correlating Committee

Robert G. Planer, *Chairman*
Johnson & Higgins

Lydia A. Butterworth, *Secretary*
National Fire Protection Association
(Nonvoting)

J. S. Barritt, Industrial Risk Insurers
Thomas E. Goonan, Schirmer Engineering Corp.
Edward Jefferson, UniRoyal, Inc.
W. P. Thomas, Jr., Kemper Group
C. R. Thomson, Canadian Wood Council

Nonvoting

Wesley L. D. Chisholm, Liberty Mutual Insurance Co.
Rep. NFPA Comm. on Motor Vehicle & Hwy. FP.
R. A. Pedersen, Washington Surveying & Rating Bureau
Rep. NFPA Comm. on Marine Terminals

Technical Committee on

General Storage

W. P. Thomas, Jr., *Chairman*
Kemper Group

J. S. Barritt, Industrial Risk Insurers
Robert E. Bean, Trail Park Fire Control
Martin M. Brown, White Plains, NY
J. P. Carroll, SPI
Robert C. Everson, Berkeley Heights, NJ
Thomas E. Goonan, Schirmer Engineering Corp.
W. R. Heitzig, Dow Chemical Co.
Rep. Chemical Manufacturers Assn.
Allen I. Hjertstedt, IRM Insurance
Richard D. Jacobson, Factory Mutual Research Corp.
Edward Jefferson, Uniroyal, Inc.
Rep. NFPA Industrial Fire Protection Section
R. S. Johnson, Owens-Illinois Inc.
Raymond J. Malek, Paul J. Grunau Co.
Rep. NFSA
Robert G. Planer, Johnson & Higgins
J. P. Spollen, Western Electric Co., Inc.
R. W. Weitzel, Borden, Inc.
Rep. NFPA Industrial Fire Protection Section
Edward W. Whalen, New York Board of Fire Underwriters

Alternates

Thomas J. Brown, Jr, Factory Mutual Research Corp.
(Alternate to R. D. Jacobson)
J. D. Crawford, Johnson & Higgins
(Alternate to R. G. Planer)
Gregory L. Daum, South Orange, NJ
(Alternate to American Ins. Assn. Rep.)
Robert C. Hawker, Owens-Illinois, Inc.
(Alternate to R. S. Johnson)
Stephen R. Hoover, Kemper Group
(Alternate to W. P. Thomas)
Paul G. Mason, M&M Protection Consultants
(Alternate to M&M Protection Consultants Rep.)
E. E. Miller, Industrial Risk Insurers
(Alternate to J. S. Barritt)
Gerald W. O'Rourke, Schirmer Engineering Corp.
(Alternate to T. E. Goonan)
Henry I. Potter, General Services Admin.
(Alternate to GSA Rep.)
Lewis H. Zimmermann, Adelphia Automatic Sprinkler Co.
(Alternate to R. J. Malek)

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

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NFPA 231

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NOTICE: An asterisk (*) following the number or letter designating a paragraph indicates explanatory material on that paragraph in Appendix A.
Information on referenced publications can be found in Chapter 9 and Appendix D.

Chapter 1 Introduction

1-1 Scope.

1-1.1 This standard applies to:

1-1.1.1 Storage of materials representing the broad range of combustibles up to 30 ft (9.1 m) in height.

1-1.1.2 Storage of plastics (Groups B and C -- all configurations; Group A — free-flowing only) up to 30 ft (9.1 m) in height.

1-1.1.3 Storage of Group A plastics (except free-flowing) up to 25 ft (7.6 m) in height.

1-1.1.4 New buildings and existing buildings that are converted to storage occupancy.

NOTE: It may be used as a basis for evaluating existing storage facilities.

1-1.1.5 Outdoor Storage of a Broad Range of Combustibles. (*See Appendix C.*)

1-1.2 Storage piled higher than stated in 1-1.1.1, 1-1.1.2 or 1-1.1.3 is not within the scope of this standard and requires special consideration.

1-1.3 This standard does not apply to:

1-1.3.1 Unsprinklered buildings.

1-1.3.2 Storage of commodities which, with their packaging and storage aids, would be classified as noncombustible.

1-1.3.3 Unpackaged bulk materials such as grain, coal or similar commodities.

1-1.3.4 Inside or outside storage of commodities covered by other NFPA standards except where specifically mentioned herein, e.g., pyroxylin plastics.

1-1.3.5 Commodities presenting special fire hazards *not* covered by specific NFPA standards, e.g., roll paper, wax-coated cartons, etc.

1-1.3.6 Storage on racks.

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

1-2* Definitions. Unless expressly stated elsewhere, for the purpose of this standard, the following definitions shall apply:

Array.

Closed Array. A storage arrangement where air movement through the pile is restricted because of 6 in. (152 mm) or less vertical flues.

Open Array.* A storage arrangement where air movement through the pile is enhanced because of vertical flues larger than 6 in. (152 mm).

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 5-sided wood, metal or cardboard boxes not more than 6 ft × 6 ft × 6 ft (1.8 m × 1.8 m × 1.8 m) in dimension with open face on the aisles. Boxes are self-supporting or supported by a structure so designed that little or no horizontal or vertical space exists around boxes.

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

Commodity. Combinations of products, packing material and container.

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 which is sufficiently strong, by reason of material, design and construction, to be shipped safely without further packaging.

Encapsulated. A method of packing consisting of a plastic sheet completely enclosing the sides and top of a pallet load containing a combustible commodity or combustible packages.

NOTE: Banding, i.e., stretch wrapping, around the sides only of a pallet load is not considered to be encapsulated

Expanded (foamed or cellular) Plastics. Those plastics, the density of which is reduced by the presence of numerous small cavities (cells), interconnecting or not, dispersed throughout their mass.

Exposed Group A Plastic Commodities. Those plastics not in packaging or coverings which will absorb water or otherwise appreciably retard the burning hazard of the commodity (paper wrapped and/or encapsulated should be considered exposed).

Free-flowing Plastic Materials. Those plastics which will fall out of their containers in a fire condition,

fill flue spaces, and create a smothering effect on the fire. Example: Powder, pellets, flakes or *random packed* small objects [razor blade dispensers, 1-2 oz (28-57 g) bottles, etc.].

Noncombustible. Commodities, packaging or storage aids which will not ignite, burn or liberate flammable gases when heated to a temperature of 1,380°F (749°C) for 5 minutes.

Packaging. 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 content or leaning of stacks across flue spaces is *not* likely to occur soon after initial fire development.

NOTE: Storage on pallets, compartmented storage, or plastic components which are held in place by materials which do not deform readily under fire conditions are examples of stable storage

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

NOTE: Leaning stacks, crushed bottom cartons, or reliance on combustible bands for stability are examples of potential pile instability under a fire condition. An increase in pile height will tend to increase instability.

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 will burn only on the exterior of the load; water from sprinklers may reach most surfaces available to burn.

Sprinkler Temperature Rating. A 165°F (74°C) rating includes temperature ratings between 135°F (57°C) and 175°F (80°C), and a 286°F (141°C) rating includes temperature ratings between 250°F (121°C) and 300°F (149°C).

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

Unit Load. A pallet load or module held together in some manner and normally transported by material-handling equipment.

Chapter 2 Classification of Storage

2-1 Commodity Classification.

2-1.1 Class I commodity is defined as essentially noncombustible products on combustible pallets, in ordinary corrugated cartons with or without single-thickness dividers, or in ordinary paper wrappings with or without pallets.

Examples of Class I products are:

Foods. Noncombustible foodstuffs and beverages. Foods in noncombustible containers; frozen foods; meats; fresh fruits and vegetables in nonplastic trays or containers; liquid dairy products in non-wax-coated paper containers or in plastic-coated paper containers; beer and wine, up to 20 percent alcohol, in metal, glass or ceramic containers in ordinary corrugated cartons.

Glass Products. Glass bottles, empty or filled with noncombustible liquids; and mirrors.

Metal Products. Metal desks with plastic tops and trim; electrical coils; electrical devices in their metal enclosures; pots and pans; electrical motors; dry cell batteries; metal parts; empty cans; stoves; washers; dryers; and metal cabinets.

Others. Oil-filled and other types of distribution transformers; cement in bags; electrical insulators; gypsum board; inert pigments; and dry insecticides.

2-1.2 Class II commodity is defined as Class I products in slatted wooden crates, solid wooden boxes, multiple thickness paperboard cartons or equivalent combustible packaging material with or without pallets.

Examples of Class II products are:

Thinly coated fine wire such as radio coil wire on reels or in cartons; incandescent or fluorescent light bulbs; Class I products if in small cartons or small packages placed in ordinary paperboard cartons; book signatures; and beer or wine up to 20 percent alcohol in wood containers.

2-1.3 Class III commodity is defined as wood, paper, natural fiber cloth, or Group C plastics or products thereof, with or without pallets. Products may contain a limited amount of Group A or B plastics. Metal bicycles with plastic handles, pedals, seats and tires are an example of a commodity with a limited amount of plastic.

Examples of Class III products are:

Leather Products. Shoes; jackets; gloves; and luggage.

Paper Products. Books; magazines; stationery; plastic-coated paper food containers; newspapers; paper or cardboard games; and tissue products.

Textiles. Natural fiber upholstered nonplastic furniture; wood or metal furniture with plastic padded and covered arm rests; mattresses without expanded plastic or

rubber; absorbent cotton in cartons; natural fiber and viscose yarns, thread, and products; synthetic thread and yarn; natural fiber clothing or textile products.

Wood Products. Doors; windows; door and window frames; combustible fiberboard; wood cabinets and furniture and other wood products.

Others. Tobacco products in paperboard cartons; nonflammable liquids such as soaps, detergents and bleaches in plastic containers; non-negative-producing film packs in sealed tin foil wrappers in paperboard packages; combustible foods or cereal products; and nonflammable pharmaceuticals.

2-1.4 Class IV commodity is defined as Class I, II or III products containing an appreciable amount of Group A plastics in ordinary corrugated cartons and Class I, II and III products in corrugated cartons with Group A plastic packing, with or without pallets. Group B plastics and free-flowing Group A plastics are also included in this class. An example of packing material is a metal typewriter in a foamed plastic cocoon in an ordinary corrugated carton. (*Figure 7-1.1, Note 3.*)

Examples of Class IV products are:

Small appliances, typewriters, and cameras with plastic parts; plastic-backed tapes; and nonviscose synthetic fabrics or clothing. Telephones; vinyl floor tiles; wood or metal frame upholstered furniture or mattresses with plastic covering and/or padding; plastic-padded metal bumpers and dashboards; insulated conductor and power cable on wood or metal reels or in cartons; inert solids in plastic containers; and building construction insulating panels of polyurethane sandwiched between nonplastic material.

2-1.5* Classification of Plastics, Elastomers and Rubber.

NOTE: The following categories are based on unmodified plastic materials. The use of fire or flame-retarding modifiers or the physical form of the material may change the classification.

Group A

ABS (Acrylonitrile-Butadiene-Styrene Copolymer)
Acrylic (Polymethyl Methacrylate)
Acetal (Polyformaldehyde)
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, e.g., coated fabric, unsupported film)
SAN (Styrene Acrylonitrile)
SBR (Styrene-Butadiene Rubber)

Group B

Cellulosics (Cellulose Acetate, Cellulose Acetate Butyrate, Ethyl Cellulose)
Chloroprene Rubber
Fluoroplastics (ECTFE Ethylene-Chlorotrifluoroethylene Copolymer; ETFE Ethylene-Tetrafluoroethylene Copolymer; FEP Fluorinated Ethylene-Propylene Copolymer)
Natural Rubber (not expanded)
Nylon (Nylon 6, Nylon 6/6)
Silicone Rubber

Group C

Fluoroplastics (PCTFE Polychlorotrifluoroethylene; PTFE Polytetrafluoroethylene)
Melamine (Melamine Formaldehyde)
Phenolic
PVC (Polyvinyl Chloride rigid or lightly plasticized, e.g., pipe, pipe fittings)
PVDC (Polyvinylidene Chloride)
PVF (Polyvinyl Fluoride)
PVDF (Polyvinylidene Fluoride)
Urea (Urea Formaldehyde)

Chapter 3 Building Construction

3-1 Construction.

3-1.1* Buildings used for storage of materials which are stored and protected in accordance with this standard may be of any of the types described in NFPA 220, *Standard 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. Protection outlined in this standard applies to buildings with or without roof vents and draft curtains.

Chapter 4 Storage Arrangement

4-1 Piling Procedures and Precautions.

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

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

4-2 Commodity Clearance.

4-2.1 The clearance between top of storage and sprinkler deflectors shall conform to NFPA 13, *Standard for the Installation of Sprinkler Systems*, except as modified by this standard.

4-2.2* If the commodity is stored above the lower chord of roof trusses, at least 1 ft (30.5 cm) clear space shall be maintained to permit wetting of the truss unless 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 the Installation of Blower and Exhaust Systems for Dust, Stock and Vapor Removal or Conveying*, Section 2-8.

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 shall be in accordance with the clearances shown on the approval agency label.

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

4-2.6 Sufficient clearance shall be maintained around the path of fire door travel to assure 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 which expand with the absorption of water.

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

4-4* Storage of Idle Pallets.

4-4.1 Wood Pallets or Nonexpanded Polyethylene Solid Deck Pallets.

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

4-4.1.2 Pallets, when stored indoors, shall be protected as indicated in Table 4-4.1.2, unless the following are met:

(a) Stored no higher than 6 ft (1.8 m), and

(b) Each pallet pile of no more than 4 stacks shall be separated from other pallet piles by at least 8 ft (1.4 m) of clear space or 25 ft (7.6 m) of commodity.

NOTE. No additional protection is necessary as long as items (a) and (b) above are met.

Table 4-4.1.2 Protection for Indoor Storage of Wood Idle Pallets or Nonexpanded Polyethylene Solid Deck Idle Pallets.

Height of Pallet Storage ft (m)	Sprinkler Density Requirements gpm/ft² [(L/S)/m²]	Area of Sprinkler Demand ft²(m²)	
		Temperature Rating 286°F (141°C)	165°F (74°C)
Up to 6 (1.8)	.20 [.14]	2,000 (186)	3,000 (279)
6 (1.8) to 8 (2.4)	.30 [.20]	2,500 (232)	4,000 (372)
8 (2.4) to 12 (3.7)	.60 [.41]	3,500 (325)	6,000 (557)
12 (3.7) to 20 (6.1)	.60 [.41]	4,500 (418)	--

4-4.2* Plastic Pallets (other than noted in 4-4.1).

4-4.2.1 Plastic pallets shall preferably be stored outdoors or in a detached shed (*see Table A-4.4.1.1*).

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

(a) When stored in cutoff rooms:

(1) The cutoff rooms shall have at least one exterior wall.

(2) The plastic pallet storage shall be separated from the remainder of the building by 3-hour rated fire walls.

(3) The storage shall be protected by sprinklers designed to deliver 0.60 gpm/ft² [0.41 (L/s)/m²] for the entire room or by high expansion foam and sprinklers as indicated in Section 5-2.

(4) The storage shall be piled no higher than 12 ft (3.7 m).

(5) Any steel columns shall be protected by 1-hour fireproofing or a side wall sprinkler directed to one side of the column at the top or at the 15-ft (4.6-m) level, whichever is lower (*see A-4-2.2*).

(b) When stored without cutoffs from other storage:

(1) Plastic pallet storage shall be piled no higher than 4 ft (1.2 m).

(2) Sprinkler protection shall employ 286°F (141°C) rated sprinklers.

(3) 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.

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. See Chapter 4 of NFPA 30, *Flammable and Combustible Liquids Code*.

Chapter 5 Fire Protection — General

5-1 Automatic Sprinkler Systems.

5-1.1 Sprinkler systems 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*, except as modified by this chapter.

5-1.2 Sprinkler system design density shall not be less than 0.15 gpm/ft² [0.10 (L/s)/m²] for any commodity class or group.

5-1.2.1 The sprinkler design density for any given area of operation for Class IV commodity shall not be less than the density of Ordinary Hazard Group 3 in Table 2-2.1(B) in NFPA 13, *Standard for the Installation of Sprinkler Systems*.

5-1.2.2 The sprinkler design density for any given area of operation for Class III commodity shall not be less than the density of Ordinary Hazard Group 2 in Table 2-2.1(B) in NFPA 13, *Standard for the Installation of Sprinkler Systems*.

5-1.2.3 For all classes of commodity, minimum water supply for sprinklers shall not be less than those given in Table 2-2.1(B) in NFPA 13, *Standard for Installation of Sprinkler Systems,* as follows:

(a) Class I and II Commodity: Ordinary Hazard Group 1

(b) Class III Commodity: Ordinary Hazard Group 2

(c) Class IV Commodity: Ordinary Hazard Group 3.

5-1.3 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 storage with regard to sprinkler requirements and water supplies for ceiling and rack sprinklers.

5-1.4 In warehouses that have portions containing rack storage and other portions containing palletized solid pile bin box or shelf storage, the standard applicable to the storage configuration shall apply.

5-1.5 The densities and areas provided in the curves in Chapters 6 and 7 are based on fire tests using standard orifice ½ in. (12.7 mm) and large orifice $^{17}/_{32}$ in. (13.5 mm) sprinklers. For use of other types of sprinklers consult the authority having jurisdiction.

5-2 High Expansion Foam.

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

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

5-2.2 High expansion foam systems shall be automatic in operation.

5-2.3 Detectors shall be listed and shall be installed at the ceiling at one-half listed spacing.

5-2.4 Detection systems, concentrate pumps, generators and other system components essential to the operation of the system shall have an approved standby power source.

5-2.5 A reduction in ceiling density to one-half that required for Class I through IV commodities, idle pallets or plastics (using the secondary demand point) will be allowed, but shall be not less than 0.15 gpm/ft² [0.10 (L/s)/m²].

5-3 Manual Inside Protection.

5-3.1 Small Hose Systems. Small hose lines [1½ in. (38 mm)] shall be available to reach all portions of the storage area, giving due consideration to access aisle configuration with maximum anticipated storage in place. Such small hose may be supplied from:

(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 (*see NFPA 13*).

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 may be omitted in storage areas where fixed, small hose lines [1½ 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 permit rapid entry into the premises by the municipal fire department, police department, or other authorized personnel in case of fire or other emergency.

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

(a) Maintaining the security of the premises.

(b) Means of summoning outside aid immediately, in an emergency.

(c) Use of hand extinguishers and hose lines on small fires and mop-up operations.

(d) Operation of sprinkler system and water supply equipment.

(e) Use of material handling equipment while sprinklers are operating to effect final extinguishment.

(f) Supervision of sprinkler valves after system is turned off so that system can be reactivated if rekindling occurs.

(g) Need for breathing apparatus.

(h) Proper operation of emergency smoke and heat venting systems where these have been provided.

NOTE: Information on emergency organization is given in the following publications:
NFPA *Industrial Fire Brigades Training Manual.*
NFPA 27, *Private Fire Brigades.*

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

5-6 Alarm Service. Central station, auxiliary, remote station, or proprietary sprinkler waterflow alarm shall be provided. Local waterflow alarm is acceptable where recorded guard service is provided. (*See NFPA 71, Standard for the Installation, Maintenance and Use of Central Station Signaling Systems; NFPA 72A, Standard for the Installation, Maintenance and Use of Local Protective Signaling Systems for Guard's Tour, Fire Alarm and Supervisory Service; NFPA 72B, Standard for the Installation, Maintenance and Use of Auxiliary Protective Signaling Systems for Fire Alarm Service; NFPA 72C, Standard for the Installation, Maintenance and Use of Remote Station Protective Signaling Systems; and NFPA 72D, Standard for the Installation, Maintenance and Use of Proprietary Protective Signaling Systems.)*

Chapter 6* Fire Protection — Commodity Classes I through IV

6-1 General.

6-1.1 Protection specified in this chapter shall apply to nonencapsulated commodities only.

6-1.2 Sprinkler design criteria for solid pile, palletized and bin box storage over 12 ft (3.7 m), and shelf storage 12 ft (3.7 m) to 15 ft (4.6 m) high, shall be in accordance with Figures 6-1.2 and 6-2.2. The density provided for the area of application may be selected from any point on the curve applicable to the commodity, classification and arrangement of the stored commodities. It is not necessary to meet more than one point on the selected curve.

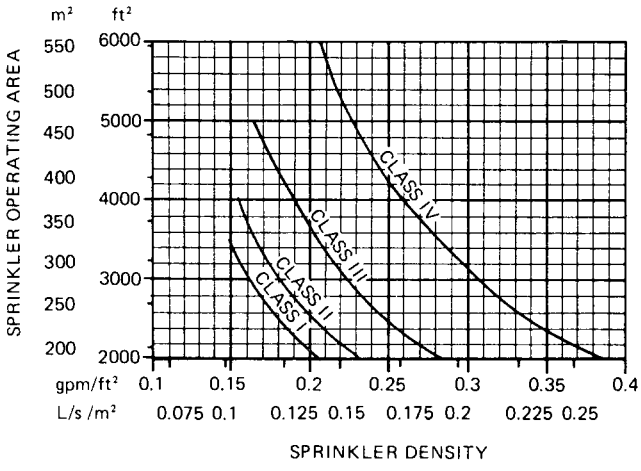

Figure 6-1.2 Sprinkler System Design Curves.

Twenty-Foot High Storage 165°F (74°C) Sprinklers. For 286°F (141°C) sprinklers, reduce sprinkler operating area 40 percent, but to not less than 2,000 ft² (186 m²).

NOTE: For storage heights other than 20 ft (6.1 m), see Figure 6-2.2.

6-1.3 Bin box and shelf storage over 12 ft (2.7 m) and provided with walkways at not over 12-ft (3.7-m) vertical intervals shall be provided with automatic sprinklers under the walkways as well as at the ceiling. The design density for ceiling and walkway sprinklers may be in accordance with the height adjustment of Figure 6-2.2.

6-2* Water Supplies.

6-2.1 Sprinkler water demand for 20 ft (6.1 m) high palletized storage, solid pile and bin box storage shall be in accordance with Figure 6-1.2.

6-2.2 Where storage height is less than 30 ft (9.1 m) high, but more than 12 ft (3.7 m) high in solid piles, palletized or bin box storage, ceiling densities indicated in the design curves, based on 20-ft (6.1-m) nominal storage height, shall be modified in accordance with Figure 6-2.2. (*See A-1-2, Available Height for Storage.*)

6-2.3 For shelf storage 12 ft (3.7 m) to 15 ft (4.6 m) high, ceiling densities indicated in the design curves in Figure 6-1.2 shall be modified in accordance with Figure 6-2.2.

6-2.4 Where dry-pipe systems are used, the areas of operation indicated in the design curves shall be increased by 30 percent. Densities shall be selected so that areas of operation, after the 30 percent increase, do not exceed the upper area limits given in the design curves.

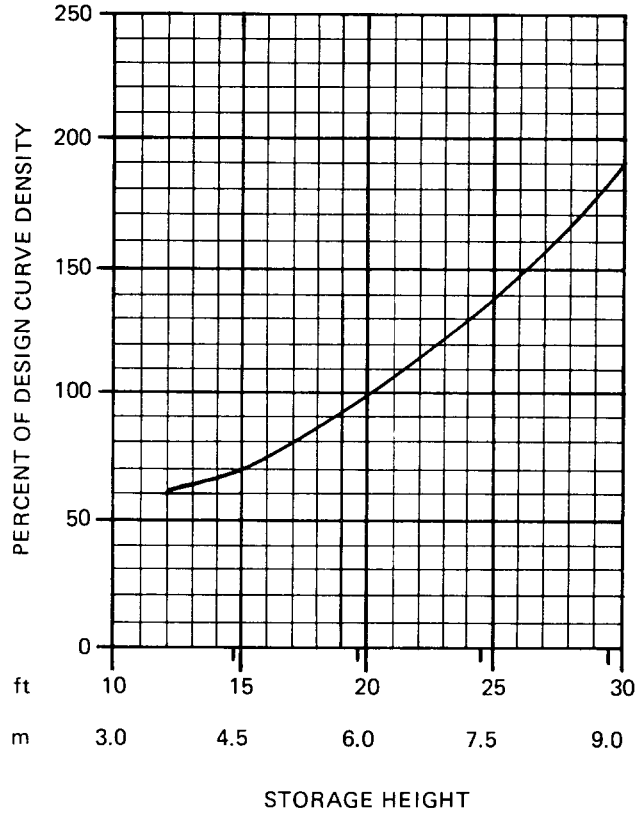

Figure 6-2.2 Ceiling Sprinkler Density Versus Storage Height.

6-2.5 Where sprinkler design density and water demand are determined by 6-1.2 and 6-2.2, at least 500 gpm (32 L/s) shall be added to the sprinkler demand for large and small hose stream demand.

6-2.6 Water supply duration shall be:

Duration (hours)

Storage Height ft (m)	Commodity Class	
	Classes I, II, & III	Class IV
12 (3.7) to 20 (6.1)	1½	2
20 (6.1) to 30 (9.1)	2	2½

6-3 High Expansion Foam (*see Section 5-2*).

Chapter 7 Fire Protection — Plastics and Rubber

7-1* General. (*See Appendix B.*)

7-1.1* Group A plastics shall be protected as indicated by Figure 7-1.1, Decision Tree. The decision tree shall be followed to determine the protection in each specific situation.

7-1.2* Factors affecting protection requirements such as closed/open array, clearance between storage and sprinklers, stable/unstable piles and two-point demands shall be applicable only to 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 giving the final protection requirements. This decision tree shall also be used to determine protection for commodities that are not wholly Group A plastics but contain such quantities and arrangements of the same 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 the same as a Class IV commodity. Storages under 12 ft (3.7 m) in height shall be protected in accordance with NFPA 13 for Ordinary Hazard Group 3.

7-1.4 Group C plastics shall be protected the same as a Class III commodity. Storages under 12 ft (3.7 m) in height shall be protected in accordance with NFPA 13 for Ordinary Hazard Group 2.

7-2 Water Supplies.

7-2.1* The design of the sprinkler system shall be based on the conditions that will routinely or periodically exist in a building creating the greatest water demand. These conditions include: (a) pile height, (b) clearance, (c) pile stability, and (d) array.

7-2.2 Design areas and densities for 20-ft (6.1-m) high storage with between 1½ ft (0.5 m) to 4½ ft (1.4 m) clearance shall be selected for the appropriate storage configuration from Figures 7-2.2(a), 7-2.2(b), 7-2.2(c), 7-2.2(d) and 7-2.2(e).

7-2.2.1 Both an initial and a secondary density/area shall be met. The initial density/area shall be taken from the section indicated on each of the curves. The secondary density shall be at least 0.25 gpm/ft² [0.17 (L/s)/m²] less than the initial density, and the minimum secondary design area, after all credits and penalties (height, clearance, array and dry systems), shall be 2,000 ft² (186 m²).

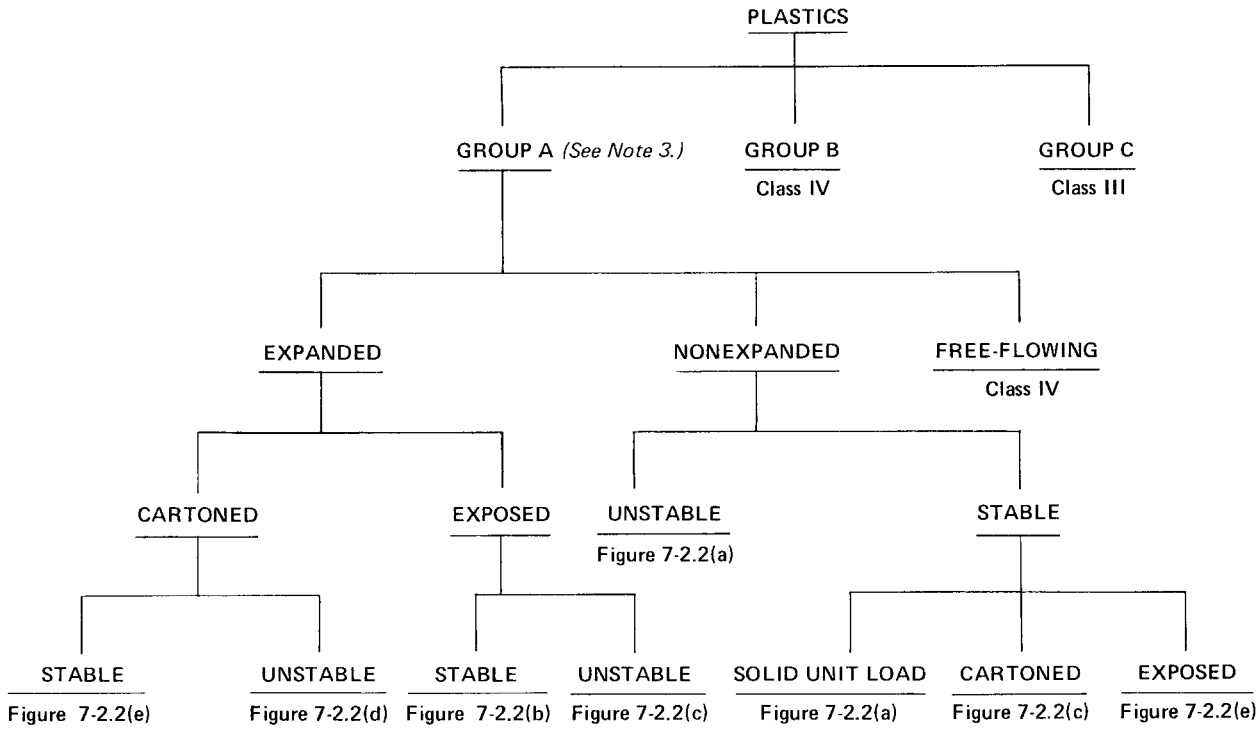

Figure 7-1.1 Decision Tree.

NOTES:

1. It is recommended that 286°F (141°C) rated sprinklers be installed, since most tests upon which this standard is based used 286°F (141°C) rated sprinklers.

2. The density/area curves are the starting points for determining proper protection in a given situation. The starting point assumes 20 ft (6.1-m) high storage and 1½-ft (0.5-m) to 4½-ft (1.4-m) clearance.

3. Cartons that contain Group A plastic material may be treated as Class IV commodities under the following conditions:

(a) There are multiple layers of corrugation or equivalent outer material that would significantly delay fire involvement of the Group A plastic.

(b) The amount and arrangement of the Group A plastic material within an ordinary carton would not be expected to significantly increase the fire hazard.

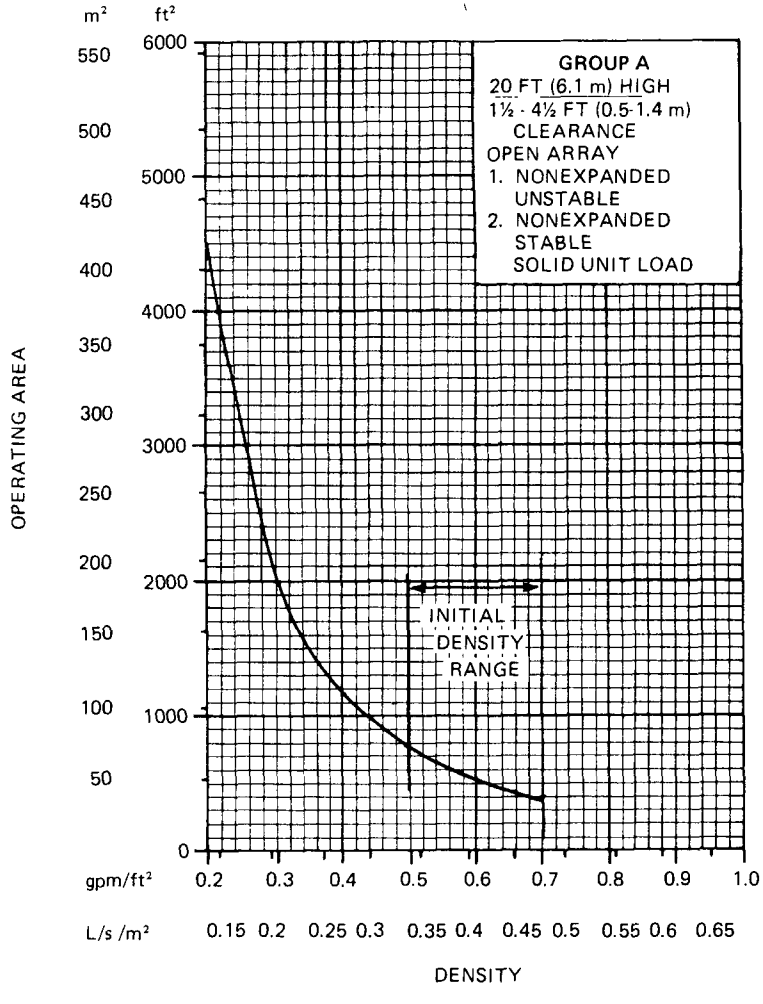

Figure 7-2.2(a)

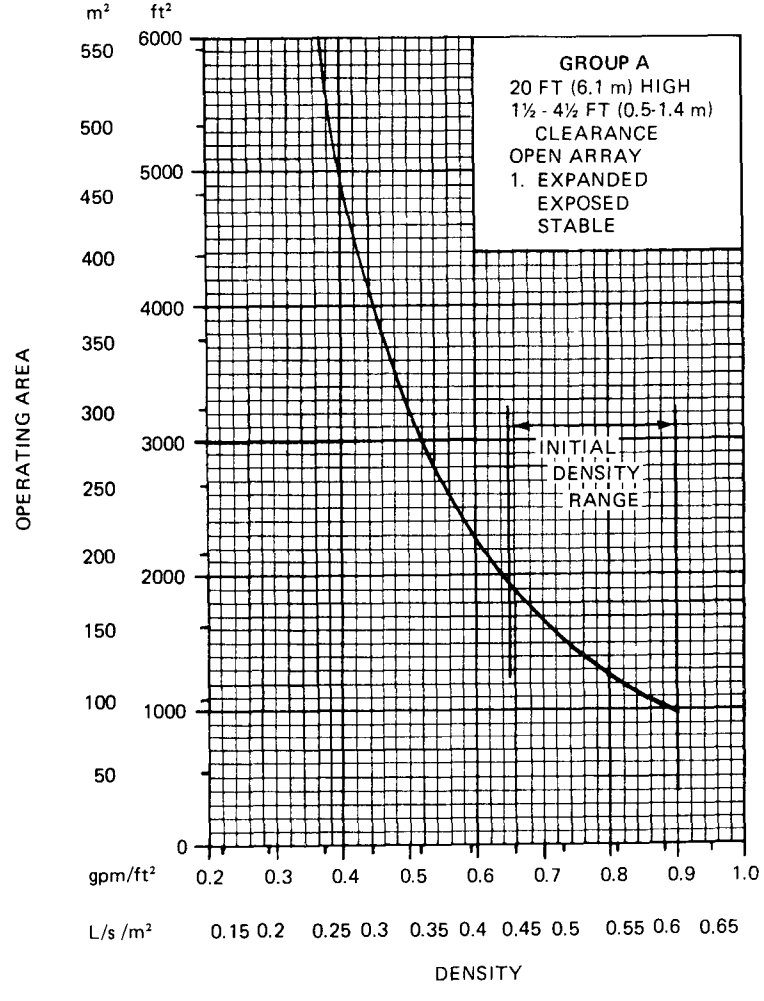

Figure 7-2.2(b)

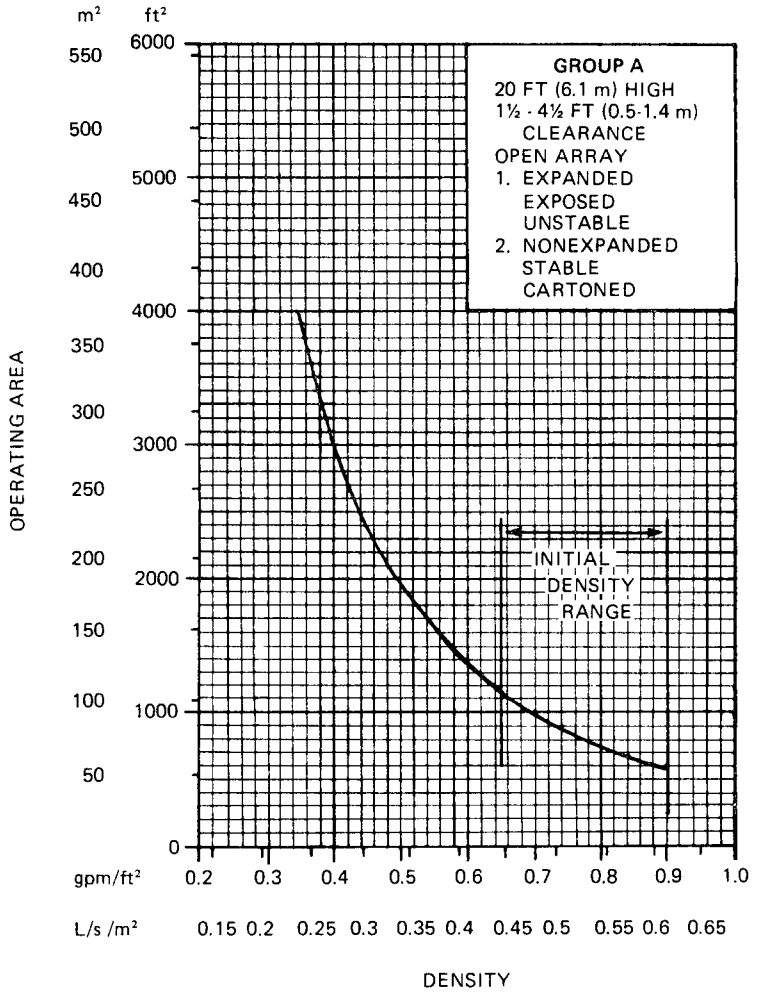

Figure 7-2.2(c)

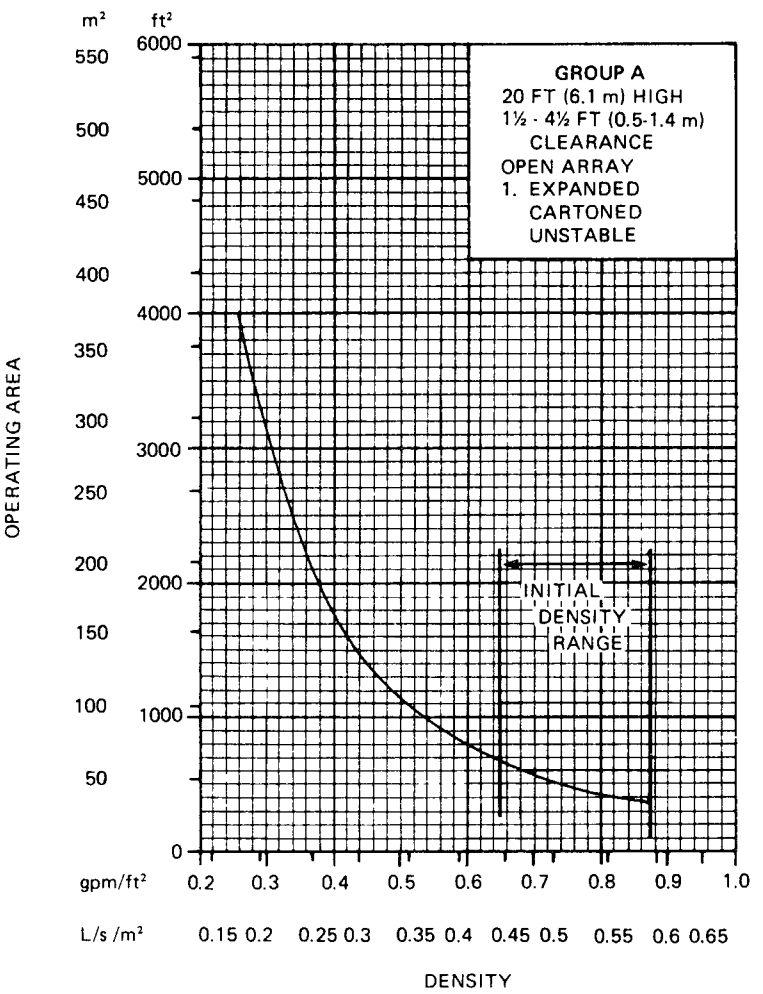

Figure 7-2.2(d)

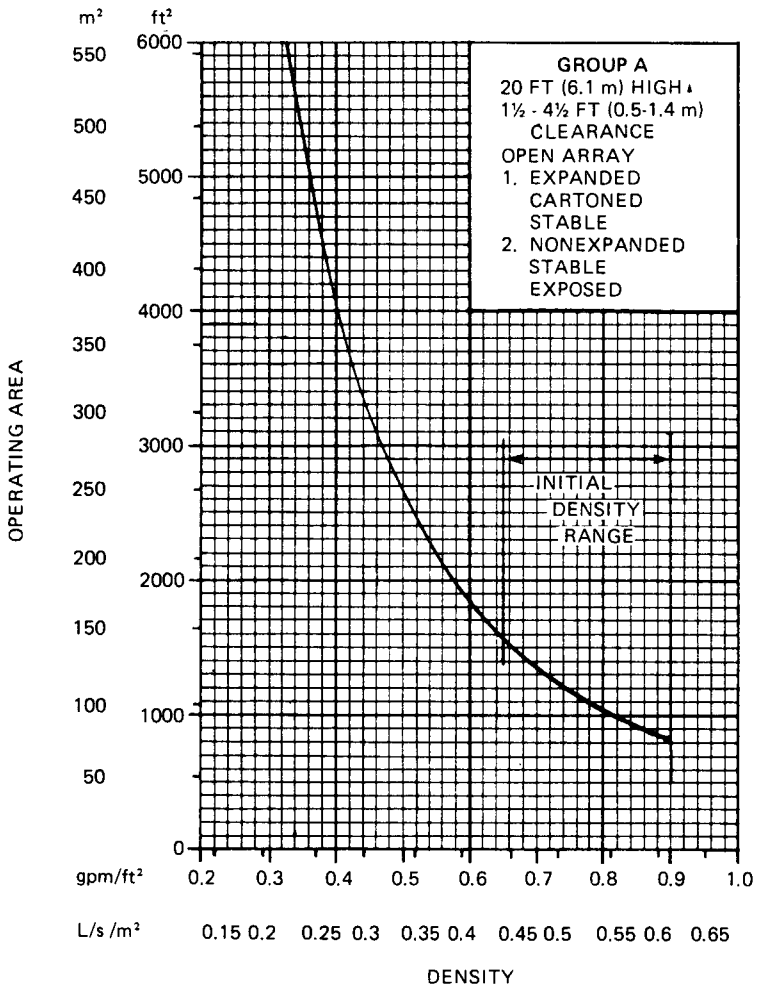

Figure 7-2.2(e)

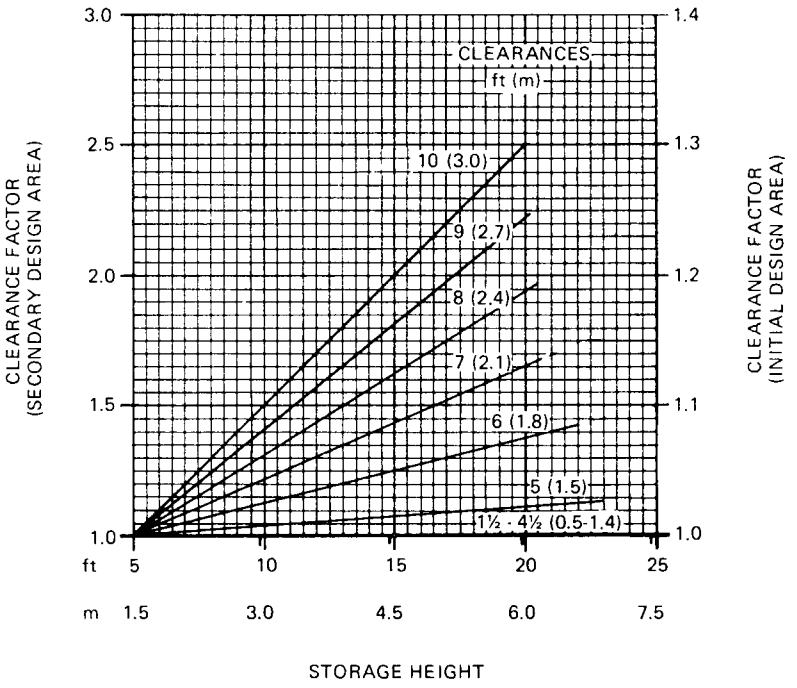

Figure 7-2.2.2

NOTE: There is insufficient test data available to define protection requirements for clearances in excess of 10 ft (3 m).

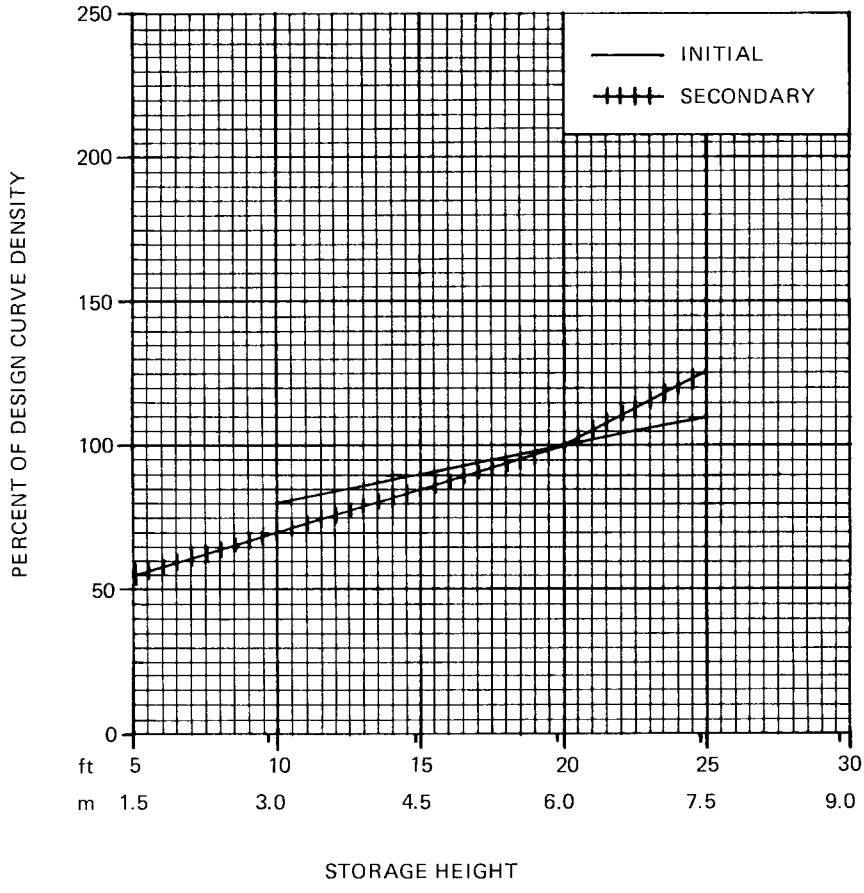

Figure 7-2.2.3

7-2.2.2 Where clearance is in excess of 4½ ft (1.4 m), the design areas for the initial and secondary demands shall be multiplied by the factors from Figure 7-2.2.2.

7-2.2.3 Where the height is other than 20 ft (6.1 m), the design densities shall be adjusted in accordance with Figure 7-2.2.3.

For storage 5 ft (1.5 m) to 10 ft (3.0 m) high, design areas and density for the secondary demand only shall be used.

7-2.3 Where there is a closed array (not including solid unit load or expanded exposed storage), the density/area shall be obtained as directed by 7-2.1 and corrected for height and clearance as directed in 7-2.2.2 and 7-2.2.3. A secondary area reduction of 50 percent for stable piles and 25 percent for unstable piles shall be applied to the less hazardous closed array.

7-2.4 Where sprinkler protection has been designed for Group A plastics, at least 500 gpm (32 L/s) shall be added to the secondary density/area demand for hose streams.

7-2.5 Water supply duration (secondary sprinkler demand plus hose streams) shall be 2-hour duration for 5 ft (1.5 m) to 20 ft (6.1 m) and 2½-hour duration for 20 ft (6.1 m) to 25 ft (7.6 m).

7-2.6* Where dry-pipe systems are used for Group A plastics, the operating area for the secondary density/area demand only, indicated in the design curves, shall be increased by 30 percent.

Chapter 8 Building Equipment, Maintenance and Operations

8-1* Mechanical Handling Equipment.

8-1.1* Industrial Trucks. Power-operated industrial trucks shall comply with NFPA 505, *Fire Safety Standard for Powered Industrial Trucks Including Type Designations, Areas of Use, Maintenance and Operation.*

8-2 Building Service Equipment.

8-2.1 Electrical equipment shall be installed in accordance with the provisions of NFPA 70, *National Electrical Code®*.

8-3 Cutting and Welding Operations.

8-3.1* When welding or cutting operations are necessary, the precautions contained in NFPA 51B, *Standard for Fire Prevention in Use of Cutting and Welding Processes*, shall be followed. When possible, work shall be removed to a safe area.

8-3.2 Welding, soldering, brazing, and cutting may be performed on building components which cannot be removed, provided no storage is located below and within 25 ft (7.6 m) of the working area and flameproof tarpaulins enclose this section. During any of these operations the sprinkler system shall be in service. Extinguishers suitable for Class A fires with a minimum rating of 2A and charged and manned inside hose lines, where provided, shall be located in the working area. A fire watch shall be maintained during these operations and for not less than 30 minutes following completion of open flame operation.

8-4 Waste Disposal. Rubbish, trash and other waste material shall be disposed of at regular intervals.

8-5 Smoking. Smoking shall be strictly prohibited, except in locations prominently designated as smoking areas. "No Smoking" signs shall be posted in prohibited areas.

8-6 Maintenance and Inspection.

8-6.1 Fire walls, fire doors and floors shall be maintained in good repair at all times.

8-6.2 The sprinkler system and the water supplies shall be maintained and serviced. (*See NFPA 13A, Recommended Practice for the Inspection, Testing and Maintenance of Sprinkler Systems.*)

8-7 Refrigeration Systems. Refrigeration systems, if used, shall conform to the recommendations of *Safety Code for Mechanical Refrigeration*, ANSI/ASHRAE 15-70.

Chapter 9 Referenced Publications

9-1 The following documents or portions thereof are referenced within this standard and shall be considered part of the requirements of this document. The edition indicated for each reference is current as of the date of the NFPA issuance of this document. These references are listed separately to facilitate updating to the latest edition by the user.

9-1.1 NFPA Publications. National Fire Protection Association, Batterymarch Park, Quincy, MA 02269.

NFPA 10-1984, *Standard for Portable Fire Extinguishers*

NFPA 11A-1983, *Standard for Medium and High Expansion Foam Systems*

NFPA 13-1985, *Standard for the Installation of Sprinkler Systems*

NFPA 24-1984, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*

NFPA 30-1984, *Flammable and Combustible Liquids Code*

NFPA 51B, *1984, Standard for Fire Prevention in Use of Cutting and Welding Processes*

NFPA 70-1984, *National Electrical Code*

NFPA 71-1982, *Standard for the Installation, Maintenance and Use of Central Station Signaling Systems*

NFPA 72A-1985, *Standard for the Installation, Maintenance and Use of Local Protective Signaling Systems for Guard's Tour, Fire Alarm and Supervisory Service*

NFPA 72B-1979, *Standard for the Installation, Maintenance and Use of Auxiliary Protective Signaling Systems for Fire Alarm Service*

NFPA 72C-1982, *Standard for the Installation, Maintenance and Use of Remote Station Protective Signaling Systems*

NFPA 72D-1979, *Standard for the Installation, Maintenance and Use of Proprietary Protective Signaling Systems*

NFPA 91-1983, *Standard for the Installation of Blower and Exhaust Systems for Dust, Stock and Vapor Removal or Conveying*

NFPA 220-1979, *Standard Types of Building Construction*

NFPA 231C-1980, *Standard for Rack Storage of Materials*

NFPA 505-1982, *Fire Safety Standard for Powered Industrial Trucks Including Type Designations, Areas of Use, Maintenance and Operation*

9-1.2 ASHRAE Code. American Society of Heating, Refrigerating and Air Conditioning Engineers, United Engineering Center, 345 East 49th Street, New York, NY 10017.

ASHRAE 15-1970, *Safety Code for Mechanical Refrigeration*

Appendix A

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

A-1-2 Definitions.

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

Available Height for Storage. For new sprinkler installations, maximum height of storage is the height at which commodities can be stored above the floor when the minimum required unobstructed space below sprinklers is maintained. For the evaluation of existing situations, maximum height of storage is the maximum existing, if space between sprinklers and storage is equal to or greater than required.

Compartmented. Cartons used in most of the Factory Mutual-sponsored plastic tests involved ordinary 200-lb (90.7-kg) test, outside corrugated cartons with 5 layers of vertical pieces of corrugated carton used as dividers on the inside. There were also single horizontal pieces of corrugated carton between each layer. Other tests sponsored by the SPI, IRI, FM and Kemper used two

vertical pieces of carton (not corrugated) to form an "X" in the carton for separation of product. This was not considered compartmented, as the pieces of carton used for separations were flexible (not rigid) and only two pieces were in each carton.

Container. Container designates cartons, wrappings, etc. Fire retardant containers or tote boxes do not of themselves create a need for automatic sprinklers unless coated with oil or grease. Containers may lose their fire retardant properties if washed. For obvious reasons, they should not be exposed to rainfall.

Pile Stability. Pile stability has been shown to be a difficult item to judge under fire conditions, prior to the fire. In the test work completed, compartmented cartons (described above) have shown to be stable under fire conditions. Those tests that were not compartmented tended to be unstable under fire conditions.

A-2-1.5 The classes of plastics used in this standard were basically derived from a series of large-scale and laboratory-type small-scale fire tests using a variety of expanded and nonexpanded plastic materials. It is recognized that not all plastics in a class will burn with exactly the same characteristics.

A-3-1.1 With protection installed in accordance with this standard, fire protection of overhead steel and steel columns may not be necessary.

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

It is desirable to provide walls or partitions 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 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, protection specified in Sections 5-1, 6-1 and 7-1 were developed without the use of such venting. However, venting through eaveline windows, doors, monitors, gravity or mechanical exhaust systems is essential to smoke removal after control of the fire is achieved. (*See NFPA 204M, 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. (10.2 cm) clearance from the floor.

A-4-2.2 Protection for exposed steel structural roof members may be needed and should be provided as indicated by the authority having jurisdiction.

A-4-2.5 Incandescent light fixtures should have shades or guards to prevent ignition of commodity from hot bulbs where 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 and cross aisles should be located opposite window or door openings in exterior walls. This is of particular importance in buildings where exterior openings are few. Aisle width should be at least 8 ft (2.4 m). In judging the adequacy of existing sprinkler protection, aisle spacing and frequency should be given consideration.

A-4-4 Idle pallet storage introduces a severe fire condition. Stacking idle pallets in piles is the best arrangement of combustibles to promote rapid spread of fire, heat release and complete combustion. After pallets are used for a short time in warehouses, they dry out and edges become frayed and splintered. In this condition, they are subject to easy ignition from a small ignition source. Again, high piling increases considerably both the challenge to sprinklers and the probability of involving a large number of pallets when fire occurs.

A-4-4.1.1 (*See Table A-4-4.1.1*)

Table A-4-4-1.1 Recommended Clearance Between Outside Idle Pallet Storage and Building.

Wall Construction		Minimum Distance, ft(m) of Wall from Storage of		
Wall Type	Openings	Under 50 Pallets	50 to 200 Pallets	Over 200 Pallets
Masonry	None	0	0	0
	Wired Glass with outside sprinklers one-hour doors	0	10 (3.0)	20 (6.1)
	Wired or Plain Glass with outside sprinklers ¾-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 should also be provided for combustible eave lines, vent openings, etc.
2. When 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 are generally not a reliable means of protection unless property is attended to at all times by plant emergency personnel.
4. Open sprinklers controlled by a deluge valve are preferred.

A-4-4.2 A fire in stacks of idle plastic and 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 expand to other dry or partially wet areas. This process of jumping 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 with ceiling sprinklers is by a great amount of prewetting. In high stacks, this cannot be done without abnormally high water supplies. The storage of empty wood pallets should not be permitted in an unsprinklered warehouse containing other storage.

A-5-1.5 Curves are based on operation of standard sprinklers. Use of "quick response" or other special sprinklers should be based on appropriate tests as approved by the Authority Having Jurisdiction.

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 system should be kept in operation during manual fire fighting operations until visibility has cleared so that the fire can be clearly seen and the extent of fire reduced to a stage requiring only mopping up. It is essential that charged hose lines be available before venting is started because of a possible increase in fire intensity. When a sprinkler valve is 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 exercised 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 [2½ in. (64 mm)] and related equipment should be available.

A-6 As an example of the use of curves in Figure 5-1.2, cereal storage on pallets 20 ft (6.1 m) high would be a Class III commodity. Using the Class III curve in Figure 6-1.2, any point on the curve can be selected.. If 165°F (74°C) heads are to be used on a wet-pipe system, the sprinkler system could be designed to provide a density of 0.25 gpm [0.17 (L/s)/m²] over an area of 2,500 ft² (232 m²). This requires a water supply of 625 gpm (39 L/s) at the proper pressure to supply the area and density selected. To this water supply must be added the quantity required for hose streams in 6-2.5. Total water supply would then be 1,125 gpm (71 L/s) for a duration of at least 90 minutes. Wet systems are recommended for storage warehouses except where it is impractical to provide heat. If a dry system is to be used in the previous example, a density of 0.25 gpm/ft² [0.17 (L/s)/m²] can still be used, but the area of application must be increased to 3,250 ft² (302 m²). This means the water supply for sprinklers should be 812 gpm (51 L/s).

The conclusions arrived at for water demand are a theoretical minimum. Actual water demand will be greater as a result of system sprinkler design.

A-6-2 Recommended water supplies contemplate successful sprinkler operation. Because of the small, but still significant, number of uncontrolled fires in sprinklered properties for various reasons, there should be an adequate water supply 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 large orifice [^{1}\$7x$_{32}$ in. (13.5 mm)] sprinklers and 80- or 100-ft² (7.4- or 9.3-m²) sprinkler spacing. These and other tests have indicated that with densities of 0.40 gpm/ft² [0.27 (L/s)/m²] and higher, better results are obtained with large orifice and 70- to 100-ft² (6.5- to 9.3-m²) sprinkler spacing than when using ½-in. (12.7-mm) orifice sprinklers at 50-ft² (4.6-m²) spacing. A discharge pressure of 100 psi (689 kPa) was used as a starting point on one of the fire tests. It was successful, but has a 1½-ft (0.5-m) clearance between the top of storage and ceiling sprinklers. A clearance of 10 ft (3.0 m) may have produced a different result due to the tendency of the higher pressure to atomize the water and the greater distance for the fine water droplets to travel to the burning fuel.

A-7-1.1 Two direct comparisons between 165°F (74°C) and 286°F (141°C) rated sprinklers is possible:

(a) With nonexpanded polyethylene 1-gal (3.8-L) bottles in corrugated cartons, a 3-ft (0.9-m) clearance, and the same density, approximately the same number of sprinklers operated [9 to 286°F (141°C) VS 7 at 165°F (74°C)].

(b) With exposed, expanded polystyrene meat trays, a 9.5-ft (1.9-m) clearance, and the same density, 3 times as many 165°F (74°C) rated sprinklers operated as did 286°F (141°C) rated sprinklers [11 at 286°F (141°C) VS 33 at 165°F (74°C)].

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 may change protection requirements considerably. Design should be on the side of higher densities and areas of application, and the various reductions allowed should be applied cautiously. For evaluation of existing situations, however, the allowances may be quite helpful.

A-7-2.1 An evaluation for each field situation should be made to determine the worst applicable height-clearance relationship which 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) as compared to 3 ft (0.9 m) and where a pile is stable as compared to an unstable pile. Since a system is designed for a particular clearance, the system could be inadequate when significant areas do not have piling to the design height and larger clearances exist between stock and sprinklers. This can also be true where the packaging or arrangement is changed so that stable piping is created where unstable piling existed. Recognition of these conditions is essential to avoid installation of protection which is inadequate or becomes inadequate because of changes.

No tests were conducted simulating a peaked roof configuration. However, it is expected that the principles of Chapter 7 still apply. The worst applicable height-clearance relationship which can be expected to occur also has to be found and protection designed for it. If storage is all at the same height, the worst height-clearance relationship creating the greatest water demand would occur under the peak. If commodities are stored higher under the peak, the various height-clearance relationships should be tried and the one creating the greatest water demand used for designing protection.

A-7-2.6 Wet systems are recommended for storage occupancies. Dry-pipe systems are acceptable only where it is impractical to provide heat.

A-8-1 Locomotives should not be allowed to enter storage areas.

A-8-1.1 Industrial trucks using gas or liquid fuel should be refueled outside of the storage building at a location designated for that purpose.

A-8-3.1 The use of welding, cutting, soldering or brazing torches in the storage areas introduces a severe fire hazard. The use of mechanical fastenings and mechanical saws or cutting wheels is recommended.

Appendix B

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

Appendix B explains and gives examples of the methods and procedures to follow in using this standard to determine proper protection for Group A plastics.

Metric Conversion Factors for Examples

To convert from	to	Multiply by
feet (ft)	meter (m)	0.3048
square feet (ft^2)	meter^2 (m^2)	0.0920
gal/min (gpm)	liter/second (L/s)	0.0631
gal per min/ft^2 (gpm/ft^2)	liter per second/m^2[(L/s)/m^2]	0.679

Example 1

Building height _____ 26 ft

Sprinkler deflector height from floor _____ 25 ft

Commodity _____ rolls of nonexpanded polyethylene film on end on pallets. One roll completely fills one pallet. Each roll with pallet is 5 ft high.

Storage height normally _____ 20 ft

Wet or dry sprinkler system _____ wet

Clearance normally _____ 5 ft

Open or closed array _____ flue spaces are 10 in.: open array.

(The conclusions arrived at for water demand are theoretical minimum. Actual water demand will be greater as a result of system sprinkler design.)

It was decided commodity is a Group A plastic (*see Commodity Classifications, Chapter 2*).

From storage description it was decided it was solid-unit load storage (it would burn only on exterior of unit load) and it was determined it was nonexpanded.

From decision tree (*see Figure 7-1.1*) — Group A, stable, nonexpanded, solid unit load, it says to go to Figure 7-2.2(a).

From Figure 7-2.2(a):

For initial demand there is a range: 0.7 gpm/ft^2 over 400 ft^2 to 0.5 gpm/ft^2 over 780 ft^2.

It is decided to choose . . . . 0.7 gpm/ft^2 over 400 ft^2.

For secondary demand there is a range: 0.5 gpm/ft^2 over 780 ft^2 to 0.2 gpm/ft^2 over 4,500 ft^2.

At least a 0.25-gpm/ft^2 difference between the initial density and the secondary density is needed. Also a minimum *final* design area of 2,000 ft^2 for the secondary point is necessary. Therefore, it is decided to pick 0.32 gpm/ft^2 over 1,800 ft^2.

The initial demand is 0.7 gpm/ft^2 over 400 ft^2 and the secondary demand is 0.32 gpm/ft^2 over 1,800 ft^2. However, these demands are for a 20-ft high, 1½- to 4½-ft clearance condition.

The actual condition is 20 ft high and a 5-ft clearance.

To adjust for height use Figure 7-2.2.3:

Initial demand: 100 percent × 0.7 gpm/ft^2 = 0.7 gpm/ft^2

Secondary demand: 100 percent × 0.32 gpm/ft^2 = 0.32 gpm/ft^2

To adjust for clearance use Figure 7-2.2.2:

Initial demand: 1.02 × 400 ft^2 = 408 ft^2

Secondary demand: 1.13 × 1,800 ft^2 = 2,034 ft^2

For 20-ft high storage and 5-ft clearance the demand is:

Initial demand: 0.7 gpm/ft^2 over 408 ft^2

Secondary demand: 0.32 gpm/ft^2 over 2,034 ft^2

However, sometimes storage height is only 3 pallet loads high, or 15 ft high with 10-ft clearance.

The demand for 20-ft high storage and 1½-ft to 4½-ft clearance *was*:

Initial demand: 0.7 gpm/ft^2 over 400 ft^2

Secondary demand: 0.32 gpm/ft^2 over 1,800 ft^2

To adjust for height use Figure 7-2.2.3:

Initial demand: 90 percent × 0.7 gpm/ft^2 = 0.63 gpm/ft^2

Secondary demand: 85 percent × 0.32 gpm/ft^2 = 0.27 gpm/ft^2

To adjust for clearance use Figure 7-2.2.2:

Initial demand: 1.2 × 400 ft^2 = 480 ft^2

Secondary demand: 2.0 × 1,800 ft^2 = 3,600 ft^2

For 15-ft high storage and 10-ft clearance the demand is:

Initial demand: 0.63 gpm/ft^2 over 480 ft^2

Secondary demand: 0.27 gpm/ft^2 over 3,600 ft^2

Conclusion:

0.7 gpm/ft^2 over 408 ft^2 = 285 gpm
0.32 gpm/ft^2 over 2,034 ft^2 = 650 gpm
} 20-ft high storage, 5-ft clearance

0.63 gpm/ft^2 over 480 ft^2 = 302 gpm
0.27 gpm/ft^2 over 3,600 ft^2 = 972 gpm
} 15-ft high storage, 10-ft clearance

The greatest gpm demand would be for 15-ft high storage. Therefore, the protection specified would be:

Commodity: Rolls P.E. Film
Stable/Unstable: Stable
Storage Height: 20 ft
Open/Closed Array: Open
Clear Space: 5 ft
Wet/Dry System: Wet

Fig. No.		Density / Area	Hgt. Fact.	Density (Adj.) / Area	Clearance Fact.	Density / Area (Adj.)	Array Fact.	Density / Area (Adj.)	Dry Penalty	Density / Area (Adj.)	Notes:
7-2.2(a)	Initial	0.7 / 400	100%	0.7 / 400	1.02	0.7 / 408	None				285 gpm
	Secondary	0.32 / 1,800	100%	0.32 / 1,800	1.13	0.32 / 2,034	None		None		650 gpm

Commodity: Rolls P.E. Film
Stable/Unstable: Stable
Storage Height: 15 ft
Open/Closed Array: Open
Clear Space: 10 ft
Wet/Dry System: Wet

Fig. No.		Density / Area	Hgt. Fact.	Density (Adj.) / Area	Clearance Fact.	Density / Area (Adj.)	Array Fact.	Density / Area (Adj.)	Dry Penalty	Density / Area (Adj.)	Notes:
7-2.2(a)	Initial	0.7 / 400	90%	0.63 / 400	1.2	0.63 / 480	None				302 gpm
	Secondary	0.32 / 1,800	85%	0.27 / 1,800	2.0	0.27 / 3,600	None		None		972 gpm

Initial demand: 0.63 gpm/ft² over 500 ft²
Secondary demand: 0.27 gpm/ft² over 3,600 ft²
(Areas should be rounded to nearest 100 ft²)

Example 2

Building height _____ 30 ft
Sprinkler deflector height from floor _____ 29 ft
Commodity _____ polyethylene bottles in compartmented cartons on pallets. The height of one loaded pallet is 6 ft.
Normal storage height _____ 18 ft
Wet or dry sprinkler system ____ wet
Clearance normally _____ 11 ft high
Open or closed array _____ flue spaces were 11 in.: open array.

(The conclusions arrived at for water demand are theoretical minimum. Actual water demand will be greater as a result of system sprinkler design.)

It was decided commodity is a Group A plastic (*see Commodity Classifications, Chapter 2*).

From storage description it was determined to be stable, nonexpanded and cartoned.

From decision tree (*see Figure 7-1.1*) — Group A, stable, nonexpanded, cartoned, it says go to Figure 7-2.2(c)

From Figure 7-2.2(c)

For initial demand there is a range: 0.9 gpm/ft² over 600 ft² to 0.6 gpm/ft² over 1,350 ft².

It is decided to choose ..... 0.9 gpm/ft² over 600 ft².

For secondary demand there is a range: 0.65 gpm/ft² over 1,150 ft² 0.35 gpm/ft² over 4,000 ft².

At least a 0.25 gpm/ft² difference between the initial density and the secondary density is needed. Also a minimum *final* design area of 2,000 ft² for the secondary point is necessary. Therefore, it is decided to pick 0.65 gpm/ft² over 1,150 ft².

The initial demand is 0.9 gpm/ft² over 600 ft² and the secondary demand is 0.65 gpm/ft² over 1,150 ft². However, these demands are for a 20-ft high, 1½-ft to 4½-ft clearance condition.

Actual condition is 18-ft high and an 11-ft clearance.

To adjust for height use Figure 7-2.2.3:

Initial demand: 96 percent of 0.9 gpm/ft² = 0.86 gpm/ft²

Secondary demand: 94 percent of 0.65 gpm/ft² = 0.61 gpm/ft²

To adjust for clearance use Figure 7-2.2.2:

Initial demand: 1.25 x 600 ft² = 756 ft²

Secondary demand: 2.3 x 1150 ft² = 2,645 ft²

For 18-ft high storage and 11-ft clearance the demand is:

Initial demand: 0.86 gpm/ft² over 756 ft²

Secondary demand: 0.61 gpm/ft² over 2,645 ft²

However, sometimes storage height is 24 ft high with 5-ft clearance.

The demand for 20-ft high storage and 1½-ft to 4½-ft clearance *was:*

Initial demand: 0.9 gpm/ft² over 600 ft²

Secondary demand: 0.65 gpm/ft² over 1,150 ft²

However, since the clearance factor for increasing the area is going to be small and a final area of at least 2,000 ft² is needed, it is decided to pick a density for the secondary point which would create an area demand closer to the 2,000 ft² area.