NFPA No.

231C

RACK STORAGE OF MATERIALS 1974

NATIONAL FIRE PROTECTION ASSOCIATION

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Standard for

Rack Storage of Materials

NFPA No. 231C— 1974

1974 Edition of No. 231C

This edition of NFPA No. 231C was adopted in May 1974 and supersedes the 1973 edition. The entire format of the standard has been revised, numerous editorial changes have been made, and new material has been added.

Origin and Development of No. 231C

In August of 1967, representatives of the rack manufacturers, the fire protection equipment field, the insurance community, and industrial users met and organized the Rack Storage Fire Protection Committee. This Committee developed, and financially sponsored, a program of full scale fire tests for the storage of combustible materials in racks.

In 1968 the NFPA Committee on Rack Storage of Materials was organized. All of the data developed by the Rack Storage Fire Protection Committee was subsequently turned over to the NFPA Committee. Thus, it was possible for the NFPA Committee to write a standard supported entirely by actual fire test data. NFPA No. 231C was first adopted at the Annual Meeting in May 1971.

In 1972 revisions included making some former recommendations mandatory and new material was added to the Appendix. In 1973 it was further revised to include storage for heights above 25 feet, and the relocation of advisory material to the appendix.

Committee on

Rack Storage of Materials

A. E. Sheppard, *Chairman,*
Factory Mutual Research Corp., 1151 Boston-Providence Turnpike, Norwood, MA 02062

Jerome L. Huff, *Secretary,*
Hartman Engineering, A Division of Hartman Metal Fabricators, Inc.,
66 School St., Victor, NY 14564
(Rep. Rack Manufacturers Product Section of The Material Handling Institute, Inc.)

John J. Ahern, NFPA Committee on Electronic Computer Systems

R. R. Barczak, Johnson & Higgins, Inc.

J. S. Barritt, Factory Insurance Assn.

E. Bertram Berkley, Envelope Manufacturers Assn.

J. P. Cuthbertson, Shell Chemical Co.

Francis C. Evans, NFPA Sectional Committee on Detection Devices

Robert C. Everson, Marsh & McLennan, Inc.

Lee Hall, Controlled Mechanical Storage Systems Product Section, The Material Handling Institute, Inc.

John T. Higgins, Industrial Fire Protection Section

R. S. Johnson, Subcommittee on High Piled Storage, NFPA Committee on General Storage

A. M. Lownsbury, American Warehousemen's Assn.

D. N. Meldrum, NFPA Committee on Foam

Andrew J. Myer, Travelers Insurance Co.

C. Bart Nixon, National-American Wholesale Grocers Assn.

W. Robert Powers, NFPA Committee on General Storage

Robert L. Retelle, American Insurance Assn.

E. J. Schiffhauer, Eastman Kodak Co.

Chester W. Schirmer, Schirmer Engineering Corp.

James C. Spence, American Iron & Steel Institute

William Testa, National Automatic Sprinkler & Fire Control Association

William A. Webb, Rolf Jensen & Associates, Inc.

H. V. Williamson, Fire Equipment Manufacturers Assn.

Jack A. Wood, National Automatic Sprinkler & Fire Control Association

George M. Woods, Jr., American Mutual Insurance Alliance

Donald P. Yuellig, Fire Marshals Assn. of North America

Alternates.

W. A. Alstedt, Controlled Mechanical Storage Systems Product Section, The Materials Handling Institute, Inc. (Alternate to Lee Hall)

Wayne E. Ault, National Automatic Sprinkler & Fire Control Association (Alternate to Jack A. Wood)

L. B. Donkle, Rack Manufacturers Product Section of The Materials Handling Institute, Inc. (Alternate to Jerome L. Huff)

G. M. Hidzick, American Mutual Insurance Alliance (Alternate to George M. Woods, Jr.)

Daniel M. McGee, American Iron & Steel Institute (Alternate to James C. Spence)

William J. Swingler, Factory Insurance Association (Alternate to J. S. Barritt)

W. P. Thomas, Factory Mutual Research Corp. (Alternate to A. E. Sheppard)

Kenneth A. Zuber, Fire Equipment Manufacturers Assn. (Alternate to H. V. Williamson)

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.

TABLE OF CONTENTS

Chapter 1. Introduction 231C- 5
1-1 Application and Scope 231C- 5
1-2 Definitions 231C- 5

Chapter 2. Classification of Storage 231C- 8
2-1 Commodity Classifications 231C- 8

Chapter 3. Building Construction 231C-10
3-1 Construction 231C-10
3-2 Fire Protection of Steel 231C-10
3-3 Ventilation 231C-10

Chapter 4. Storage Arrangements 231C-11
4-1 Rack Structure 231C-11
4-2 Rack Loading 231C-11
4-3 Flue Space 231C-11
4-4 Aisle Widths 231C-12
4-5 Storage Heights 231C-12
4-6 Commodity Clearances 231C-12
4-7 Storage of Empty Combustible Pallets 231C-12

Chapter 5. Fire Protection — General 321C-13
5-1 Protection Systems 231C-13
5-2 Ceiling Sprinklers 231C-13
5-3 Ceiling Sprinkler Spacing 231C-13
5-4 Ceiling Sprinkler Discharge Pressure 231C-13
5-5 In-Rack Sprinkler System Size 231C-13
5-6 In-Rack Sprinkler System Control Valves 231C-14
5-7 In-Rack Sprinkler Water Demand 231C-14
5-8 Sprinkler Water Flow Alarm 231C-14
5-9 Hose Connections 231C-14
5-10 Hose Streams 231C-14
5-11 Duration of Water Supplies 231C-14
5-12 High Expansion Foam 231C-14
5-13 High Expansion Foam Detectors 231C-15
5-14 Solid and Slatted Shelves 231C-15

Chapter 6. Fire Protection — Storage Up to and Including 25 Feet in Height 231C-16
Part A — General 231C-16
6-1 In-Rack Sprinkler Size 231C-16
6-2 In-Rack Sprinkler Pipe Size 231C-16
6-3 In-Rack Sprinkler Water Shields 231C-16
6-4 In-Rack Sprinkler Location 231C-16
6-5 In-Rack Sprinkler Discharge Pressure 231C-16

6-6 In-Rack Sprinkler Water Demand 231C–16
6–7 Ceiling Sprinkler Water Demand 231C–17
6–8 High Expansion Foam Submergence 231C–20
6–9 High Expansion Foam Ceiling Sprinkler Density 231C–20
6–10 In-Rack Sprinkler Location 231C–20
6–11 In-Rack Sprinkler Spacing 231C–21

Part B — Double and Single Row Racks 231C–22
6–12 Ceiling Sprinkler Water Demand 231C–22

Part C — Multiple Row Racks 231C–22
6–13 In-Rack Sprinkler Location 231C–22
6–14 Ceiling Sprinkler Water Demand 231C–23

Chapter 7. Fire Protection — Storage Over 25 Feet in Height . . 231C–38
Part A — General 231C–38
7–1 In-Rack Sprinkler Size 231C–38
7–2 In-Rack Sprinkler Spacing 231C–38
7–3 In-Rack Pipe Size 231C–38
7–4 In-Rack Water Shields 231C–38
7–5 In-Rack Sprinkler Location 231C–38
7–6 In-Rack Sprinkler Discharge Pressure 231C–50
7–7 In-Rack Sprinkler Water Demand 231C–50
7–8 High Expansion Foam Submergence 231C–50
7–9 High Expansion Foam — Ceiling Sprinkler Water Demand . 231C–50

Part B — Single and Double Row Racks 231C–50
7–10 In-Rack Sprinkler Location 231C–50
7–11 In-Rack Sprinkler Horizontal Barriers 231C–52
7–12 Ceiling Sprinkler Water Demand 231C–52

Part C — Multiple Row Racks 231C–52
7–13 In-Rack Sprinkler Location 231C–52
7–14 In-Rack Sprinkler Spacing 231C–52
7–15 Ceiling Sprinkler Water Demand 231C–57

Chapter 8. Equipment 231C–58
8–1 Mechanical Handling Equipment 231C–58

Chapter 9. Building Maintenance and Operation 231C–59
9–1 Building Operations Other Than Storage 231C–59
9–2 Waste Disposal 231C–59
9–3 Smoking 231C–59
9–4 Maintenance 231C–59
9–5 Plant Emergency Organization 231C–59
9–6 General Fire Protection 231C–59

Appendix A 231C–60

Appendix B 231C–78

Index 231C–89

Standard for

Rack Storage of Materials

NFPA No. 231C — 1974

NOTICE

An asterisk (*) preceding the number designating a paragraph or section in the text indicates recommendations in regard to that paragraph or section in Appendix A.

A dagger (†) preceding the number designating a paragraph or section in the text indicates explanatory test data and procedures in regard to that paragraph or section in Appendix B.

Chapter 1 Introduction

†1-1 Application and Scope.

This standard applies to storage of materials representing the broad range of combustibles stored over 12 feet in height on racks. For storage heights of 12 feet or less, see *Sprinkler Systems, NFPA 13 — 1974.*

Storage on plastic pallets or plastic shelves is outside the scope of this standard.

Storage of high hazard materials such as tires, plastics, and flammable liquids, is outside the scope of this standard. See *Flammable and Combustible Liquids Code, NFPA 30 — 1973; Cellulose Nitrate Motion Picture Film, NFPA 40 — 1974; Pyroxylin Plastic, NFPA 43 — 1967; Ammonium Nitrate Storage, NFPA 490 — 1970; Liquefied Petroleum Gases, NFPA 58 — 1974; Fur Storage, Fumigation and Cleaning, NFPA 81 — 1969; Indoor General Storage, NFPA 231 — 1974;* and *Protection of Records, NFPA 232 — 1970* for standards applying to such commodities or to other methods of storage.

Bin storage and shelf storage are outside the scope of this standard.

1-2 Definitions. Unless expressly stated elsewhere, the following terms shall, for the purpose of this standard, have the meanings indicated below.

Bulkhead. A vertical barrier across the rack.

Commodity. Designates combinations of product, packing material, and container.

Pallets. A material handling aid designed to support a unit load with stringers to provide support for material handling devices (*see Fig. 1-2.1*).

Encapsulated. A method of packaging consisting of a plastic sheet completely enclosing the sides and top of a pallet load containing a combustible commodity or a combustible package or a group of combustible commodities or combustible packages. Totally noncombustible commodities on wood pallets enclosed only by a plastic sheet as described are not considered to fall under this definition.

Face Sprinklers. Standard sprinklers located in transverse flue spaces along the aisle or in the rack, within 18 inches of the aisle face of storage to oppose vertical development of fire on the external face of storage.

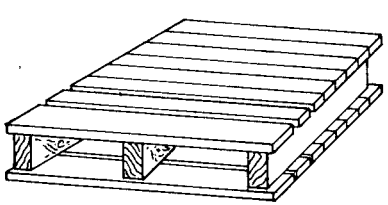
Horizontal Barrier. A solid barrier in the horizontal position covering the entire rack including all flue spaces at certain height increments to prevent vertical fire spread.

Longitudinal Flue Space. The space between rows of storage perpendicular to the direction of loading (*see Fig. 1-2.2*).

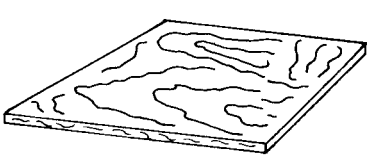
Racks. Any combination of vertical, horizontal, and diagonal members that support stored materials. Some rack structures use solid shelves. Racks may be fixed or portable (*see Figs. A4-1.1a through j*).

Shelf Storage. Storage in structures usually less than 30 inches deep, seldom more than two feet between shelves and seldom higher than 12 feet.

Slave Pallet. A special pallet captive to a material handling system (*see Fig. 1-2.1*).



Conventional Pallet



Solid Flat Bottom Wood Pallet

Fig. 1-2.1 Typical Pallets.

Transverse Flue Space. The space between rows of storage parallel to the direction of loading (*see Fig. 1-2.2*).

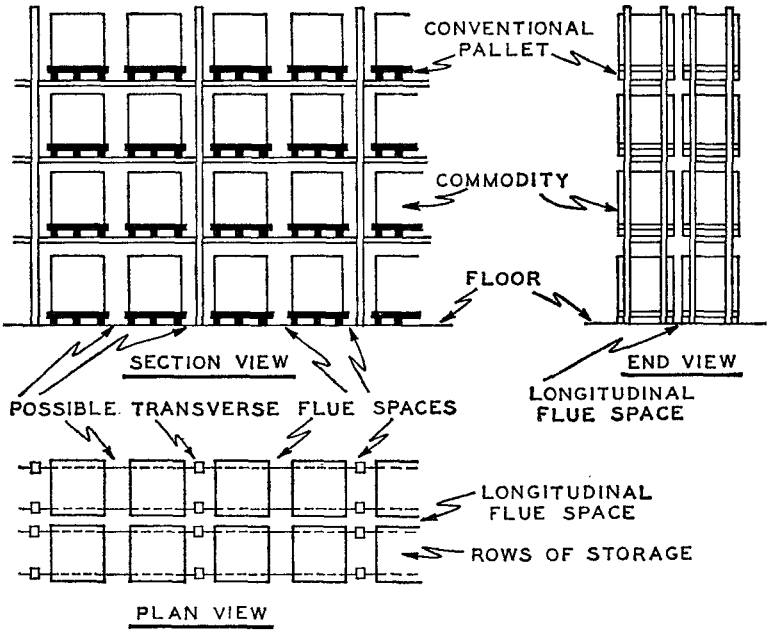


Fig. 1-2.2 Typical Double Row (Back-to-Back) Rack Arrangement.

Chapter 2 Classification of Storage

†2-1 Commodity Classifications.

2-1.1 The following guide for commodity classification applies specifically to rack storage and is not related to any other method of classification of materials.

2-1.1.1 Class I commodity is defined as essentially noncombustible products on wood pallets, or in ordinary corrugated cartons with or without single thickness dividers, or in ordinary paper wrappings; on wood pallets. Such products may have a negligible amount of plastic trim, such as knobs or handles.

Examples of Class I products are:

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.

GLASS PRODUCTS. Glass bottles, empty or filled with noncombustible liquids; mirrors.

FOODS. Foods in noncombustible containers; frozen foods; meats; fresh fruits and vegetables in nonplastic trays or containers; dairy products in nonwax coated paper containers; beer or wine, up to 20 percent alcohol, in metal, glass or ceramic containers.

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

2-1.1.2 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 on wood 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, beer or wine up to 20 percent alcohol in wood containers; and Class I products, if in small cartons or small packages placed in ordinary corrugated cartons.

2-1.1.3 Class III commodity is defined as wood, paper, natural fiber cloth, or products thereof, on wood pallets. Products may contain a limited amount of 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:

PAPER PRODUCTS. Books, magazines, stationery; plastic coated paper food containers; newspapers; paper or cardboard games; tissue products; rolled paper on side or steel banded on end.

LEATHER PRODUCTS. Shoes; jackets; gloves; and luggage.

WOOD PRODUCTS. Doors; windows; door and window frames; combustible fiberboard; wood cabinets; furniture and other wood 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; and natural fiber and viscose yarns, thread, and products; natural fiber clothing or textile products.

OTHERS. Tobacco products in paperboard cartons; nonflammable liquids such as soaps, detergents and bleaches, and nonflammable pharmaceuticals in plastic containers; combustible foods or cereal products; and nonnegative producing film packs in sealed metal foil wrappers in paperboard packages.

2-1.1.4 Class IV commodity is defined as Class I, II, and/or III products containing an appreciable amount of plastics in a paperboard carton or Class I, II and/or III products with plastic packing in paperboard cartons on wood pallets.

Examples of Class IV products are: small appliances, typewriters and cameras with plastic parts; plastic backed tapes and synthetic fabrics or clothing. An example of packing material is a metal product in a foamed plastic cocoon in a corrugated carton.

Class IV commodity also includes:

TEXTILES. Synthetic thread and yarn except viscose and nonviscose synthetic fabrics or clothing.

OTHERS. Telephones; vinyl floor tile; wood or metal frame upholstered furniture or mattresses with plastic covering and/or padding; and plastic padded metal dashboards or metal bumpers.

Chapter 3 Building Construction

3-1 Construction.

3-1.1 Buildings used for the rack storage of materials, which are protected in accordance with this standard, may be of any of the types described in *Standard Types of Building Construction, NFPA 220 — 1961.*

3-2 Fire Protection of Steel.

†**3-2.1** With sprinkler systems installed in accordance with design curves in Chapters 6 and 7, fire protection of roof steel is not necessary.

†**3-2.2** When ceiling sprinklers and sprinklers in racks are installed in accordance with design curves in Chapters 5 and 6, fire protection of steel building columns is not necessary.

†**3-2.3** When storage height exceeds 15 feet, and ceiling sprinklers only are installed, fire protection by one of the following methods is required for all types of steel building columns located within the racks, or for vertical rack members that support the building:

(a) One hour fire proofing

(b) Side wall sprinklers, at the 15-foot elevation, pointed towards one side of the steel column.

(c) For storage heights above 15 feet, up to and including 20 feet, provision of ceiling sprinkler density for a minimum of 2000 square feet with 165°F or 286°F temperature-rated sprinklers as follows:

Commodity Class	4 ft. Aisle	8 ft. Aisle
I	0.37	0.33
II	0.44	0.37
III	0.49	0.42
IV	0.68	0.57

3-3 Ventilation.

†**3-3.1** Design curves are based upon roof vents and draft curtains not being used.

Chapter 4 Storage Arrangements

4-1 Rack Structure.

*4-1.1 Typical rack configurations are described in Appendix A4-1.1.

4-2 Rack Loading.

*4-2.1 Racks shall not be loaded beyond their design capacity.

4-3 Flue Space.

†4-3.1 In double row racks with height of storage up to and including 25 feet, and without solid shelves, no minimum or maximum longitudinal flue space (back-to-back clearance) is necessary. An approximate six-inch transverse flue space between loads or at rack uprights shall be maintained. (*See Fig. 4-3.1.*)

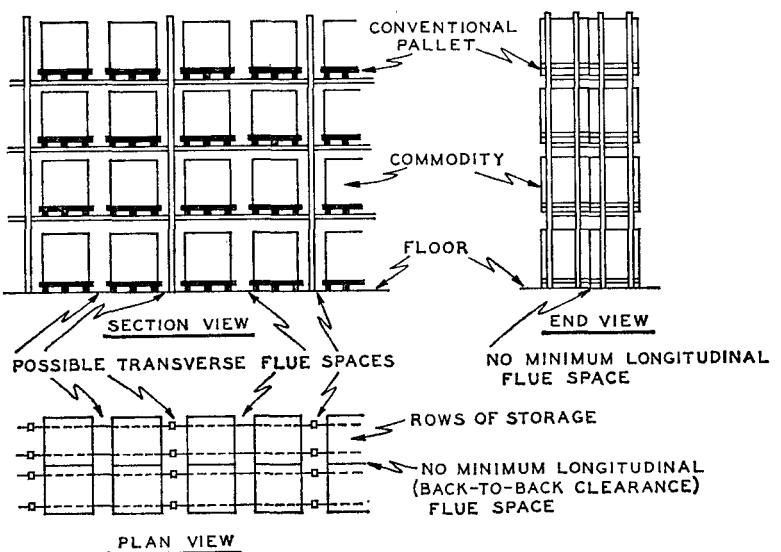


Fig. 4-3.1 Typical Double Row Rack

4-3.2 In double row racks with solid shelves, minimum six-inch flue spaces shall be maintained between the shelf sections thereby defining the shelf size (*see Figs. A4-3.2, A4-1.1c* and *d*).

4-4 Aisle Widths.

4-4.1 Aisle widths and depth of racks are determined by material handling methods. Width of aisles shall be considered in the design of the protection system (*see Chapters 5, 6 and 7*).

4-4.2 This standard contemplates that aisle widths will be maintained either by fixed rack structures or control in placing of portable racks. Any decrease in aisle width shall require a review of the adequacy of the protective system.

*4-5 Storage Heights.

†**4-5.1** The distance from the top of the pile to the ceiling sprinkler deflectors shall be not less than 18 inches.

4-6 Commodity Clearances.

*4-6.1 Commodity clearances shall be maintained in accordance with NFPA Standards as follows: *Heat Producing Appliances, NFPA 89M — 1971;* and *Blower and Exhaust Systems, NFPA 91 — 1973.*

*4-6.2 Incandescent Light Fixtures.

4-7 Storage of Empty Combustible Pallets.

4-7.1 For bulk storage of emtpy combustible pallets, see *Indoor General Storage, NFPA 231 — 1974.*

Chapter 5 Fire Protection — General

5-1 Protection Systems.

5-1.1 Protection systems which are provided for rack storage facilities shall be in accordance with the provisions of this chapter.

5-2 Ceiling Sprinklers.

***5-2.1** Where automatic sprinkler systems are installed, they shall be in accordance with *Installation of Sprinkler Systems, NFPA 13 — 1974,* except as modified by this Rack Storage of Materials Standard.

***5-2.2** In buildings that are occupied in part for rack storage of commodities, where only a portion of the sprinkler system is hydraulically designed, the design area shall extend 15 feet beyond the area occupied by the racks.

5-3 Ceiling Sprinkler Spacing.

5-3.1 Sprinkler spacing for high piled storage occupancies as defined in *NFPA 13 — 1974,* shall apply to Class I, II, III or IV commodities except as modified in 5-3.2 of this standard.

5-3.2 Sprinkler spacing may exceed 100 square feet, but shall not exceed 130 square feet, in systems hydraulically designed in accordance with the design curves shown in Figs 6-11.1a through g and 6-13.1a through d for densities below 0.25 gpm per square foot. Densities shall not be less than those shown on the design curves.

†5-3.3 For the purpose of selecting sprinkler spacings in hydraulically designed sprinkler systems, to obtain a stipulated density, 60 psi shall be the maximum discharge pressure used at the calculation starting point.

5-4 Ceiling Sprinkler Discharge Pressure.

†5-4.1 The minimum discharge from any ceiling sprinkler in the design area shall be 15 gpm in designs of new systems.

5-5 In-Rack Sprinkler System Size.

5-5.1 The area protected by a single system of sprinklers in racks (in-rack sprinklers) shall not exceed 40,000 square feet of floor area occupied by the racks including aisles regardless of the number of intermediate sprinkler levels.

5-6 In-Rack Sprinkler System Control Valves.

5-6.1 When sprinklers are installed in racks, separate indicating gate valves and drains shall be provided for ceiling sprinklers and sprinklers in racks, except such drains and valves are not required for small in-rack installations of less than 20 sprinklers (*see A5-8*).

5-7 In-Rack Sprinkler Water Demand.

5-7.1 Water demand of sprinklers installed in racks shall be added to ceiling sprinkler water demand at the point of connection.

*†5-8 Sprinkler Water Flow Alarm.

5-9 Hose Connections.

†5-9.1 For first aid fire fighting and for mop-up operations small (1½ inch) hose lines shall be available to cover all areas of the rack structure. 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 all sprinkler control valves

(d) Adjacent sprinkler systems.

5-10 Hose Streams.

5-10.1 For hose stream demand at least 500 gallons per minute shall be added to the sprinkler demand for Class I, II, III and IV commodities.

5-11 Duration of Water Supplies.

†5-11.1 For double row racks the water supply duration shall be at least 1½ hours for Class I, II and III commodities and at least two hours for Class IV commodities. For multiple row racks the water supply duration shall be at least two hours for all classifications of commodities.

5-12 High Expansion Foam.

***5-12.1** When high expansion foam systems are installed they shall be in accordance with *High Expansion Foam Systems, NFPA 11A — 1970,* except as modified by this Rack Storage of Materials Standard and they shall be automatic in operation.

5-12.2 When high expansion foam systems are used in combination with ceiling sprinklers, in-rack sprinklers are not required.

5-13 High Expansion Foam Detectors.

5-13.1 Detectors shall be listed by a recognized testing laboratory and shall be installed:

(a) At ceiling only at ½ listed spacing, or

(b) At ceiling at listed spacing and in racks at alternate levels, or

(c) Listed for rack storage installation and installed in accordance with their listing to provide response within one minute after ignition using ignition source equal to that used on the rack storage testing program.

5-14 Solid and Slatted Shelves.

*__5-14.1__ Slatted shelves shall be considered the same as solid shelves.

†__5-14.2__ Sprinklers shall be installed at the ceiling and beneath each shelf in double or multiple row racks with solid shelves that obstruct both longitudinal and transverse flue spaces. Design curves for combined ceiling and in-rack sprinklers shall be used with this storage configuration. (*See Fig. A4-3.2.*)

Chapter 6 Fire Protection — Storage Up to and Including 25 Feet in Height

Part A. General

NOTE: See also Chapter 5.

6-1 In-Rack Sprinkler Size.

6-1.1 Sprinklers in racks shall be ordinary temperature classification with nominal ½-inch orifice size pendent or upright.

6-2 In-Rack Sprinkler Pipe Size.

6-2.1 The number of sprinklers and the pipe sizing on a line of sprinklers in racks is restricted only by hydraulic calculations, and not by any piping schedule.

6-3 In-Rack Sprinkler Water Shields.

†**6-3.1** Water shields shall be provided directly above in-rack sprinklers when there is more than one level if not shielded by horizontal barriers.

6-4 In-Rack Sprinkler Location.

6-4.1 In double row racks without solid shelves with height of storage over 20 feet and in muliple row racks or double row racks with solid shelves, a minimum six-inch clear space shall be maintained between the sprinkler deflectors and the top of a tier of storage.

6-5 In-Rack Sprinkler Discharge Pressure.

6-5.1 Sprinklers in racks shall discharge at not less than 15 psi for all classes of commodity.

6-6 In-Rack Sprinkler Water Demand.

†**6-6.1** Water demand for sprinklers installed in racks shall be based on simultaneous operation of the most hydraulically remote:

(a) 6 sprinklers when only one level is installed in racks with Class I, II or III commodity.

(b) 8 sprinklers when only one level is installed in racks with Class IV commodity.

(c) 10 sprinklers (5 on each two top levels) when more than one level is installed in racks with Class I, II or III commodity.

(d) 14 sprinklers (7 on each two top levels) when more than one level is installed in racks with Class IV commodity.

6-7 Ceiling Sprinkler Water Demand.

*†**6-7.1** Design curves in Figs. 6-12.1a through g apply to nominal 20 foot height of storage.

6-7.2 For height of storage up to and including 25 feet protected with ceiling sprinklers only and for height of storage up to and including 20 feet protected with ceiling sprinklers and minimum acceptable in-rack sprinklers, densities given in design curves shall be adjusted according to Fig. 6-7.2, but to not less than 15 gpm per sprinkler.

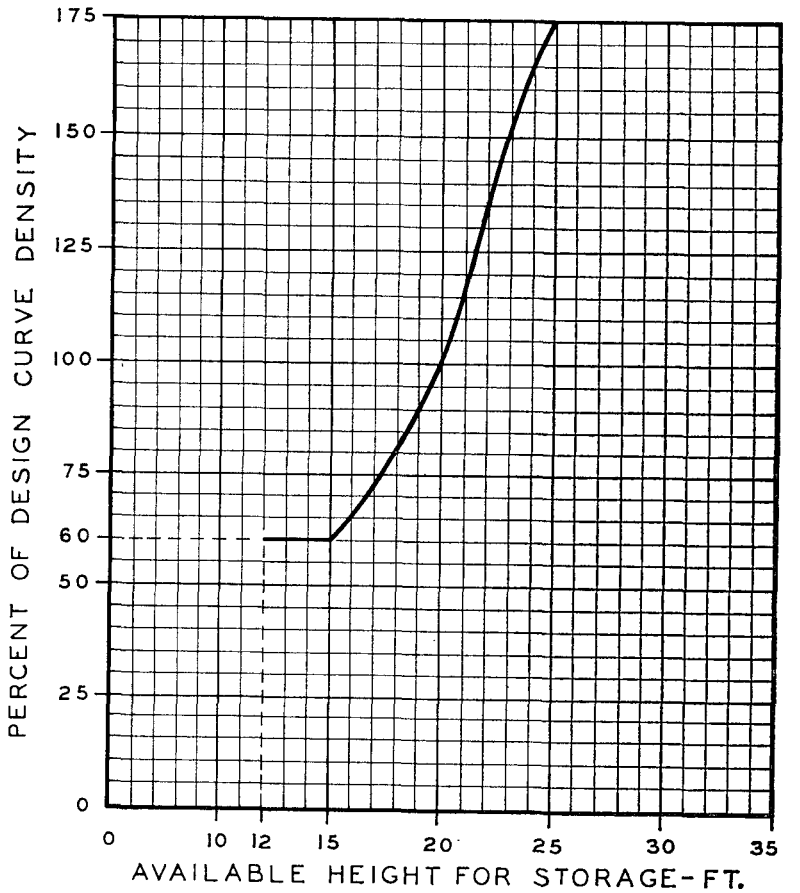


Fig. 6-7.2 Ceiling Sprinkler Design Curve.

6-7.3 For height of storage over 20 feet up to and including 25 feet protected with ceiling sprinklers and minimum acceptable in-rack sprinklers, densities given in design curves shall be used. Densities shall not be adjusted per Fig. 6-7.2.

6-7.4 For height of storage up to and including 20 feet protected with ceiling sprinklers and with more than one level of in-rack sprinklers, but not in every tier, densities given in design curves and adjusted according to Fig. 6-7.2 can be reduced an additional 20 percent, but to not less than 15 gpm per sprinkler.

6-7.5 For height of storage over 20 feet up to and including 25 feet protected with ceiling sprinklers and with more than one level of in-rack sprinklers, but not in every tier, densities given in design curves can be reduced 20 percent, but to not less than 15 gpm per sprinkler. Densities shall not be adjusted per Fig. 6-7.2.

6-7.6 For height of storage up to and including 20 feet protected with ceiling sprinklers and in-rack sprinklers at each tier, densities given in design curves and adjusted according to Fig. 6-7.2 can be reduced an additional 40 percent but to not less than 15 gpm per sprinkler.

6-7.7 For height of storage over 20 feet up to and including 25 feet protected with ceiling sprinklers and in-rack sprinklers at each tier, densities given in design curves can be reduced 40 percent but to not less than 15 gpm per sprinkler. Densities shall not be adjusted per Fig. 6-7.2.

6-7.8 The design curves indicate water demands for nominal 165°F and nominal 286°F sprinklers at the ceiling. The 165°F design curves shall be used for sprinklers with ordinary and intermediate temperature classification but not less than 160°F. The 286°F design curve shall be used for sprinklers with high temperature classification.

†**6-7.9** When clearance from top of storage to ceiling is less than 4½ feet (*see 4-5.1*), the sprinkler operating area indicated in curves E, F, G, and H in Figs. 6-12.1a, b, c, d, e, f, and g can be reduced as indicated in Fig. 6-7.9, but not less than 2,000 square feet (*see 6-7.10*).

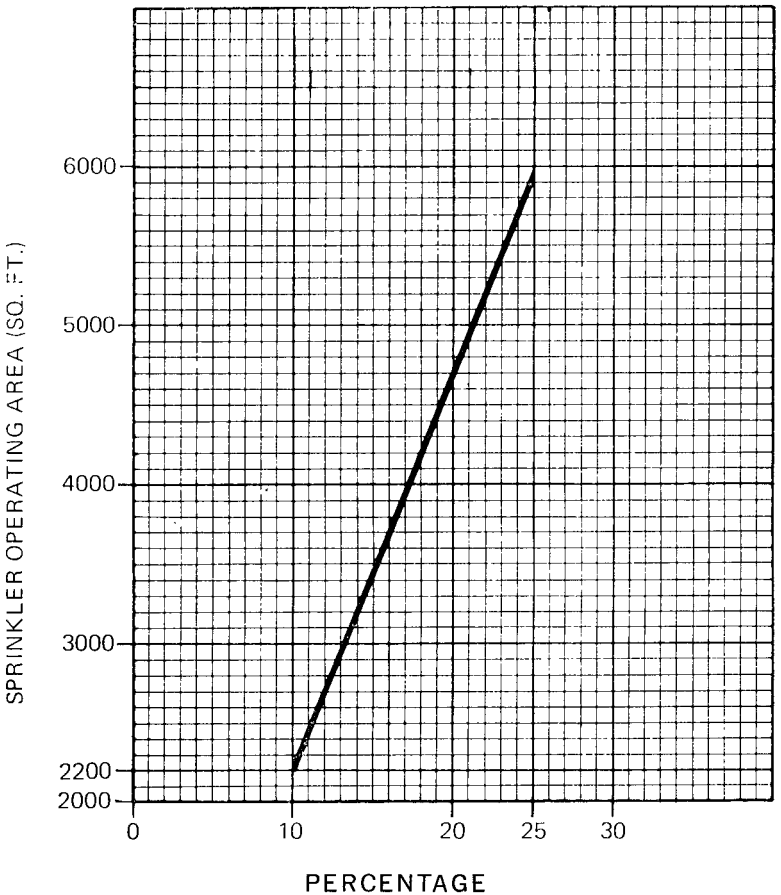


Fig. 6-7.9 Reduction in Sprinkler Operating Area

6-7.10 When clearance from ceiling to top of Class I or II encapsulated storage is 1½ to 3 feet, sprinkler operating area indicated in Curve F only of Fig. 6-12.1(e) may be reduced by 50 percent but to not less than 2000 square feet.

6-7.11 Where solid flat bottom wood pallets are used, or solid shelves four feet to eight feet deep (*see Fig. A4-3.2*) are used with height of storage up to and including 25 feet, the densities indicated in the design curves, based on conventional pallets, shall be increased 20 percent for the given area. This percentage shall be applied to the density resulting from the application of Fig. 6-7.2. This increase does not apply when in-rack sprinklers are installed.

6-8 High Expansion Foam Submergence.

*6-8.1 When high expansion foam systems are used without sprinklers the maximum submergence time shall be five minutes for Class I, II or III commodities and four minutes for Class IV commodities.

6-8.2 When high expansion foam systems are used in combination with ceiling sprinklers, the maximum submergence time shall be seven minutes for Class I, II or III commodities and four minutes for Class IV commodities.

6-9 High Expansion Foam Ceiling Sprinkler Density.

6-9.1 When high expansion foam systems are used in combination with ceiling sprinklers, the minimum ceiling sprinkler design shall be a density of 0.2 gpm per square foot for Class I, II or III commodities or 0.25 gpm per square foot for Class IV commodities for the most hydraulically remote 2,000 square foot operating area.

6-10 In-Rack Sprinkler Location.

6-10.1 In double row racks without solid shelves, one level of in-rack sprinklers shall be installed for Class IV nonencapsulated storage exceeding 22 feet in height and for Class I, II, III, and IV encapsulated storage exceeding 20 feet in height. (*See Table 6-12.1.*)

*†**6-10.2** In-rack sprinklers at one level only for storage up to and including 20 feet high in double row racks shall be located at ½ to ⅔ of the storage height. The elevation of in-rack sprinkler deflectors with respect to storage is not a consideration.

6-10.3 In-rack sprinklers at one level only for storage over 20 feet high and up to and including 25 feet high in double row racks shall be located at the tier level nearest ½ to ⅔ of the storage height.

6-10.4 In-rack sprinklers at two levels only for storage up to and including 25 feet high in double row racks shall be located at ¼ to ⅓ and ⅔ to ¾ of the storage height.

6-10.5 In-rack sprinklers at two levels only for storage up to and including 25 feet high in multiple row racks shall be located at tier levels nearest ¼ to ⅓ and ⅔ to ¾ of the storage height.

6-10.6 In racks with solid shelves or without solid shelves but with storage higher than 20 feet, a minimum of six inches shall be maintained between the sprinkler deflector and top of a tier of storage.

6-11 In-Rack Sprinkler Spacing.

***6-11.1** Maximum horizontal spacing of sprinklers in double row racks with nonencapsulating storage up to and including 25 feet in height shall be in accordance with the following table:

	Commodity Class		
Aisle Widths	**I & II**	**III**	**IV**
8 ft.	12 ft.	12 ft.	8 ft.
4 ft.	12 ft.	8 ft.	8 ft.

For encapsulated storage, maximum horizontal spacing is 8 feet.

†**6-11.2** The sprinklers installed in racks with height of storage up to and including 20 feet may be spaced without regard to rack uprights except as noted in 6-13.5, 7-14.3 and Table 7-10.1.

Part B. Double and Single Row Racks

NOTE: See also Chapter 5.

6-12 Ceiling Sprinkler Water Demand.

*6-12.1 For Class I, II, III or IV commodities encapsulated or nonencapsulated in double row racks, ceiling sprinkler water demand in terms of density (gpm per square foot) and area of sprinkler operation (square feet of ceiling or roof) shall be selected from curves given in Figs. 6-12.1a through g. The curves in Figs. 6-12.1a through g also apply to portable racks arranged in the same manner as double row racks or multiple row racks. Design is intended to be at a single point on the appropriate curve related to the storage configuration and commodity class. It is not necessary to meet all points on the selected curve. Fig. 6-7.2 shall be used to adjust density for storage height unless otherwise specified.

†6-12.2 Design curves for single and double row racks shall be selected corresponding to aisle width. For aisle widths between four feet and eight feet a direct linear interpolation between curves may be made. Density given for eight foot wide aisles shall be applied to aisles wider than eight feet. Density given for four foot wide aisles shall be applied to aisles narrower than four feet down to 3½ feet. Aisles narrower than 3½ feet shall be considered as multiple row racks.

Part C. Multiple Row Racks

NOTE: See also Chapter 5.

6-13 In-Rack Sprinkler Location

6-13.1 For encapsulated or nonencapsulated storage in multiple row racks no deeper than 16 feet with aisles no narrower than eight feet, one level of in-rack sprinklers shall be installed for Class II and III storage over 20 feet in height. One level of in-rack sprinklers shall be installed for Class IV storage over 15 feet up to and including 20 feet in height and two levels of in-rack sprinklers shall be installed for Class IV storage over 20 feet in height (*see Table 6-13.1*).

6-13.2 For encapsulated or nonencapsulated storage in multiple row racks deeper than 16 feet or with aisles less than eight feet wide, one level of in-rack sprinklers shall be installed for Class I, II and III storage over 15 feet in height. One level of in-rack sprinklers shall be installed for Class IV storage over 15 feet up to and including 20 feet in height and two levels of in-rack sprinklers shall be installed for Class IV storage exceeding 20 feet in height (*see Table 6-13.2*).

*__6-13.3__ Maximum horizontal spacing of sprinklers on branch lines in multiple row racks with nonencapsulating storage up to and including 25 feet in height shall not exceed 12 feet for Class I, II or III commodities and eight feet for Class IV commodities with area limitations of 100 square feet per sprinkler for Class I, II or III commodities, and 80 square feet per sprinkler for Class IV commodities. (Rack plan view shall be considered in determining area covered by each sprinkler. Aisles are not to be included in area calculations.)

6-13.4 A minimum of six inches shall be maintained between the sprinkler deflector and top of a tier of storage.

6-13.5 In-rack sprinklers shall be located at least two inches from rack uprights.

6-14 Ceiling Sprinkler Water Demand.

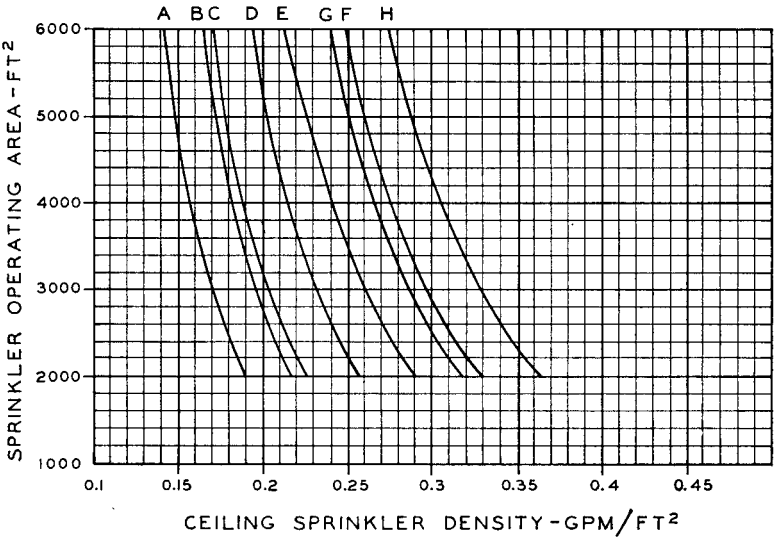
6-14.1 For nonencapsulated Class I, II, III or IV commodities ceiling sprinkler water demand in terms of density (gpm per square foot) and area of sprinkler operation (square feet of ceiling or roof) shall be selected from curves given in Fig. 6-14.1a through d. The curves in Fig. 6-14.1a through d also apply to portable racks arranged in the same manner as multiple row racks. Design is intended to be at a single point on the appropriate curve related to the storage configuration and commodity class. It is not necessary to meet all points on the selected curve. Fig. 6-7.2 shall be used to adjust density for storage height unless otherwise specified. (*See A6-11.1.*)

6-14.2 For encapsulated Class I, II or III commodities with height of storage up to and including 25 feet on multiple row racks, ceiling sprinkler density shall be 25 percent greater than for nonencapsulated commodities on multiple row racks.

6-14.3 For encapsulated Class IV commodities with height of storage up to and including 25 feet on multiple row racks, ceiling sprinkler density shall be 50 percent greater than for nonencapsulated commodities on multiple row racks.

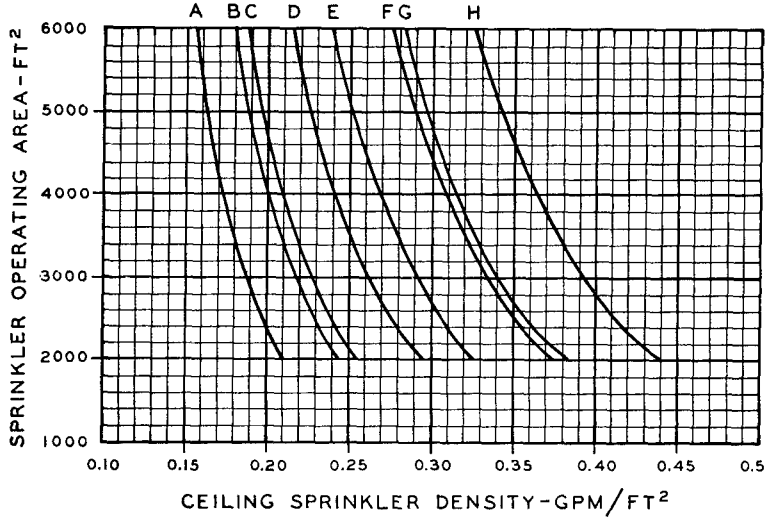
Height	Commodity Class	Encapsulated	Aisles (Ft) (4-4.1) (B6-12.2)	Sprinklers Mandatory In-Rack	Ceiling Sprinkler Water Demand					
					With In-Rack Sprinklers			Without In-Rack Sprinklers		
					Fig.	Curves	Apply Fig. 6-7.2	Fig.	Curves	Apply Fig. 6-7.2
Over 12 Ft., Up to 20 Ft.	I	No	4	No	6-12.1a	C & D	Yes	6-12.1a	G & H	Yes
			8			A & B			E & F	
		Yes	4	No	6-12.1e	C & D		6-12.1e	G & H	Yes
			8			A & B			E & F	
	II	No	4	No	6-12.1b	C & D		6-12.1b	G & H	Yes
			8			A & B			E & F	
		Yes	4	No	6-12.1e	C & D		6-12.1e	G & H	Yes
			8			A & B			E & F	
	III	No	4	No	6-12.1c	C & D		6-12.1c	G & H	Yes
			8			A & B			E & F	
		Yes	4	1 Level	6-12.1f	C & D				
			8			A & B				
	IV	No	4	No	6-12.1d	C & D		6-12.1d	G & H	Yes
			8			A & B			E & F	
		Yes	4	1 Level	6-12.1g	C & D				
			8			A & B				
Over 20 Ft., Up to 22 Ft.	I	No	4	No	6-12.1a	C & D	No	6-12.1a	G & H	Yes
			8			A & B			E & F	
		Yes	4	1 Level	6-12.1e	C & D				
			8			A & B				
	II	No	4	No	6-12.1b	C & D		6-12.1b	G & H	Yes
			8			A & B			E & F	
		Yes	4	1 Level	6-12.1e	C & D				
			8			A & B				
	III	No	4	No	6-12.1c	C & D		6-12.1c	E & F	Yes
			8			A & B			G & H	
		Yes	4	1 Level	6-12.1f	C & D				
			8			A & B				
	IV	No	4	No	6-12.1d	C & D		6-12.1d	E & F	Yes
			8			A & B			G & H	
		Yes	4	1 Level	6-12.1g	C & D				
			8			A & B				
Over 22 Ft., Up to 25 Ft.	I	No	4	No	6-12.1a	C & D	No	6-12.1a	G & H	Yes
			8			A & B			E & F	
		Yes	4	1 Level	6-12.1e	C & D				
			8			A & B				
	II	No	4	No	6-12.1b	C & D		6-12.1b	G & H	Yes
			8			A & B			E & F	
		Yes	4	1 Level	6-12.1e	C & D				
			8			A & B				
	III	No	4	No	6-12.1c	C & D		6-12.1c	G & H	Yes
			8			A & B			E & F	
		Yes	4	1 Level	6-12.1f	C & D				
			8			A & B				
	IV	No	4	1 Level	6-12.1d	C & D				
			8			A & B				
		Yes	4		6-12.1g	C & D				
			8			A & B				

Table 6-12.1 Double row racks. Height of Storage up to and Including 25 Ft., Aisles Wider Than 4 Ft., Without Solid Shelves.



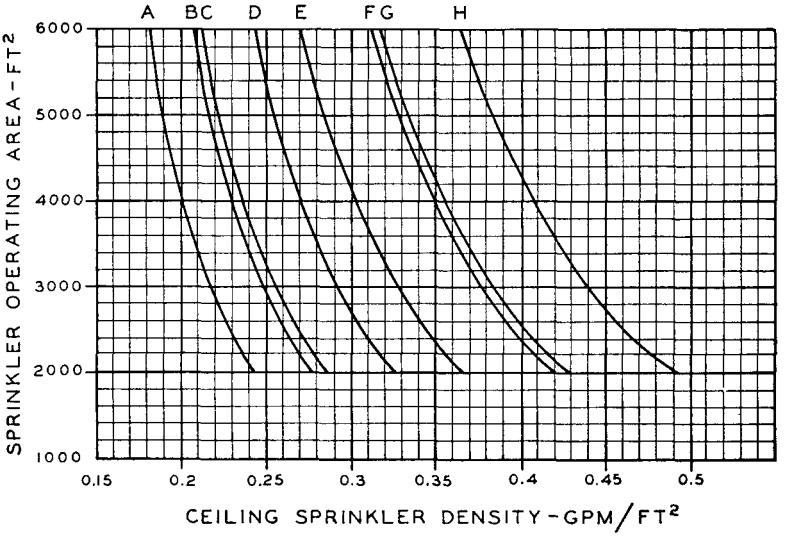
Curve	Legend
A	*8 ft. aisles with 286°F ceiling sprinklers and 165°F in-rack sprinklers*
B	*8 ft. aisles with 165°F ceiling sprinklers and 165°F in-rack sprinklers*
C	*4 ft. aisles with 286°F ceiling sprinklers and 165°F in-rack sprinklers*
D	*4 ft. aisles with 165°F ceiling sprinklers and 165°F in-rack sprinklers*
E	*8 ft. aisles with 286°F ceiling sprinklers*
F	*8 ft. aisles with 165°F ceiling sprinklers*
G	*4 ft. aisles with 286°F ceiling sprinklers*
H	*4 ft. aisles with 165°F ceiling sprinklers*

Fig. 6-12.1a Double Row Racks — 20 Foot High Rack Storage — Sprinkler System Design Curves — Class I Nonencapsulated Commodities — Conventional Pallets.



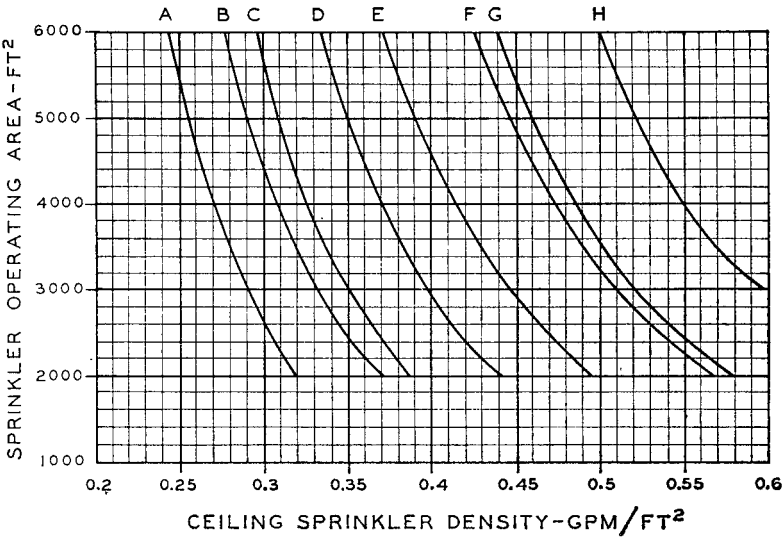
Curve	Legend
A	*8 ft. aisles with 286°F ceiling sprinklers and 165°F in-rack sprinklers*
B	*8 ft. aisles with 165°F ceiling sprinklers and 165°F in-rack sprinklers*
C	*4 ft. aisles with 286°F ceiling sprinklers and 165°F in-rack sprinklers*
D	*4 ft. aisles with 165°F ceiling sprinklers and 165°F in-rack sprinklers*
E	*8 ft. aisles with 286°F ceiling sprinklers*
F	*8 ft. aisles with 165°F ceiling sprinklers*
G	*4 ft. aisles with 286°F ceiling sprinklers*
H	*4 ft. aisles with 165°F ceiling sprinklers*

Fig. 6-12.1b. Double Row Racks — 20 Foot High Rack Storage — Sprinkler System Design Curves — Class II Nonencapsulated Commodities — Conventional Pallets.



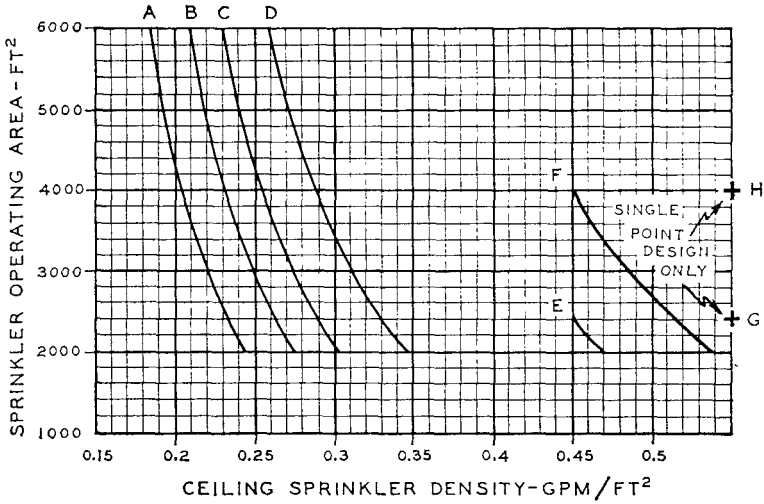
Curve	Legend
A	*8 ft. aisles with 286°F ceiling sprinklers and 165°F in-rack sprinklers*
B	*8 ft. aisles with 165°F ceiling and 165°F in rack sprinklers*
C	*4 ft. aisles with 286°F ceiling sprinklers and 165°F in-rack sprinklers*
D	*4 ft. aisles with 165°F ceiling sprinklers and 165°F in-rack sprinklers*
E	*8 ft. aisles with 286°F ceiling sprinklers*
F	*8 ft. aisles with 165°F ceiling sprinklers*
G	*4 ft. aisles with 286°F ceiling sprinklers*
H	*4 ft. aisles with 165°F ceiling sprinklers*

Fig. 6-12.1c. Double Row Racks — 20 Foot High Rack Storage — Sprinkler System Design Curves — Class III Nonencapsulated Commodities — Conventional Pallets.



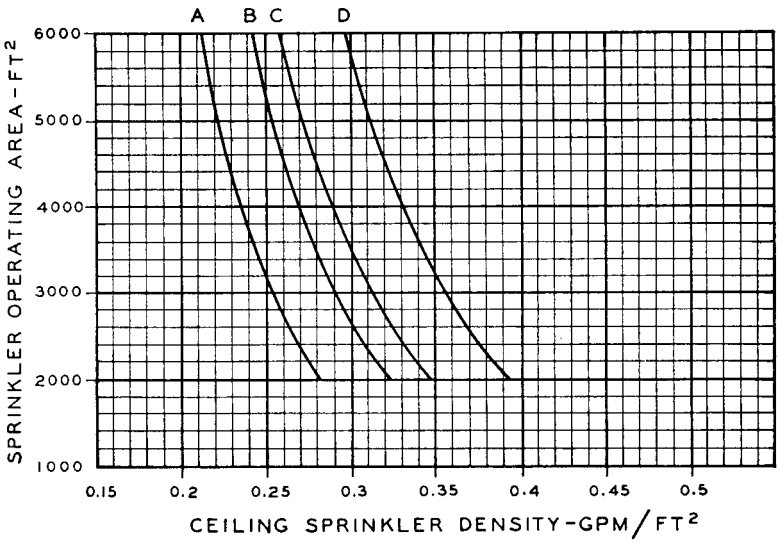
Curve	Legend
A	*8 ft. aisles with 286°F ceiling sprinklers and 165°F in-rack sprinklers*
B	*8 ft. aisles with 165°F ceiling sprinklers and 165°F in-rack sprinklers*
C	*4 ft. aisles with 286°F ceiling sprinklers and 165°F in-rack sprinklers*
D	*4 ft. aisles with 165°F ceiling sprinklers and 165°F in-rack sprinklers*
E	*8 ft. aisles with 286°F ceiling sprinklers*
F	*8 ft. aisles with 165°F ceiling sprinklers*
G	*4 ft. aisles with 286°F ceiling sprinklers*
H	*4 ft. aisles with 165°F ceiling sprinklers*

Fig. 6-12.1d. Double Row Racks — 20 Foot High Rack Storage — Sprinkler System Design Curves — Class IV Nonencapsulated Commodities — Conventional Pallets.



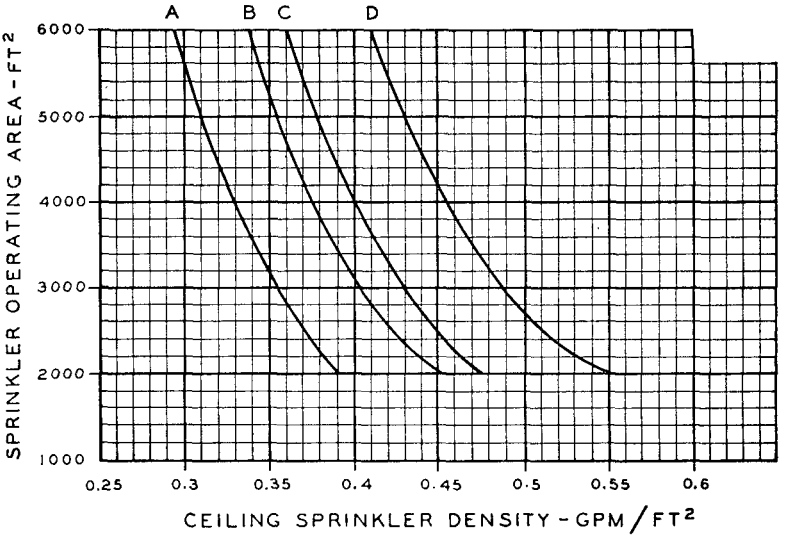
Curve	Legend
A	*— 8 ft. aisles with 286°F ceiling sprinklers and 165°F in-rack sprinklers*
B	*— 8 ft. aisles with 165°F ceiling sprinklers and 165°F in-rack sprinklers*
C	*— 4 ft. aisles with 286°F ceiling sprinklers and 165°F in-rack sprinklers*
D	*— 4 ft. aisles with 165°F ceiling sprinklers and 165°F in-rack sprinklers*
E	*— 8 ft. aisles with 286°F ceiling sprinklers*
F	*— 8 ft. aisles with 165°F ceiling sprinklers*
G	*— 4 ft. aisles with 286° ceiling sprinklers*
H	*— 4 ft. aisles with 165° ceiling sprinklers*

Fig. 6-12.1e. Double Row Racks — 20 Foot High Rack Storage — Sprinkler System Design Curves — Class I & II Encapsulated Commodities — Conventional Pallets.



Curve	Legend
A	*8 ft. aisles with 286°F ceiling sprinklers and 165°F in-rack sprinklers*
B	*8 ft. aisles with 165°F ceiling sprinklers and 165°F in-rack sprinklers*
C	*4 ft. aisles with 286°F ceiling sprinklers and 165°F in-rack sprinklers*
D	*4 ft. aisles with 165°F ceiling sprinklers and 165°F in-rack sprinklers*

Fig. 6-12.1f. Double Row Racks — 20 Foot High Rack Storage — Sprinkler System Design Curves — Class III Encapsulated Commodities — Conventional Pallets.



Curve	Legend
A	*— 8 ft. aisles with 286°F ceiling sprinklers and 165°F in-rack sprinklers*
B	*— 8 ft. aisles with 165°F ceiling sprinklers and 165°F in-rack sprinklers*
C	*— 4 ft. aisles with 286°F ceiling sprinklers and 165°F in-rack sprinklers*
D	*— 4 ft. aisles with 165°F ceiling sprinklers and 165°F in-rack sprinklers*

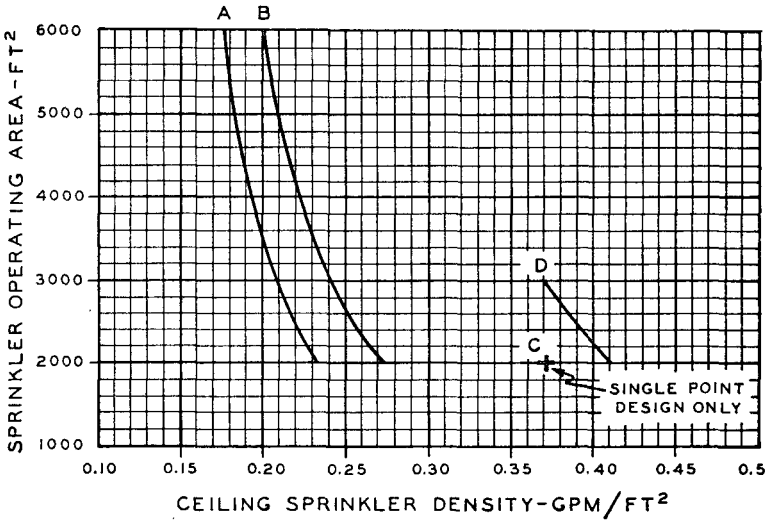
Fig. 6-12.1g. Double Row Racks — 20 Foot High Rack Storage — Sprinkler System Design Curves — Class IV encapsulated Commodities — Conventional Pallets.

Table 6-13.1 Multiple-Row Racks. Rack Depth Up to 16 Ft., Aisles Wider Than 8 Ft., Storage Height Up To 25 Ft.

Height	Commodity Class	Encapsulated	Sprinklers Mandatory In-Racks	Ceiling Sprinkler Water Demand							
				With In-Rack Sprinklers				Without In-Rack Sprinklers			
				Fig. No.	Curves	Apply Fig. 6-7.2	1.25x Density	Fig. No.	Curves	Apply Fig. 6-7.2	1.25x Density
Over 12 Ft Up to 15 Ft	I	No	No	6-14.1a	A&B	Yes	No	6-14.1a	C&D	Yes	No
		Yes		6-14.1a			Yes	6-14.1a	C&D		Yes
	II	No		6-14.1b			No	6-14.1b	C&D	Yes	No
		Yes		6-14.1b			Yes	6-14.1b	C&D		Yes
	III	No	No	6-14.1c			No	6-14.1c	C&D	Yes	No
		Yes	No	6-14.1c			Yes	6-14.1c	C&D	Yes	Yes
	IV	No	No	6-14.1d			No	6-14.1d	A&B	No	No
		Yes	No	6-12.1d			1.50x Density	6-12.1d	E&F	Yes	1.50x Density
Over 15 Ft Up to 20 Ft	I	No	No	6-14.1a	A&B	Yes	No	6-14.1a	C&D	Yes	No
		Yes		6-14.1a			Yes	6-14.1a	C&D		Yes
	II	No		6-14.1b			No	6-14.1b	C&D	Yes	No
		Yes		6-14.1b			Yes	6-14.1b	C&D		Yes
	III	No	No	6-14.1c			No	6-14.1c	C&D	Yes	No
		Yes	No	6-14.1c			Yes	6-14.1c	C&D	Yes	Yes
	IV	No	1 Level	6-14.1d			No				
		Yes		6-12.1d			1.50x Density				
Over 20 Ft Up to 25 Ft	I	No	No	6-14.1a	A&B	No	No	6-14.1a	C&D	Yes	No
		Yes		6-14.1a			Yes	6-14.1a	C&D		Yes
	II	No	1 Level	6-14.1b			No				
		Yes		6-14.1b			Yes				
	III	No		6-14.1c			No				
		Yes		6-14.1c			Yes				
	IV	No	2 Level	6-14.1d			No				
		Yes		6-14.1d			1.50x Density				

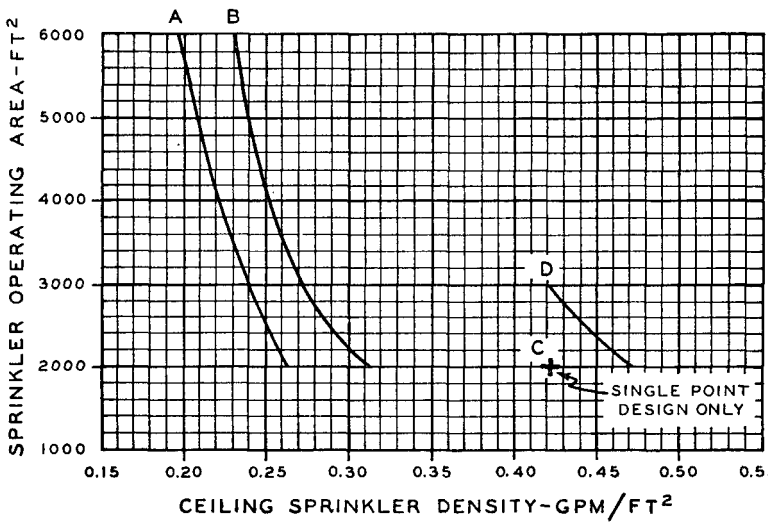
Height	Commodity Class	Encapsulated	Sprinklers Mandatory In-Racks	Ceiling Sprinkler Water Demand							
				With In-Rack Sprinklers				Without In-Rack Sprinklers			
				Fig. No.	Curves	Apply Fig. 6-7.2	1.25x Density	Fig. No.	Curves	Apply Fig. 6-7.2	1.25x Density
Over 12 Ft Up to 15 Ft	I	No	No	6-14.1a	A&B	Yes	No	6-14.1a	C&D	Yes	No
		Yes		6-14.1a			Yes	6-14.1a	C&D		Yes
	II	No		6-14.1b			No	6-14.1b	C&D	Yes	No
		Yes		6-14.1b			Yes	6-14.1b	C&D		Yes
	III	No		6-14.1c			No	6-14.1c	C&D	Yes	No
		Yes	No	6-14.1c			Yes	6-14.1c	C&D	Yes	Yes
	IV	No	No	6-14.1d			No	6-14.1d	A-B	No	No
		Yes	No	6-12.1d	C&D		1.50x Density	6-12.1d	G&H	Yes	1.50x Density
Over 15 Ft Up to 20 Ft	I	No	1 Level	6-14.1a	A&B	Yes	No				
		Yes		6-14.1a			Yes				
	II	No		6-14.1b			No				
		Yes		6-14.1b			Yes				
	III	No		6-14.1c			No				
		Yes		6-14.1c			Yes				
	IV	No		6-14.1d			No				
		Yes		6-12.1d	C&D		1.50x Density				
Over 20 Ft Up to 25 Ft	I	No	1 Level	6-14.1a	A&B	No	No				
		Yes		6-14.1a			Yes				
	II	No		6-14.1b			No				
		Yes		6-14.1b			Yes				
	III	No		6-14.1c			No				
		Yes		6-14.1c			Yes				
	IV	No	2 Levels	6-14.1d			No				
		Yes		6-12.1d	C&D		1.50x Density				

Table 6-13.2 Multiple-Row Racks. Rack Depth Over 16 Ft. or Aisles Narrower Than 8 Ft. Storage Height Up to 25 Ft.



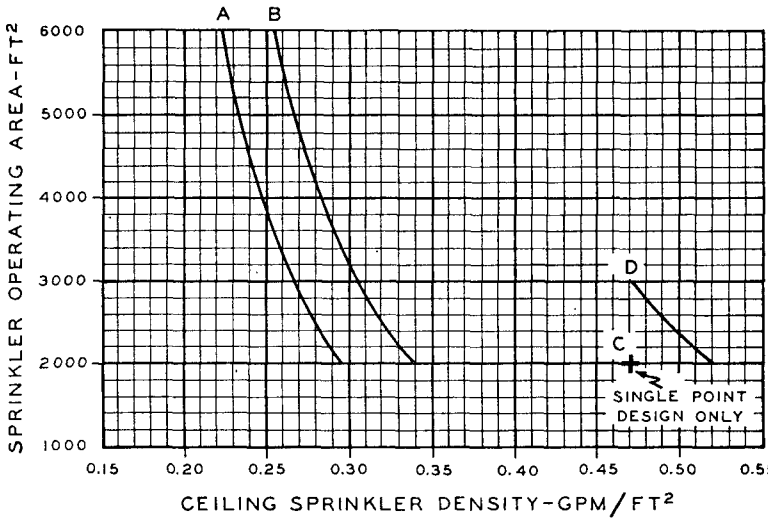
Curve	Legend
A	*8 ft. aisles with 286°F ceiling sprinklers and 165°F in-rack sprinklers*
B	*8 ft. aisles with 165°F ceiling sprinklers and 165°F in-rack sprinklers*
C	*8 ft. aisles with 286°F ceiling sprinklers*
D	*8 ft. aisles with 165°F ceiling sprinklers*

Fig. 6-14.1a. Multiple Row Racks — 20 Foot High Rack Storage — Sprinkler System Curves Storage — Class I Nonencapsulated Commodities — Conventional Pallets.



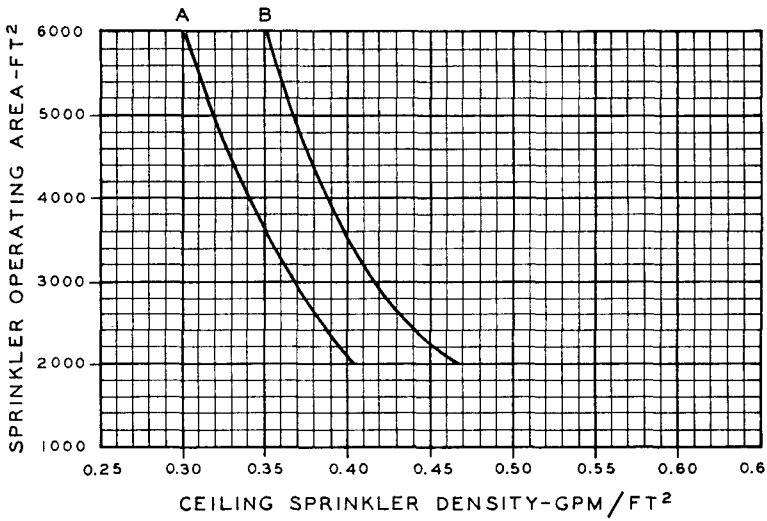
Curve	Legend
A	*— 8 ft. aisles with 286°F ceiling sprinklers and 165°F in-rack sprinklers*
B	*— 8 ft. aisles with 165°F ceiling sprinklers and 165°F in-rack sprinklers*
C	*— 8 ft. aisles with 286°F ceiling sprinklers*
D	*— 8 ft. aisles with 165°F ceiling sprinklers*

Fig. 6-14.1b. Multiple Row Racks — 20 Foot High Rack Storage — Sprinkler System Design Curves — Class II Nonencapsulated Commodities — Conventional Pallets.



Curve	Legend
A	*8 ft. aisles with 286°F ceiling sprinklers and 165°F in-rack sprinklers*
B	*8 ft. aisles with 165°F ceiling sprinklers and 165°F in-rack sprinklers*
C	*8 ft. aisles with 286°F ceiling sprinklers*
D	*8 ft. aisles with 165°F ceiling sprinklers*

Fig. 6-14.1c. Multiple Row Racks — 20 Foot High Rack Storage — Sprinkler System Design Curves — Class III Nonencapsulated Commodities — Conventional Pallets.



Curve	Legend	Curve	Legend
A	*— 8 ft. aisles with 286°F ceiling sprinklers and 165°F in-rack sprinklers*	*B*	*— 8 ft. aisles with 165°F ceiling sprinklers and 165°F in-rack sprinklers*

Fig. 6-14.1d. Multiple Row Racks — 20 Foot High Rack Storage — Sprinkler System Design Curves — Class IV Nonencapsulated Commodities — Conventional Pallets.

NOTE: Curves A and B also apply to ceiling sprinklers only for height of storage up to and including 15 feet and Fig. 6-7.9 shall not be applied.

Chapter 7
Fire Protection — Storage Over 25 Feet in Height

Part A. General

7-1 In-Rack Sprinkler Size.

7-1.1 Sprinklers in racks shall be ordinary temperature classification with nominal ½-inch orifice size pendent or upright.

7-2 In-Rack Sprinkler Spacing.

7-2.1 In-rack sprinklers shall be staggered horizontally and vertically when installed as indicated in Table 7-10.1, Figs. 7-10.1a through j, and 7-10.3.

7-3 In-Rack Sprinkler Pipe Size.

7-3.1 The number of sprinklers and the pipe sizing on a line of sprinklers in racks is restricted only by hydraulic calculations, and not by any piping schedule.

7-4 In-Rack Sprinkler Water Shields.

7-4.1 Water shields shall be provided directly above in-rack sprinklers when there is more than one level if not shielded by horizontal barriers (*see Appendix B6-3.1*).

7-7 In-Rack Sprinkler Water Demand.

7-5.1 In double row or multiple row racks, a minimum six-inch clear space shall be maintained between the sprinkler deflectors and the top of a tier of storage. Face sprinklers in such racks shall be located a minimum of three inches from rack uprights and no more than 18 inches from the aisle face of storage. Other sprinklers in racks shall be located a minimum of two feet from rack uprights.

7-6 In-Rack Sprinkler Discharge Pressure.

7-6.1 Sprinklers in racks shall discharge at not less than 30 psi for all classes of commodity (*see Appendix B5-4.1*).

7-7 In-Rack Sprinkler Water Demand.

7-7.1 Water demand for sprinklers installed in racks shall be based on simultaneous operation of the most hydraulically remote:

(a) 6 sprinklers when only one level is installed in racks with Class I, II or III commodity.

(b) 8 sprinklers when only one level is installed in racks with Class IV commodity.

(c) 10 sprinklers (5 on each two top levels) when more than one level is installed in racks with Class I, II or III commodity.

(d) 14 sprinklers (7 on each two top levels) when more than one level is installed in racks with Class IV commodity.

7-8 High Expansion Foam Submergence.

7-8.1 With height of storage over 25 feet up to and including 35 feet when high expansion foam systems are used, they shall be used in combination with ceiling sprinklers. The maximum submergence time for the high expansion foam shall be five minutes for Class I, II or III commodities and four minutes for Class IV commodities.

7-9 High Expansion Foam—Ceiling Sprinkler Water Demand.

7-9.1 When high expansion foam is used in combination with ceiling sprinklers, the sprinkler design shall be 0.2 gpm per square foot for Class I, II or III commodities and 0.25 gpm per square foot for Class IV commodities over the most hydraulically remote 2,000 square foot area.

Part B. Double and Single Row Racks

7-10 In-Rack Sprinkler Location.

7-10.1 In double row racks without solid shelves and with a maximum of 10 feet between top of storage and ceiling, in-rack sprinklers shall be installed as indicated in Table 7-10.1 and Figs. 7-10.1a through j. The highest level of in-rack sprinklers shall not be more than 10 feet below top of storage (*see 7-11.1*).

7-10.2 In-rack sprinklers for storage higher than 25 feet in double row racks shall be spaced horizontally and located in horizontal space nearest the vertical intervals indicated in Table 7-10.1, Figs. 7-10.1a through j.

*__7-10.3__ In single row racks without solid shelves with height of storage over 25 feet and a maximum of 10 feet between top of storage and ceiling, sprinklers shall be installed as indicated in Fig. 7-10.3.

Table 7-10.1 Double-Row Racks Without Solid Shelves, Storage Higher Than 25 Feet, Aisles Wider Than 4 Feet.

Commodity Class	In-rack sprinklers — approximate vertical spacing at tier nearest the vertical distance and maximum horizontal spacing (1) (2).		Fig. No.	Maximum Storage Height	Stagger	Ceiling Sprinkler Operating Area	Ceiling Sprinkler Density .gpm/sq. ft.) (6) Clearance (5) Up to 10 ft. (7)	
	Longitudinal Flue (3)	Face (4)					165°	286°
I	Vertical 20 ft. Horizontal 10 ft. under horizontal Barriers	None	7-10.1a	30 ft.	No	2000 sq. ft.	0.25	0.35
	Vertical 20 ft. Horizontal 10 ft.	Vertical 20 ft. Horizontal 10 ft.	7-10.1b	Higher than 25 ft.	Yes		0.25	0.35
II&III	Vertical 10 ft. or at 15 ft. & 25 ft. Horizontal 10 ft.	None	7-10.1c	30 ft.	Yes	2000 sq. ft.	0.30	0.40
	Vertical 10 ft. Horizontal 10 ft.	Vertical 30 ft. Horizontal 10 ft.	7-10.1d	Higher than 25 ft.	Yes		0.30	0.40
	Vertical 20 ft. Horizontal 10 ft.	Vertical 20 ft. Horizontal 5 ft.	7-10.1e		Yes		0.30	0.40
	Vertical 25 ft. Horizontal 5 ft.	Vertical 25 ft. Horizontal 5 ft.	7-10.1f		No		0.30	0.40
	Horizontal barriers at 20 ft. Vertical Intervals-2 lines of sprinklers under barriers-maximum horizontal spacing 10 ft. staggered.		7-10.1g		Yes		0.30	0.40
IV	Vertical 15 ft. Horizontal 10 ft.	Vertical 20 ft. Horizontal 10 ft.	7-10.1h	Higher than 25 ft.	Yes	2000 sq. ft.	0.35	0.45
	Vertical 20 ft. Horizontal 5 ft.	Vertical 20 ft. Horizontal 5 ft.	7-10.1i		No		0.35	0.45
	Horizontal barriers at 15 ft. Vertical intervals-2 lines of sprinkler under barriers-maximum horizontal spacing 10 ft. staggered		7-10.1j		Yes		0.35	0.45

Footnotes — see page 41.

Footnotes to Table 7-10.1

[1]Minimum in-rack sprinkler pressure, 30 psi (7-6.1)

[2]Water shields required (6-3.1 and 7-4.1)

[3]Install sprinklers at least 2 ft. from uprights (A6-10.2)

[4]Install sprinklers at least 3 in. from uprights (7-5.1)

[5]Clearance is distance between maximum height of storage and ceiling

[6]For encapsulated commodity increase density 25% (7-12.1)

[7]See 7-10.3, 7-11.1, 7-12.1 and A7-12.1 for protection suggestions when clearance is greater than 10 feet

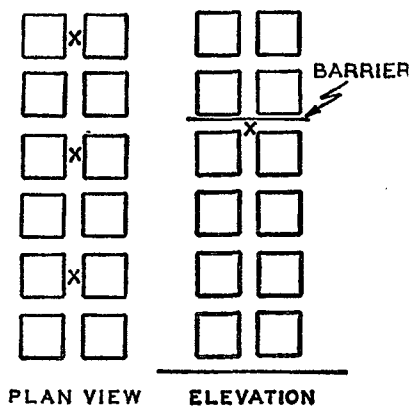


Fig. 7-10.1a. In-Rack Sprinkler Arrangement, Class I Commodity, Maximum Height of Storage 25 Ft. to 30 Ft.

NOTE:
1. Symbol X indicates in-rack sprinklers.

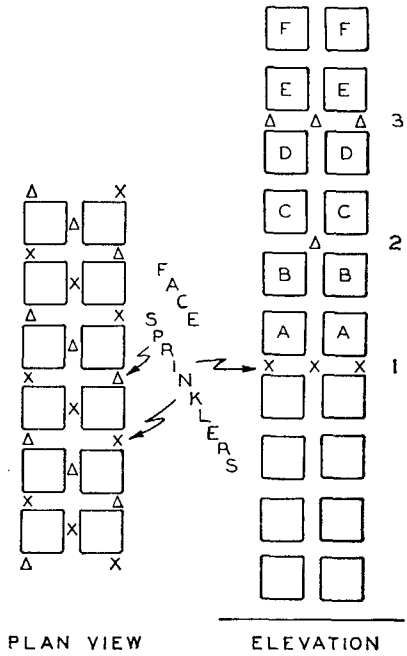


Fig. 7-10.1b. In-Rack Sprinkler Arrangement, Class I Commodity, Height of Storage over 25 Feet.

NOTES

1. Sprinklers labeled 1 (the selected array from Table 7–2.1) required when loads labeled A or B represent top of storage.
2. Sprinklers labeled 1 and 2 required when loads labeled C or D represent top of storage.
3. Sprinklers labeled 1 and 3 required when loads labeled E or F represent top of storage.
4. For storage higher than represented by loads labeled F, the cycle defined by notes 2 and 3 is repeated WITH STAGGER AS INDICATED.
5. Symbols △ or X indicate sprinklers on vertical or horizontal stagger.

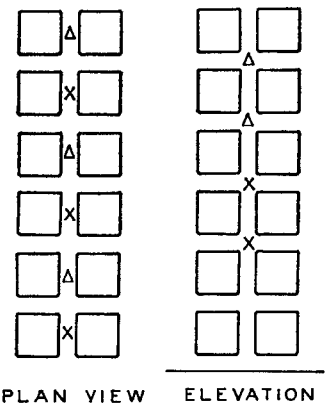


Fig. 7-10.1c. In-Rack Sprinkler Arrangement, Class I, II or III Commodity, Maximum Height of Storage 25 Ft. to 30 Ft.

NOTES:

1. Alternate location of in-rack sprinklers. Sprinklers may be installed at the second and fourth or the third and fifth tiers.
2. Symbols △ or X indicate sprinklers on vertical or horizontal stagger.

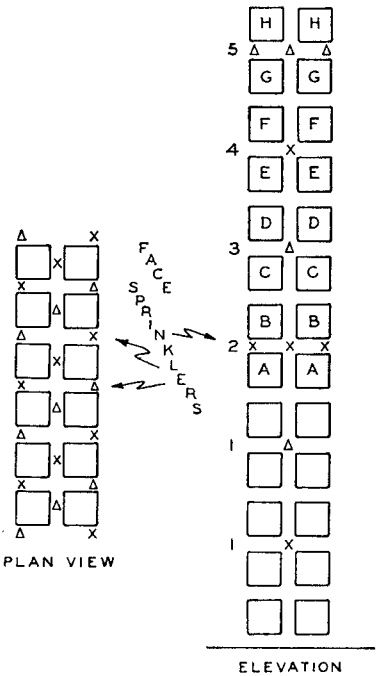


Fig. 7-10.1d. In-Rack Sprinkler Arrangement, Class I, II or III Commodity, Height of Storage over 25 Feet.

NOTES:

1. Sprinklers labeled 1 required when loads labeled A represent the top of storage.
2. Sprinklers labeled 1 and 2 required when loads labeled B or C represent top of storage.
3. Sprinklers labeled 1, 2 and 3 required when loads labeled D or E represent top of storage.
4. Sprinklers labeled 1, 2, 3 and 4 required when loads labeled F or G represent top of storage.
5. Sprinklers labeled 1, 2, 3, 4 and 5 required when loads labeled H represent top of storage.
6. For storage higher than represented by loads labeled H, the cycle defined by Notes 3, 4 and 5 is repeated with stagger as indicated.
7. The indicated face sprinklers may be omitted when commodity consists of unwrapped or unpackaged metal parts on wood pallets.
8. Symbols △ or × indicate sprinklers on vertical or horizontal stagger.

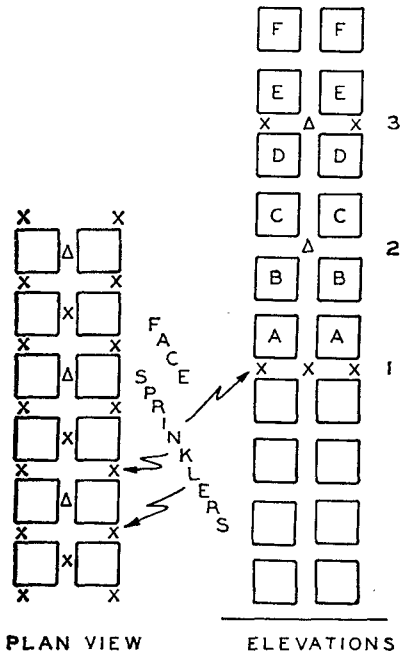


Fig. 7-10.1e. In-Rack Sprinkler Arrangement, Class I, II or III Commodity, Height of Storage Over 25 Feet.

NOTES:

1. Sprinklers labeled 1 (the selected array from Table 7-10.1) required when loads labeled A or B represent top of storage.

2. Sprinklers labeled 1 and 2 required when loads labeled C or D represent top of storage.

3. Sprinklers labeled 1 and 3 required when loads labeled E or F represent top of storage.

4. For storage higher than represented by loads labeled F, the cycle defined by notes 2 and 3 is repeated, with stagger as indicated.

5. Symbols △ or X indicate sprinklers on vertical or horizontal stagger.

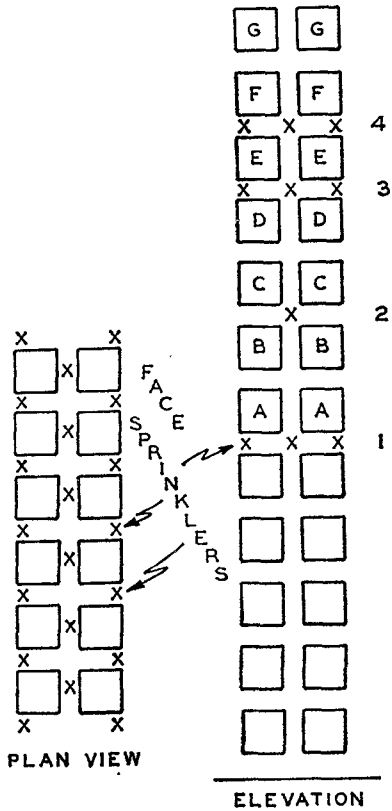


Fig. 7-10.1f. In-Rack Sprinkler Arrangement, Class I, II or III Commodity, Height of Storage over 25 Feet.

NOTES:

1. Sprinklers labeled 1 (the selected array from Table 7-10.1) required when loads labeled A or B represent top of storage.

2. Sprinklers labeled 1 and 2 required when loads labeled C or D represent top of storage.

3. Sprinklers labeled 1 and 3 required when loads labeled E represent top of storage.

4. Sprinklers labeled 1 and 4 required when loads labeled F or G represent top of storage.

5. For storage higher than represented by loads labeled G, the cycle defined by notes 2, 3, and 4 is repeated.

6. Symbol X indicates face and in-rack sprinklers.

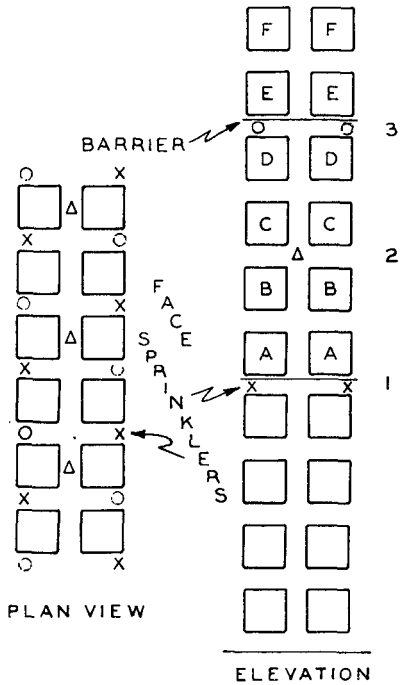


Fig. 7-10.1g. In-Rack Sprinkler Arrangement, Class I, II or III Commodity, Height of Storage over 25 Feet.

NOTES:

1. Sprinklers labeled 1 (the selected array from Table 7-10.1) required when loads labeled A or B represent top of storage.
2. Sprinklers labeled 1 and 2 required when loads labeled C or D represent top of storage.
3. Sprinklers labeled 1 and 3 required when loads E or F represent top of storage.
4. For storage higher than represented by loads labeled F, the cycle defined by notes 2 and 3 is repeated.
5. Symbols O, △ or X indicate sprinklers on vertical or horizontal stagger.

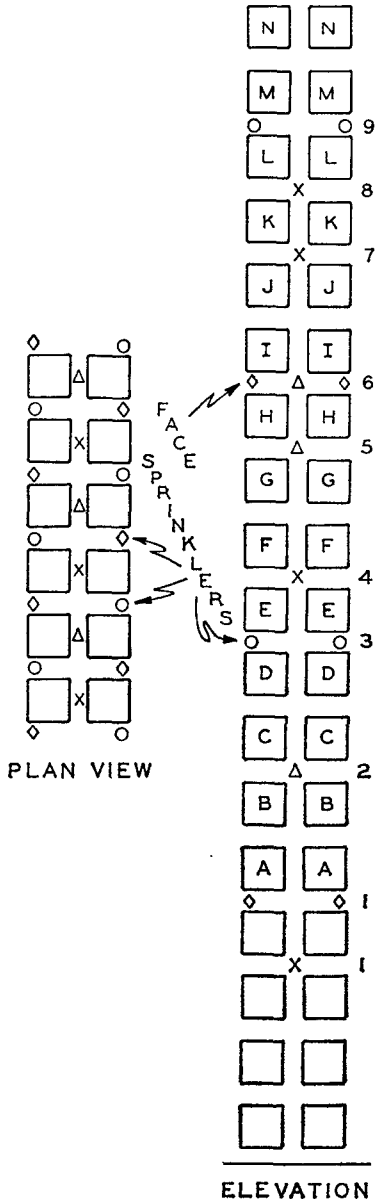


Fig. 7-10.1h. In-Rack Sprinkler Arrangement, Class I, II, III or IV Commodity, Height of Storage over 25 Feet.

NOTES:

1. Sprinklers labeled 1 (the selected array from Table 7-10.1) required when loads labeled A or B represent top of storage.

2. Sprinklers labeled 1 and 2 required when loads labeled C or D represent top of storage.

3. Sprinklers labeled 1, 2, and 3 required when loads labeled E or F represent top of storage.

4. Sprinklers labeled 1, 2, 3 and 4 required when loads labeled G represent top of storage.

5. Sprinklers labeled 1, 2, 3, 4 and 5 required when loads labeled H represent top of storage.

6. Sprinklers labeled 1, 2, 3, 4 and 6 (not 5) required when loads labeled I or J represent top of storage.

7. Sprinklers labeled 1, 2, 3, 4, 6 and 7 required when loads labeled K represent top of storage.

8. Sprinklers labeled 1, 2, 3, 4, 6 and 8 required when loads labeled L represent top of storage.

9. Sprinklers labeled 1, 2, 3, 4, 6, 8 and 9 required when loads labeled M or N represent top of storage.

10. For storage higher than represented by loads labeled N, the cycle defined by notes 1 through 9 is repeated, with stagger as indicated. In the cycle, loads labeled M are equivalent to loads labeled A.

11. Symbols, O, ◇, X, △, indicate sprinklers on vertical or horizontal stagger.

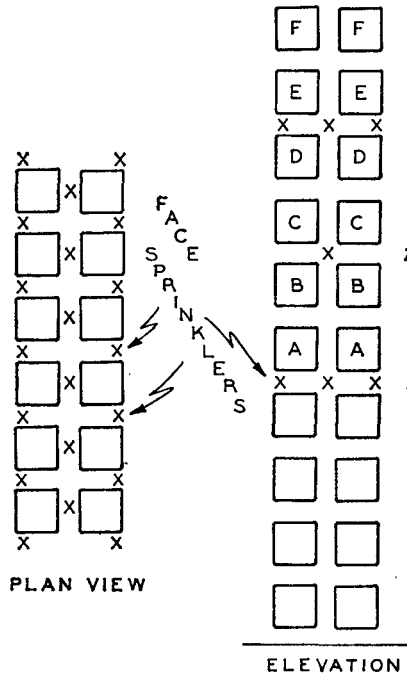


Fig. 7-10.1i. In-Rack Sprinkler Arrangement, Class I, II, III or IV Commodity, Height of Storage over 25 Feet.

NOTES:

1. Sprinklers labeled 1 (the selected array from Table 7-10.1) required when loads labeled A or B represent top of storage.

2. Sprinklers labeled 1 and 2 required when loads labeled C or D represent top of storage.

3. Sprinklers labeled 1 and 3 required when loads labeled E or F represent top of storage.

4. For storage higher than represented by loads labeled F, the cycle defined by notes 2 and 3 is repeated.

5. Symbol X indicates face and in-rack sprinklers.

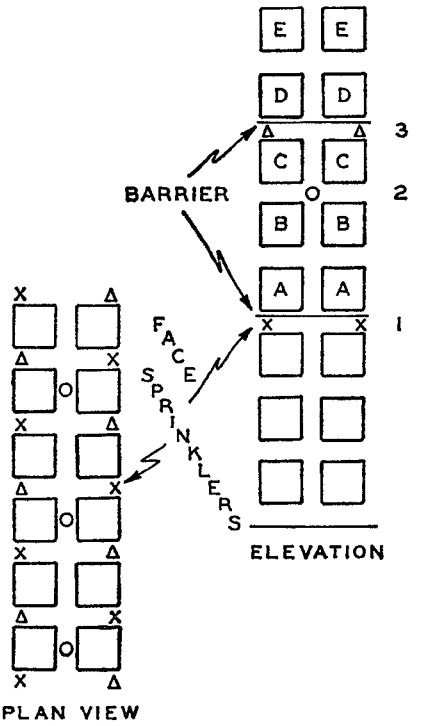
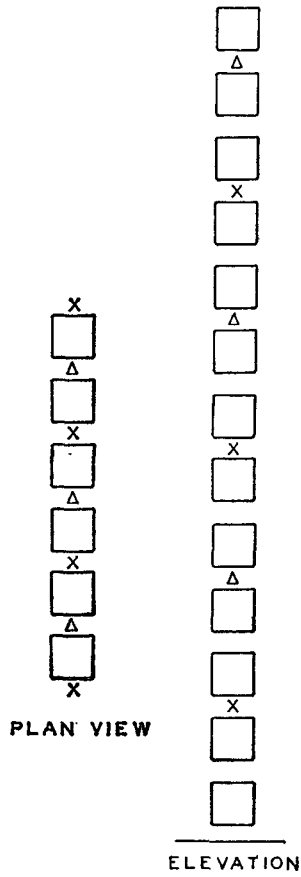


Fig. 7-10.1j. In-Rack Sprinkler Arrangement, Class I, II, III or IV Commodity. Height of Storage over 25 Feet.

NOTES:

1. Sprinklers and barrier labeled 1 (the selected array from Table 7-10.1) required when loads labeled A or B represent top of storage.
2. Sprinklers labeled 1 and 2 and barrier labeled 1 required when loads labeled C represent top of storage.
3. Sprinklers and barriers labeled 1 and 3 required when loads labeled D or E represent top of storage.
4. For storage higher than represented by loads labeled E, the cycle defined by notes 2 and 3 is repeated.
5. Symbols △ or X indicate sprinklers on vertical or horizontal stagger.
6. Symbol O indicates longitudinal flue space sprinklers.



NOTES:

1. For all storage heights, install sprinklers in every other tier and stagger as indicated.

2. Symbols △ or X indicate sprinklers on vertical or horizontal stagger.

Fig. 7-10.3. In-Rack Sprinkler Arrangement, Single Row Racks, Height of Storage over 25 Feet.

7-11 In-Rack Sprinkler Horizontal Barriers.

*7-11.1 Horizontal barriers used in conjunction with in-rack sprinklers to impede vertical fire development, shall be sheet metal, wood, or similar material and shall extend the full length and width of the rack. Barriers shall be fitted within two inches horizontally from rack uprights (*see Table 7-10.1 and Figs. 7-10.1a, g, and j*).

7-12 Ceiling Sprinkler Water Demand.

*7-12.1 Water demand for nonencapsulated storage on racks without solid shelves separated by aisles at least four feet wide and with not more than 10 feet between top of storage and sprinklers shall be based on sprinklers in a 2,000 square foot operating area, discharging a minimum of 0.25 gpm per square foot for Class I commodity, 0.3 gpm per square foot for Class II and III commodity, and 0.35 gpm per square foot for Class IV commodity, for 165°F sprinklers; or a minimum of 0.35 gpm per square foot for Class I commodity, 0.40 gpm per square foot for Class II and III commodity, and 0.45 gpm per square foot for Class IV commodity, for 286°F sprinklers (*see Table 7-10.1*).

7-12.2 Where such storage is encapsulated, ceiling sprinkler density shall be 25 percent greater than for nonencapsulated.

Part C. Multiple Row Racks

7-13 In-Rack Sprinkler Location.

*7-13.1 In multiple row racks with a maximum of 10 feet between top of storage and ceiling, in-rack sprinklers shall be installed as indicated in Figs. 7-13.1a, b and c. The highest level of in-rack sprinklers shall be not more than 10 feet below maximum height of storage for Class I, II or III commodities or five feet below top of storage for Class IV commodity (*see Table 7-13.1*).

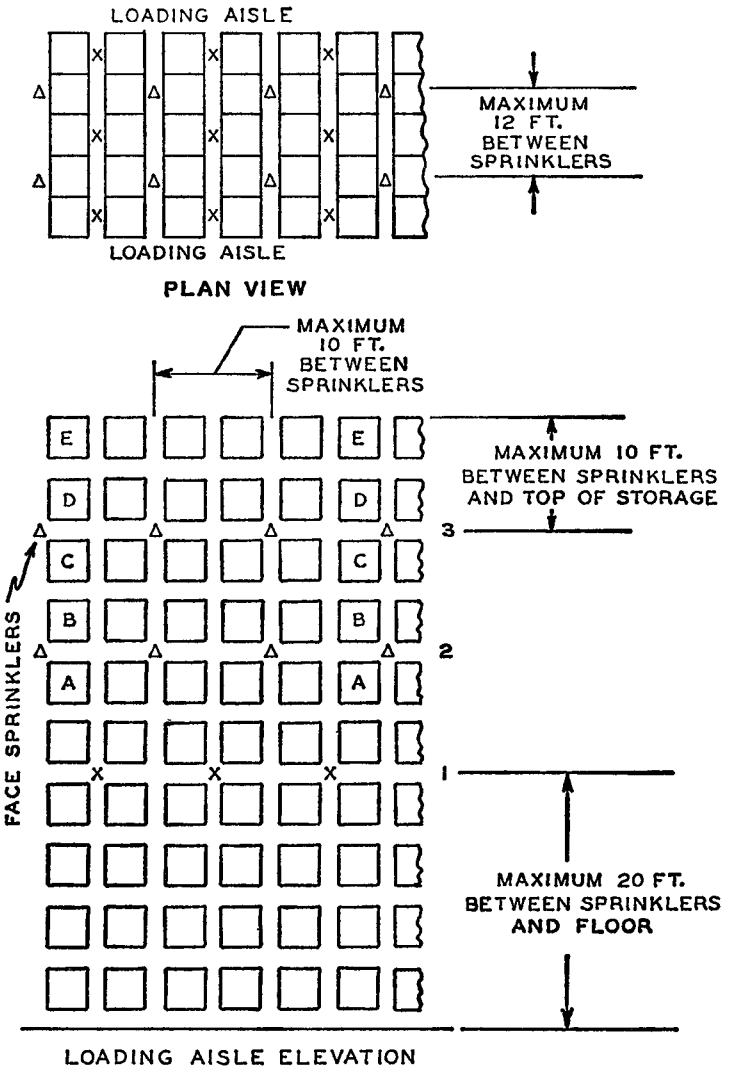
7-14 In-Rack Sprinkler Spacing.

7-14.1 Maximum horizontal spacing of sprinklers in multiple row racks with storage higher than 25 feet shall conform to Figs. 7-13.1a, b and c.

Table 7-13.1 Multiple-Row Racks. Storage Height Over 25 Ft.

Commodity Class	Encapsulated	In-Rack Sprinklers (1)			Height Limit (Ft)	Stagger	Fig. No.	Maximum Spacing From Top Of Storage To Highest In-Rack Sprinklers (Ft)	Ceiling Sprinkler Operating Area (Ft^2)	Ceiling Sprinkler Density (gpm/ft^2)	
		Approximate Vertical Spacing (Ft)	Maximum Horizontal Spacing In A Flue (Ft)	Maximum Horizontal Spacing Across Flue (Ft)						165° Rating	286° Rating
I	No	20	12	10	None	Between adjacent flues	7-13.1a	10	3000	.25	.35
	Yes									.31	.44
II&III	No	15	10	10			7-13.1b	10		.30	.40
	Yes									.37	.50
IV	No	10	10	10			7-13.1c	5		.35	.45
	Yes									.44	.56

[1]All four rack faces should be protected by sprinklers located within 18 in. of the faces, as indicated in Figs. 7-13.1a, b and c. It is not necessary for each sprinkler level to protect all faces (*see A7-13.1*).



7-13.1a. In-Rack Sprinkler Arrangement — Multiple-Row Racks, Class I Commodity. Height of Storage over 25 Feet.

NOTES:

1. Sprinklers labeled 1 required if loads labeled A represent top of storage.
2. Sprinklers labeled 1 and 2 required if loads labeled B or C represent top of storage.
3. Sprinklers labeled 1 and 3 required if loads labeled D or E represent top of storage.
4. For storage higher than represented by loads labeled E, the cycle defined by notes 2 and 3 is repeated, with stagger as indicated.
5. Symbols △ or X indicate sprinklers on vertical or horizontal stagger.

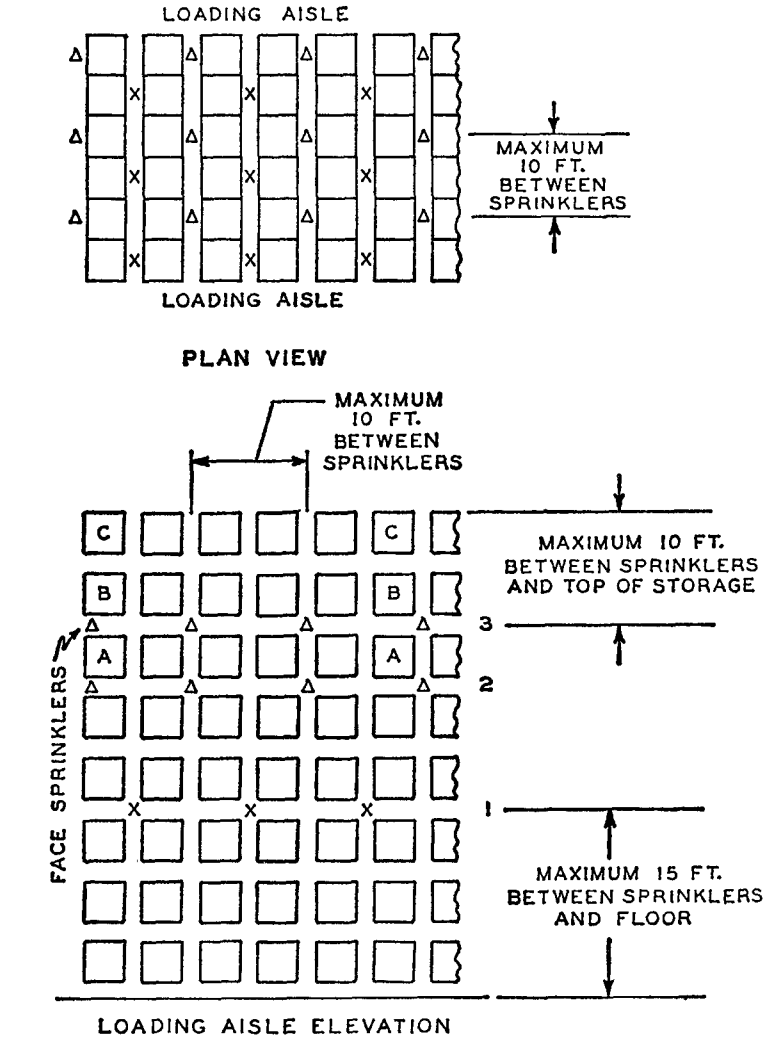
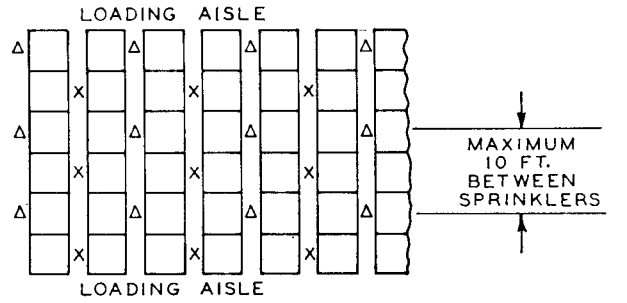


Fig. 7-13.1b. In-Rack Sprinkler Arrangement — Multiple-Row Racks, Class II or III Commodity. Height of Storage over 25 Feet.

NOTES:

1. Sprinklers labeled 1 and 2 required if loads labeled A represent top of storage.
2. Sprinklers labeled 1 and 3 required if loads labeled B or C represent top of storage.
3. For storage higher than represented by loads labeled C, the cycle defined by notes 1 and 2 is repeated, with stagger as indicated.
4. Symbols △ or X indicate sprinklers on vertical or horizontal stagger.



PLAN VIEW

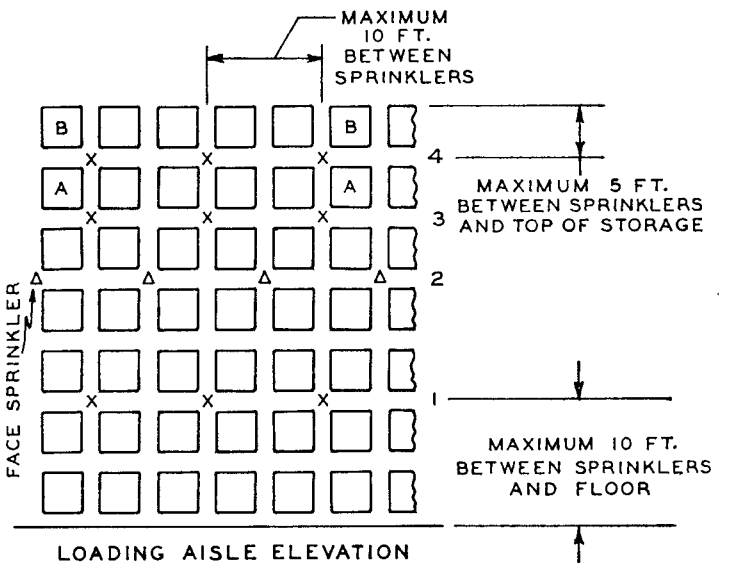


Fig. 7-13.1c. In-Rack Sprinkler Arrangement, Class IV Commodity, Multiple-Row Racks. Height of Storage over 25 Feet.

NOTES:

1. Sprinklers labeled 1, 2 and 3 required if loads labeled A represent top of storage.

2. Sprinklers labeled 1, 2 and 4 required if loads labeled B represent top of storage.

3. For storage higher than represented by loads labeled B, the cycle defined by notes 1 and 2 is repeated, with stagger as indicated.

4. Symbols △ or X indicate sprinklers on vertical or horizontal stagger.

7-14.2 A minimum six inch clear space shall be maintained between the sprinkler deflectors and the top of a tier of storage.

7-14.3 Sprinklers in racks shall be located a minimum of two feet from rack uprights.

7-15 Ceiling Sprinkler Water Demand.

7-15.1 Water demand for nonencapsulated storage on racks without solid shelves separated by aisles at least four feet wide and with not more than 10 feet between top of storage and sprinklers, shall be based on sprinklers in a 3,000 square foot operating area for multiple row racks, discharging a minimum of 0.25 gpm per square foot for Class I commodity, 0.3 gpm per square foot for Class II and III commodity, and 0.35 gpm per square foot for Class IV commodity, for 165°F sprinklers; or a minimum of 0.35 gpm per square foot for Class I commodity, 0.40 gpm per square foot for Class II and III commodity, and 0.45 gpm per square foot for Class IV commodity, for 286°F sprinklers (*see Table 7-13.1*).

7-15.2 Where such storage is encapsulated, ceiling sprinkler density shall be 25 percent greater than for nonencapsulated.

Chapter 8 Equipment

8-1 Mechanical Handling Equipment.

8-1.1 Industrial Trucks.

8-1.1.1 Power-operated industrial trucks shall be of the type designated in *Powered Industrial Trucks, NFPA 505 — 1973*, Chapter 1, Type Designations and Areas of Use, and their maintenance and operation shall be in accordance with Chapters 2 and 3.

†**8-1.1.2** Industrial trucks using LP-gas or liquid fuel shall be refueled outside of the storage building at a location designated for that purpose.

Chapter 9 Building Maintenance and Operation

9-1 Building Operations Other Than Storage.

*9-1.1 Welding, soldering, brazing, and cutting may be performed on rack or building components which cannot be removed, provided no storage is located below and within 25 feet of the working area, and flameproof tarpaulins enclose this section. During any of these operations the sprinkler system shall be in service. Two and one-half (2½) gallon water type extinguishers and charged inside hose lines shall be located in the working area. A fire watch shall be maintained during these operations and for at least 30 minutes additional.

9-2 Waste Disposal.

*9-2.1 Approved type containers for rubbish and other trash materials shall be provided.

9-3 Smoking.

9-3.1 Smoking shall be strictly prohibited, except in locations prominently designated as smoking areas, and "No Smoking" signs shall be posted in prohibited areas.

*9-4 Maintenance.

9-4.1 Fire walls, fire doors, and floors shall be maintained in good repair at all times.

*9-5 Plant Emergency Organization.

9-5.1 A fire watch shall be maintained when the sprinkler system is not in service.

*9-6 General Fire Protection.

Appendix A

This Appendix is not a part of this NFPA Standard 231C, Rack Storage of Materials, but is included for information purposes only.

The following contains additional information and recommendations bearing the same number as the text of the Standard for Rack Storage of Materials to which they apply.

Chapter 4 Storage Arrangements

A4-1.1 Rack storage as referred to in this standard contemplates commodity in a rack structure, usually steel. Many variations of dimensions are found. Racks may be single row, double row, or multiple row with or without solid shelves. The standard commodity used in most of the tests was 42 inches on a side. Type of racks covered in this standard:

Double row racks — pallets rest on two beams parallel to the aisle. Any number of pallets can be supported by one pair of beams (*see Figs. A4-1.1a, b, c and d*).

Automatic storage type rack — the pallet is supported by two rails running perpendicular to the aisle (*see Fig. A4-1.1e*).

Multiple row racks are more than two pallets deep, measured aisle to aisle — this includes drive-in racks, drive-through racks, flow-through racks, portable racks arranged in the same manner, and conventional or automatic racks with aisles less than 42 inches (*see Figs. A4-1.1f through i*).

Solid Shelving — conventional pallet rack with plywood shelves on the shelf beams (*see Figs. A4-1.1c and d*). This is a special case (*see Chapter 5*).

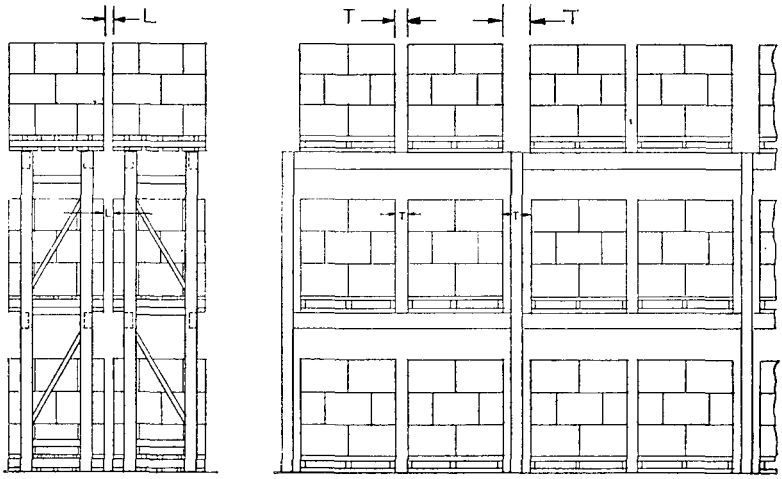
Cantilever rack — the load is supported on arms that extend horizontally from columns. The load may rest on the arms or on shelves supported by the arms (*see Fig. A4-1.1j*).

Load depth in conventional or automatic racks is considered a nominal 48 inches (*see Fig. A4-1.1b*).

A4-2.1 Fixed rack structures should be designed to facilitate removal or repair of damaged sections without resorting to flame cutting or welding in the storage area.

Where sprinklers are to be installed in racks, rack design should anticipate the additional clearances required to facilitate installation of sprinklers. The rack structure should be anchored to prevent damage to sprinkler lines and supply piping in racks.

Rack structures should be designed for seismic conditions in areas where seismic resistance of building structure is required.

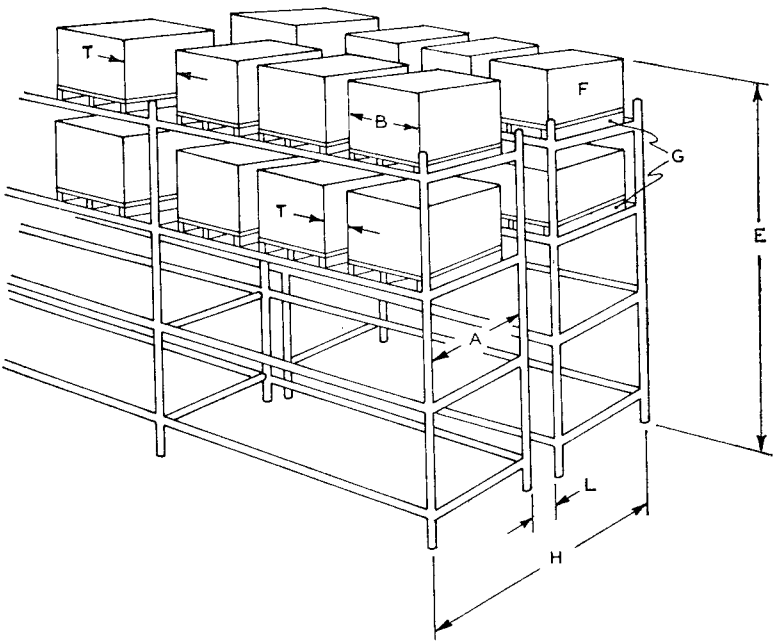


Legend

L — Longitudinal Flue Space

T — Transverse Flue Space

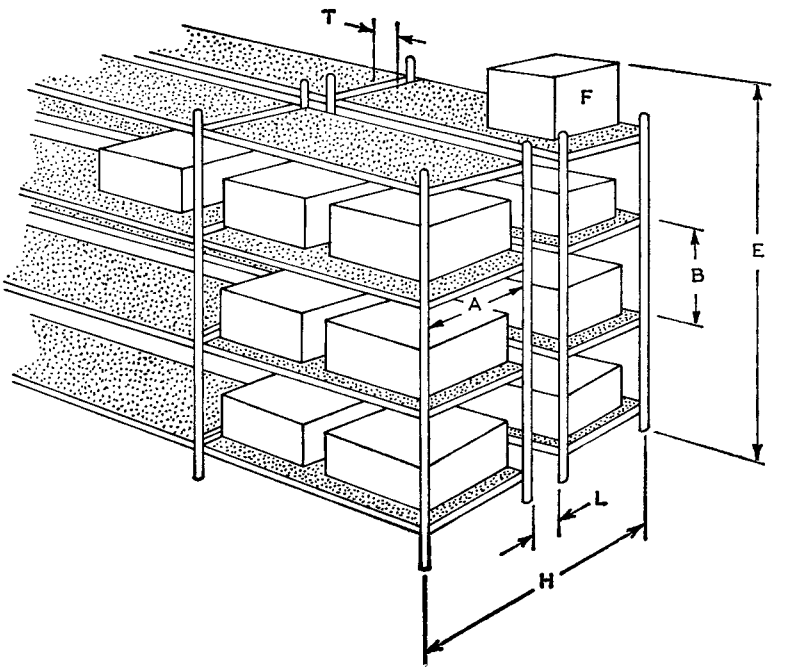
Fig. A4-1.1a. Conventional Pallet Rack.



Legend

A — Load Depth	**E — Storage Height**
B — Load Width	**F — Commodity**
T — Transverse Flue Space	**G — Pallet**
L — Longitudinal Flue Space	**H — Rack Depth**

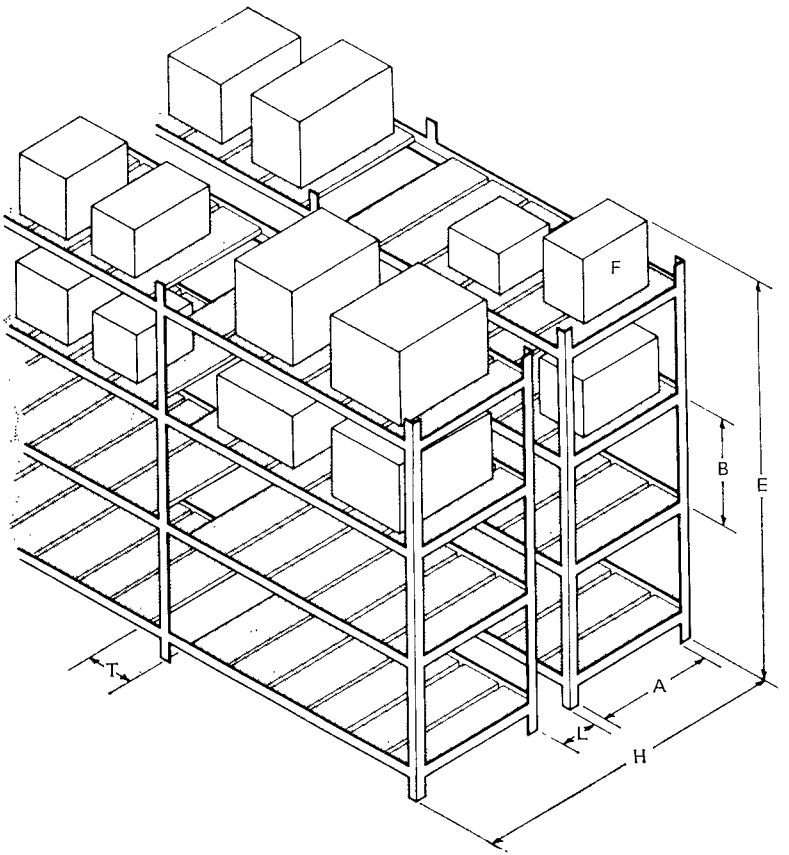
Fig. A4-1.1b. Double Row Racks without Solid or Slatted Shelves.



Legend

A — Shelf Depth	**L — Longitudinal Flue Space**
B — Shelf Height	**E — Storage Height**
T — Transverse Flue Space	**F — Commodity**

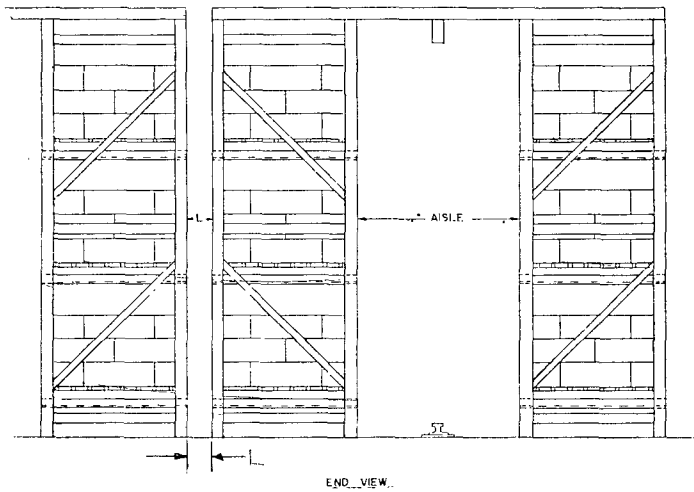
Fig. A4-1.1c. Double Row Racks with Solid Shelves.

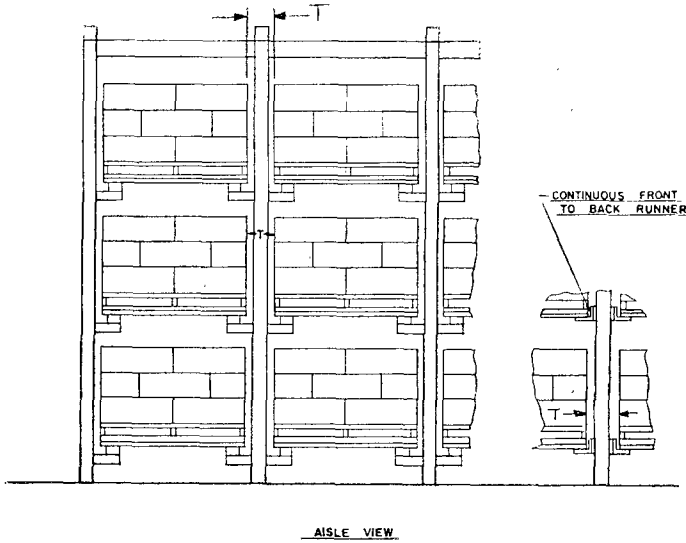


Legend

A — Shelf Depth
B — Shelf Height
H — Rack Depth
L — Longitudinal Flue Space
E — Storage Height
F — Commodity
T — Transverse Flue Space

Fig. A4-1.1d. Double Row Racks with Slatted Shelves.

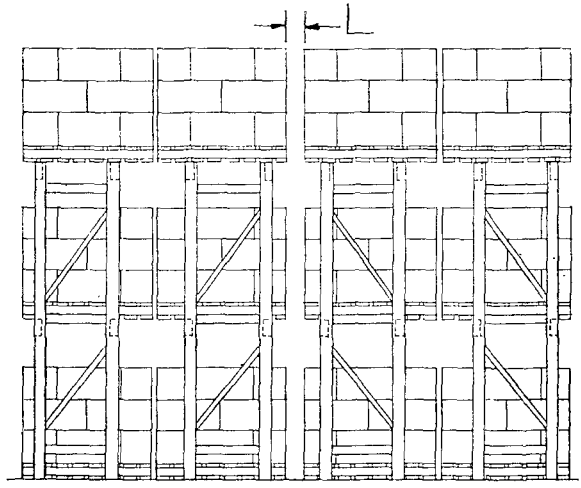




Legend

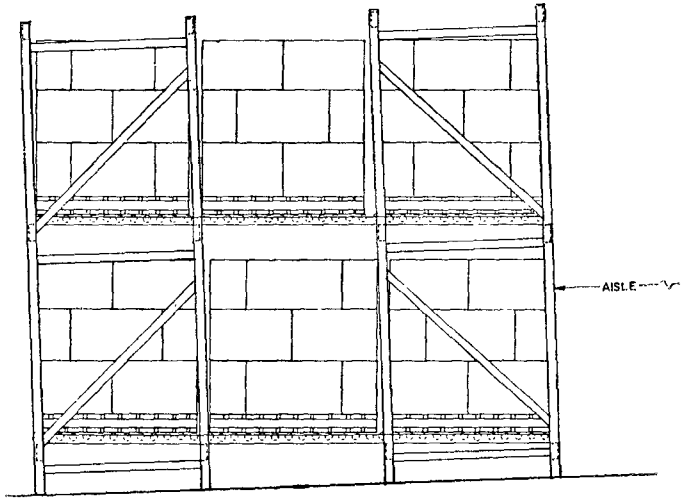
L — Longitudinal Flue Space **T — Transverse Flue Space**

Fig. A4-1.1e. Automatic Storage Type Rack.

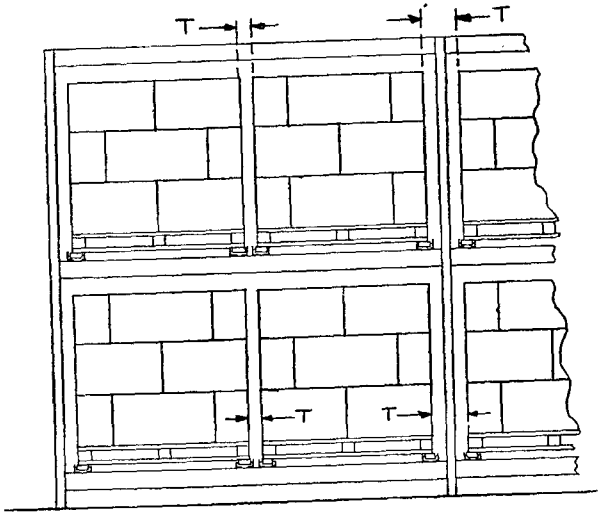


L — Longitudinal Flue Space

Fig. A4-1.1f. Multi-Row Rack to be Served by a Reach Truck.



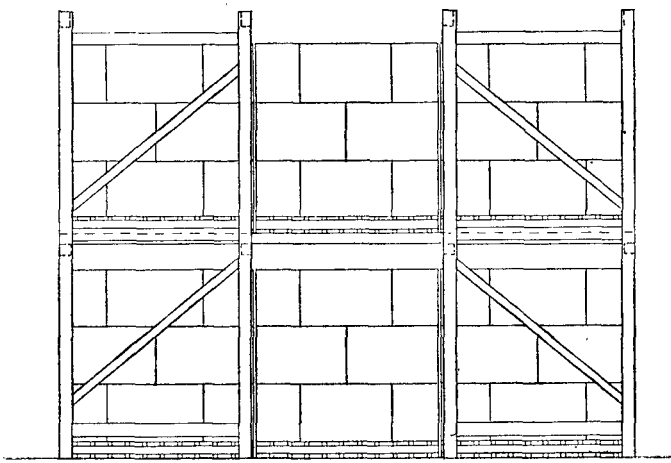
END VIEW



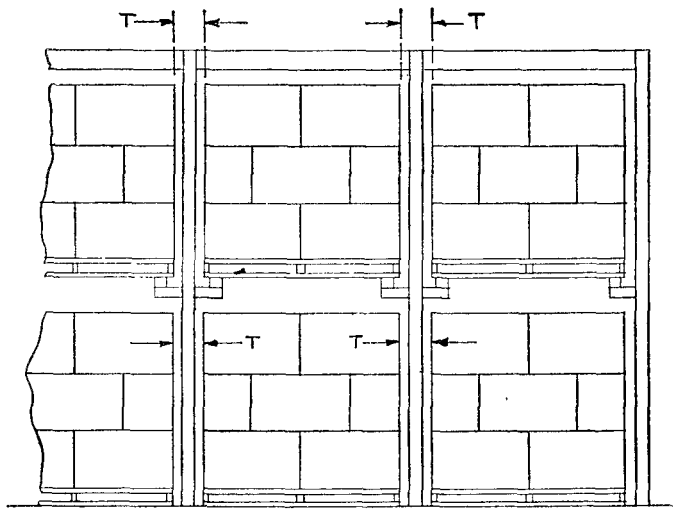
AISLE VIEW

T — Transverse Flue Space

Fig. A4-1.1g. Flow-Through Pallet Rack.



END VIEW

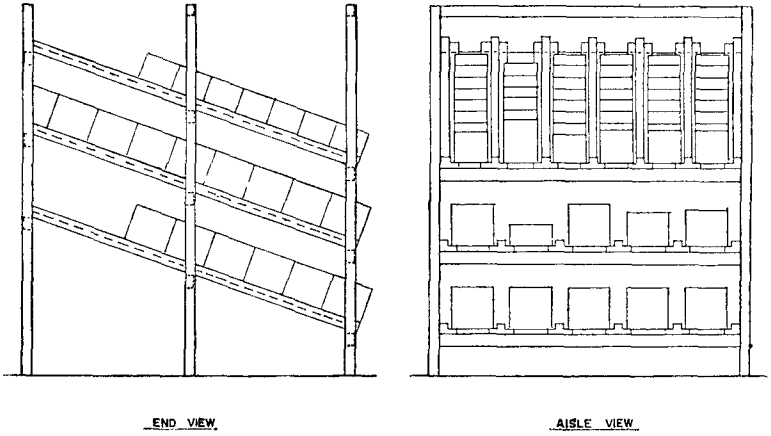


AISLE VIEW

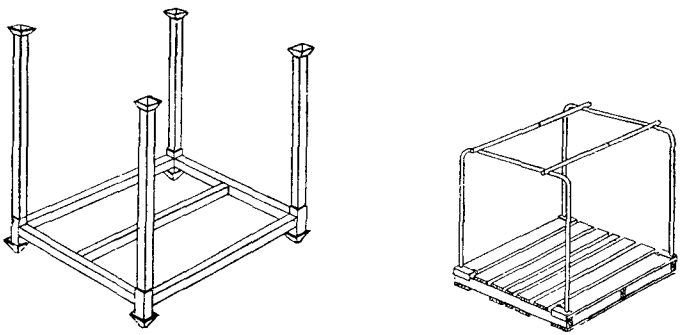
T — Transverse Flue Space

Fig. A4-1.1h. Drive-In Rack — Two or More Pallets Deep.

Fork truck drives into the rack to deposit and withdraw loads in the depth of the rack.



Flow-Through Rack



Portable Racks

Fig. A4-1.1i.

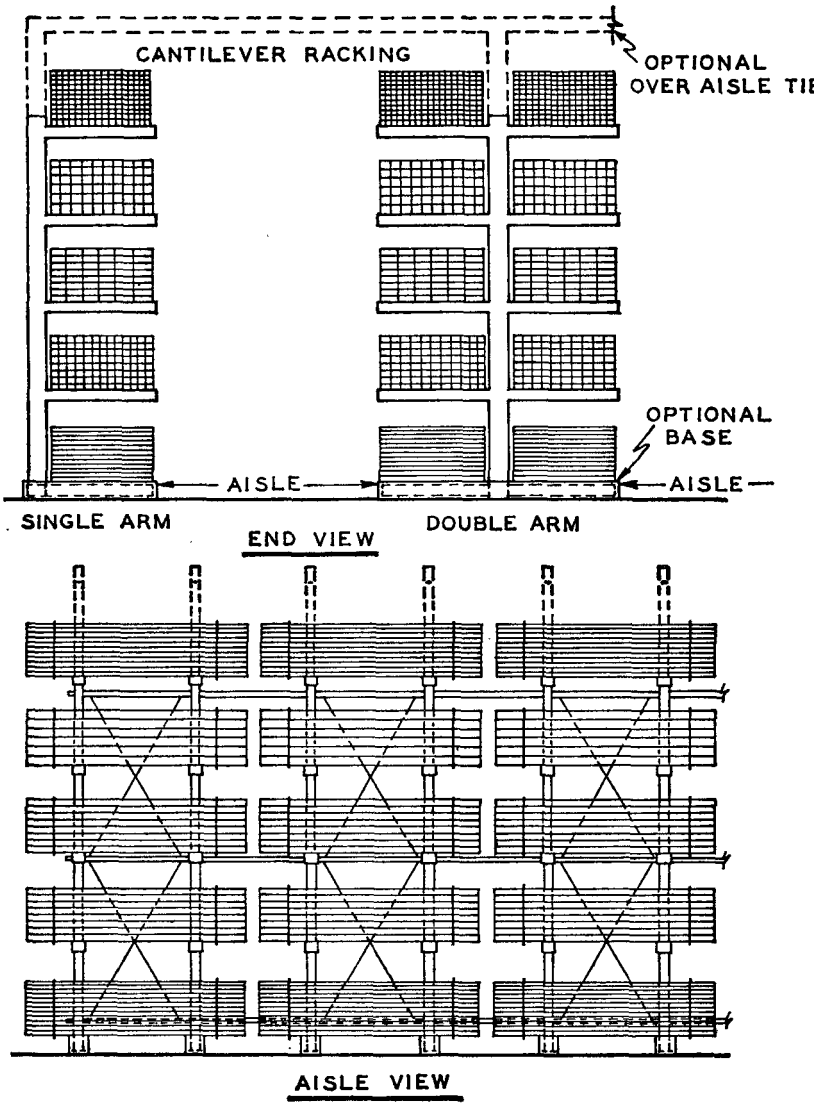
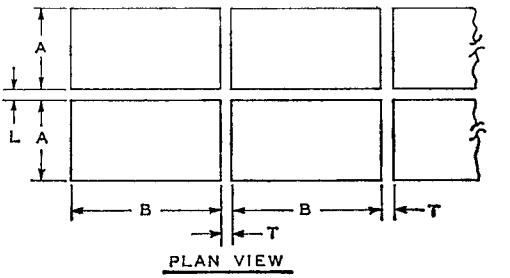


Fig. A4-1.1j. Cantilever Rack.



Legend

A — Shelf Depth
B — Shelf Length
L — Longitudinal Flue Space
T — Transverse Flue Space

Fig. A4-3.2. Double Row Rack Solid Shelf Layout.

NOTE: When shelf depth (dimension A) is deeper than four ft. but less than five ft. and shelf length (dimension B) is longer than eight ft. but less than 10 ft. protection is required in accordance with 5-5.3. Minimum six-inch flue spaces (dimensions T and L) are required between shelf sections (*see 4-3.2*).

A4-5 The fire protection system design should contemplate the maximum height of storage. For new sprinkler installations, maximum height of storage is the usable 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 or greater than required.

A4-6.1 A horizontal clearance of at least one foot should be maintained between storage and major unprotected roof structural members when storage is stored above the bottom of such members.

A4-6.2 Incandescent light fixtures should have shades or guards to prevent ignition of commodity from hot bulbs where possibility of contact with storage exists.