NFPA No.

231C

RACK STORAGE OF MATERIALS 1972

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Official NFPA Definitions

Adopted Jan. 23, 1964: Revised Dec. 9, 1969. Where variances to these definitions are found, efforts to eliminate such conflicts are in process.

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SHOULD is intended to indicate recommendations or that which is advised but not required.

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Standard for

Rack Storage of Materials

NFPA No. 231C — 1972

1972 Edition of No. 231C

This edition of NFPA No. 231C was adopted in May 1972, and supersedes the 1971 edition. Several former recommendations have been made mandatory requirements, and new material has been added to the Appendix.

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.

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Rack Storage of Materials

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SCOPE: To develop standards covering fire prevention and fire protection considerations for the rack storage of materials, including automated systems. Included are: (1) features to minimize fire damage to rack storage equipment, material handling facilities and related components, and (2) recommendations covering the fire protection needs for structures housing such racks and the contents of the racks.

Liaison shall be maintained, as needed, with the NFPA Committee on Electronic Computer Systems, the Committee on General Storage, the Sectional Committee on General Storage of Flammable Liquids, the Sectional Committee on Storage, Handling and Transportation of Hazardous Chemicals, the Safety to Life Committee, the National Electrical Code Committee and the responsible NFPA Committees and Sectional Committees handling standards dealing with fire extinguishing and signaling systems.

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Standard for

Rack Storage of Materials

NFPA No. 231C — 1972

Introduction

1. Application and Scope

This Standard applies to storage of materials representing the broad range of combustibles stored from 12 ft. to 20 ft. and 25 ft. in height on racks. For storage heights of 12 ft. or less, see NFPA No. 13.

Storage of high hazard materials such as tires, plastics, flammable liquids, and rolled paper is outside the scope of this Standard. See NFPA Nos. 30 Flammable and Combustible Liquids Code, 40 Cellulose Nitrate Motion Picture Film, 43 Pyroxylin Plastic, 490 Ammonium Nitrate Storage, 58 Liquefied Petroleum Gases, 81 Fur Storage, Fumigation and Cleaning, 231 Indoor General Storage, and 232 Protection of Records, for Standards applying to such commodities or to other methods of storage.

Bin Storage is also outside the scope of this Standard (see NFPA No. 13).

2. Definitions

BULKHEAD. A vertical barrier across the rack.

CONVENTIONAL PALLETS. A material handling aid designed to support a unit load with stringers to provide support for material handling devices (see Fig. No. 2).

LONGITUDINAL FLUE SPACE. The space between rows of storage perpendicular to the direction of loading (see Fig. No. 1).

RACKS. Any combination of vertical, horizontal, and diagonal members that support stored materials. Some rack structures utilize solid shelves. Racks may be fixed or portable (see Figs. No. A3111 through A3114).

SLAVE PALLET. A special pallet captive to a material handling system (see Fig. No. 2).

TRANSVERSE FLUE SPACE. The space between rows of storage parallel to the direction of loading (see Fig. No. 1).

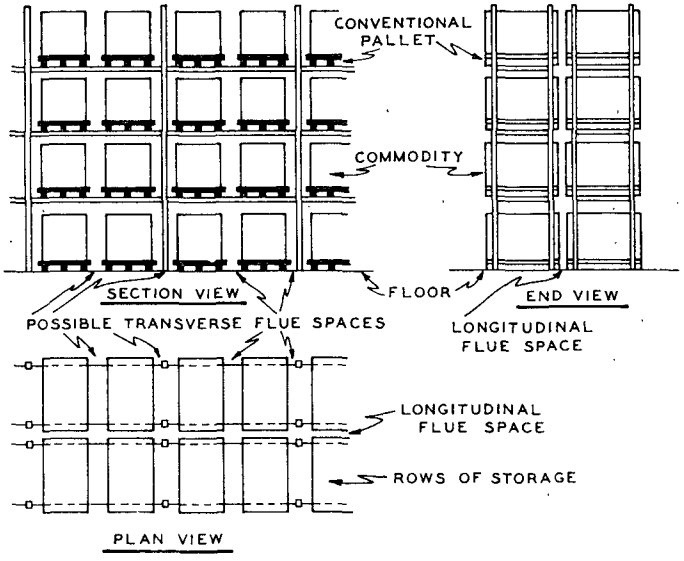


Fig. 1. Typical Conventional Double Row (Back-to-back) Rack Arrangement.

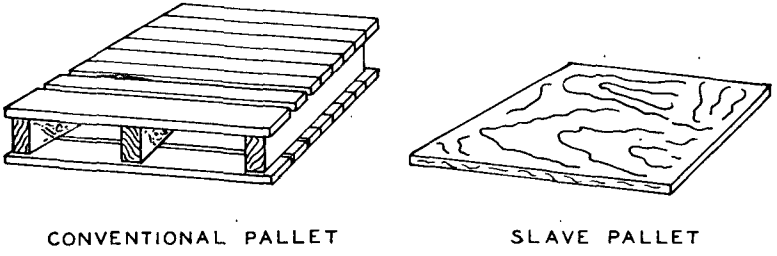


Fig. 2.

Chapter 1. Classification of Storage

11. Commodity Classifications

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

1111. Class I Commodities are defined as noncombustible products on wood pallets or in ordinary paper cartons or wrappings on wood pallets, such as: metal parts; empty cans; noncombustible food stuffs or beverages; stoves; washers; dryers; metal cabinets. Such commodities may have a negligible amount of plastic trim, such as knobs or handles.

1112. Class II commodities are defined as Class I products in slatted wooden crates or solid wooden boxes, on wood pallets.

1113. Class III commodities are defined as wood, paper, natural fiber cloth, or products thereof, containing no more than a negligible amount of plastics in the product or in the packaging material, on wood pallets, such as: natural fiber clothing or textile products; wooden cabinets; furniture or wood products; bicycles; luggage (except plastic); combustible foods or cereal products; paper products; leather goods. Bicycles with plastic handles, pedals, seats, and tires are an example of a commodity with no more than a negligible amount of plastic.

1114. Class IV commodities are defined as Class I, II, and/or III mixed with more than a relatively negligible amount of plastics used in the product or packaging material, on wood pallets, such as: small appliances with plastic parts; typewriters, cameras or electronic parts in plastic packaging in cartons; plastic back tape; synthetic fabrics or clothing.

Chapter 2. Building Construction

21. Construction

211. 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 No. 220.

22. Fire Protection Of Steel

221. With sprinkler systems installed in accordance with design curves in Chapter 4, fire protection of roof steel is not necessary except as noted in 361.

222. In all cases where ceiling sprinklers and sprinklers in racks are installed in accordance with design curves in Chapter 4, fire protection of columns is not necessary.

223. Where storage height exceeds 15 ft., and ceiling sprinklers only are installed, fire protection by one of the following methods is required for steel columns located within the racks or for vertical rack members that support the building:

(a) One hour fire proofing

(b) Side wall sprinklers placed in the web of steel columns, on one side only, pointed in at the 15 ft. elevation

(c) For storage heights above 15 ft. to and including 20 ft. provision of ceiling sprinkler density for a minimum of 2000 sq. ft. 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	—	0.57

23. Protection Of Stairways And Shafts; Emergency Exits Requirements.

231. Stairways and vertical shafts shall be enclosed with construction specified in Standard Types of Building Construction, NFPA No. 220 (see Standard for Fire Doors and Windows, NFPA No. 80 and Life Safety Code, NFPA No. 101).

232. Exit facilities shall conform to the applicable provisions of the Life Safety Code, NFPA No. 101.

24. Ventilation

241. Design curves are based upon roof vents and draft curtains not being utilized (see Appendix A-241)

242. During mop-up operations, ventilating systems, where installed, should be capable of manual exhaust operations.

25. Exposure Protection

251. Protection from exterior fire exposures should be provided in accordance with Recommended Good Practice for Protection of of Buildings from Exterior Fire Exposures, NFPA No. 80A.

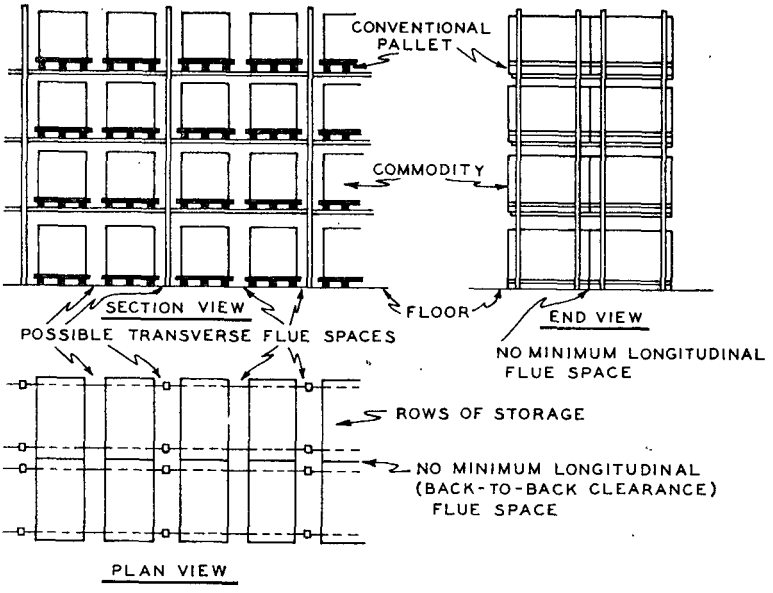


Fig. 331. Double Row Rack.

NOTE: When either Ceiling Sprinklers only or Ceiling Sprinklers and In-Rack Sprinklers are provided in accordance with Design Curves shown in Figures 4143a, b, c and d, no minimum or maximum longitudinal flue space is necessary when the minimum 6-inch transverse flue space is maintained.

Chapter 3. Storage Arrangements

31. Rack Structure

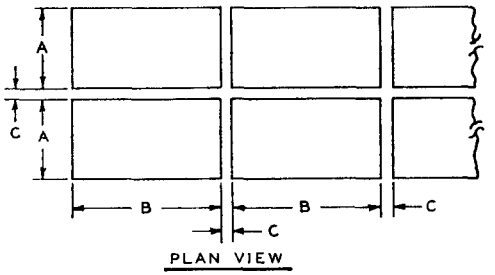
311. Typical rack configurations are shown in Figures No. 331 and 332 (see also Appendix A311).

32. Rack Design

321. Racks shall not be loaded beyond their design capacity.

322. 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.

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



Legend

Fig. 332. Double Row Rack Solid Shelf Layout.

NOTE: When shelf depth (dimension A) is deeper than 4 ft. but less than 5 ft. and shelf length (dimension B) is longer than 8 ft. but less than 10 ft. protection is required in accordance with 422, Chapter 4. Minimum 6-inch flue spaces (dimension C) are required between shelf sections (see 332, Chapter 3).

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

33. Flue Space

331. In double row racks without solid shelves, no minimum or maximum longitudinal flue space (back-to-back clearance) is necessary when a minimum 6 in. transverse flue space between loads or at uprights is maintained (see Fig. No. 331 and A3111b).

332. In double row racks with solid shelves, minimum 6 in. flue spaces shall be maintained between the shelf sections thereby defining the shelf size (see Section 42 and Figs. Nos. 332 and A3114a).

34. Aisle Widths

341. 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 Chapter 4).

342. 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.

35. Storage Heights

351. The fire protection system design shall contemplate the maximum height of storage.

352. The distance from the top of the pile to the ceiling sprinkler deflectors shall be not less than 3 ft.

36. Commodity Clearances

361. If the commodity is stored above the lower chord of roof trusses, at least 1 ft. clear space shall be maintained to permit wetting of the truss unless the truss is protected with one hour fireproofing.

362. Commodity clearances shall be maintained in accordance with NFPA Standards as follows:

Heat Producing Appliances, NFPA No. 89M
Blower and Exhaust Systems, NFPA No. 91

363. At least 1 ft. clearance shall be maintained between commodity and lights or light fixtures to prevent breakage. Light fixtures shall have approved shades or guards to prevent ignition of commodity from bare bulbs.

37. Storage Of Empty Combustible Pallets

371. For bulk storage of empty combustible pallets, see NFPA No. 231, Indoor General Storage.

Chapter 4. Fire Protection

40. General

401. Protection systems which are provided for rack storage facilities shall be in accordance with the provisions of this Chapter.

4011. Sprinkler design density and area of application shall be in accordance with the following criteria and design curves given in Figures No. 4143a through 4143h. 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.

41. Sprinkler System Design Criteria

Where automatic sprinkler systems are installed, they shall be in accordance with the Standard for Installation of Sprinkler Systems, NFPA No. 13, except as modified by this Rack Storage of Materials Standard.

411. Type of System

4111. Wet systems are recommended for most rack storage occupancies.

4112. Dry systems are acceptable only where it is impractical to provide heat.

4113. Pre-action systems may be considered for rack storage occupancies that are unheated or those highly susceptible to water damage.

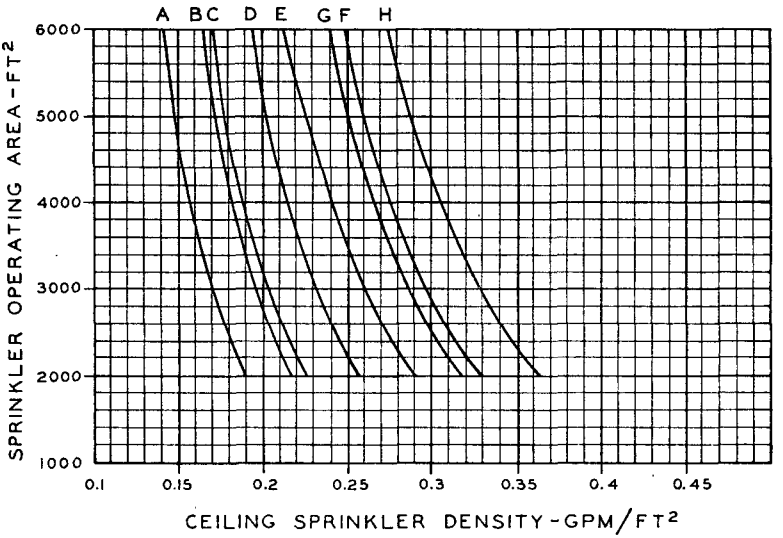
412. System Size or Area Limitation

4121. The maximum area protected by a single sprinkler system at the ceiling shall not exceed 40,000 sq. ft. (see Standard for Installation of Sprinkler Systems, NFPA No. 13).

4122. The area protected by a single system of sprinklers in racks (intermediate sprinklers) shall not exceed 40,000 sq. ft. of floor area occupied by the racks including aisles regardless of the number of intermediate sprinkler levels.

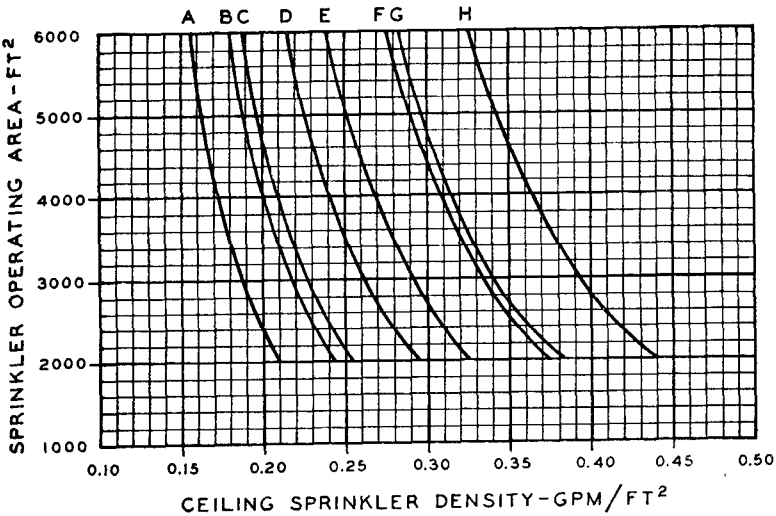
4123. The ceiling sprinkler systems and sprinkler systems in the rack should conform to the same general area boundaries.

4124. Office areas, equipment rooms, and similar areas may be protected by an extension of the ceiling sprinkler system, and such areas may be excluded from the total area limitation of 40,000 sq. ft. if a one-hour fire resistant separation is provided. The combined areas of such systems shall not exceed 52,000 sq. ft.



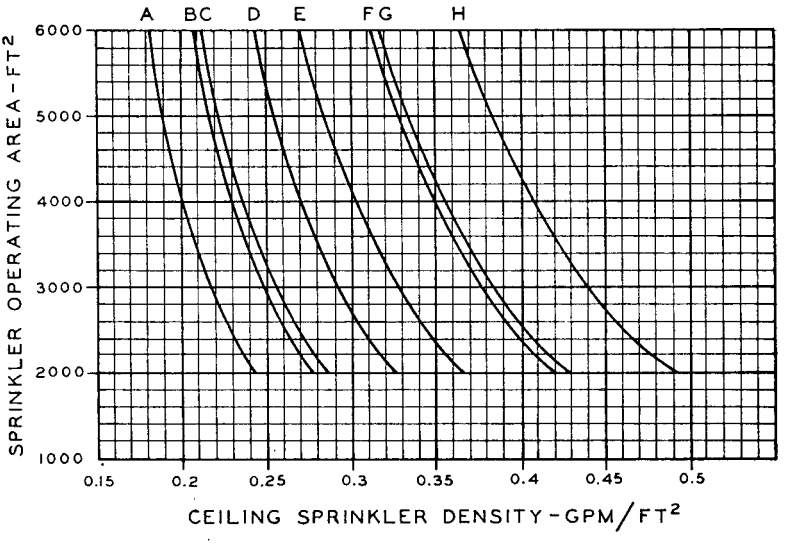
Curve	Legend
A	*8 ft. aisles with 286°F ceiling sprinklers and 165°F in-rack sprinklers*
B	*8 ft. aisles with 165°F ceiling sprinklers and 165°F in-rack sprinklers*
C	*4 ft. aisles with 286°F ceiling sprinklers and 165°F in-rack sprinklers*
D	*4 ft. aisles with 165°F ceiling sprinklers and 165°F in-rack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

Fig. 4143a. Double Row Racks — 20 Ft. High Rack Storage — Sprinkler System Design Curves — Class I Commodities — Conventional Pallets



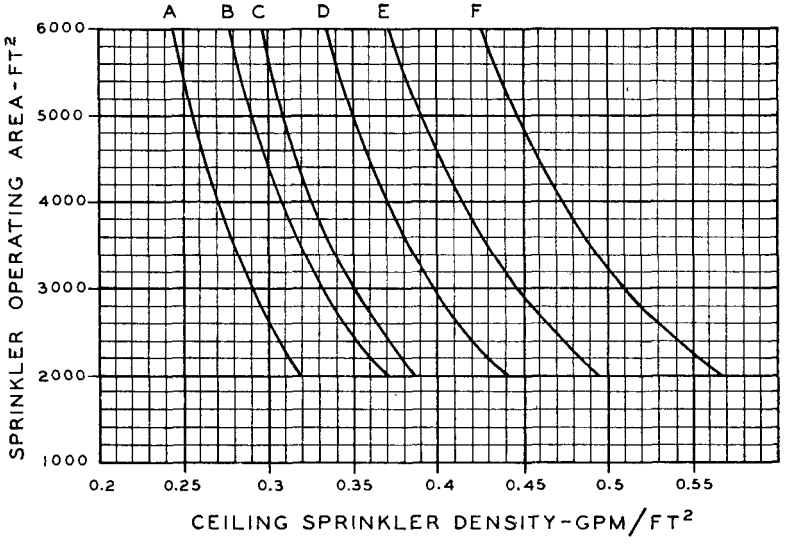
Curve	Legend
A	*8 ft. aisles with 286°F ceiling sprinklers and 165°F in-rack sprinklers*
B	*8 ft. aisles with 165°F ceiling sprinklers and 165°F in-rack sprinklers*
C	*4 ft. aisles with 286°F ceiling sprinklers and 165°F in-rack sprinklers*
D	*4 ft. aisles with 165°F ceiling sprinklers and 165°F in-rack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

Fig. 4143b. Double Row Racks — 20 Ft. High Rack Storage — Sprinkler System Design Curves — Class II Commodities — Conventional Pallets



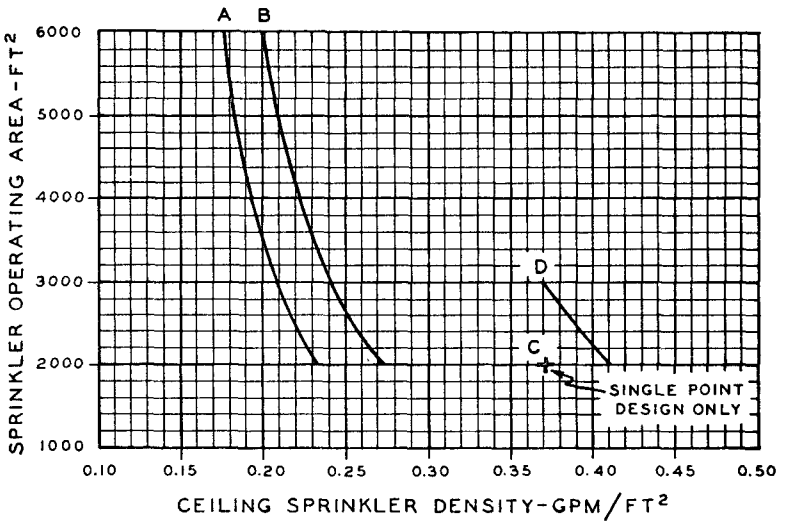
Curve	Legend
A	*8 ft. aisles with 286°F ceiling sprinklers and 165°F in-rack sprinklers*
B	*8 ft. aisles with 165°F ceiling sprinklers and 165°F in-rack sprinklers*
C	*4 ft. aisles with 286°F ceiling sprinklers and 165°F in-rack sprinklers*
D	*4 ft. aisles with 165°F ceiling sprinklers and 165°F in-rack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

Fig. 4143c. Double Row Racks — 20 Ft. High Rack Storage — Sprinkler System Design Curves — Class III Commodities — Conventional Pallets



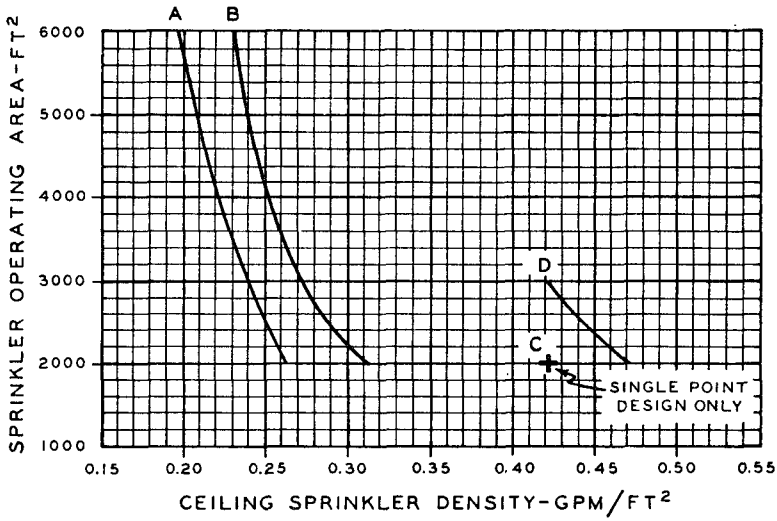
Curve	Legend
A	*8 ft. aisles with 286°F ceiling sprinklers and 165°F in-rack sprinklers*
B	*8 ft. aisles with 165°F ceiling sprinklers and 165°F in-rack sprinklers*
C	*4 ft. aisles with 286°F ceiling sprinklers and 165°F in-rack sprinklers*
D	*4 ft. aisles with 165°F ceiling sprinklers and 165°F in-rack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

Fig. 4143d. Double Row Racks — 20 Ft. High Rack Storage — Sprinkler System Design Curves — Class IV Commodities — Conventional Pallets



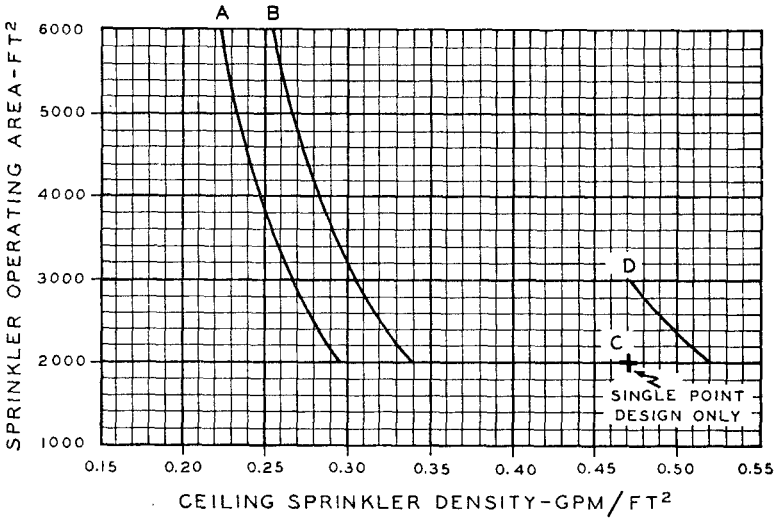
Curve	Legend
A	*10 ft. aisles with 286°F ceiling sprinklers and 165° in-rack sprinklers*
B	*10 ft. aisles with 165°F ceiling sprinklers and 165° in-rack sprinklers*
C	*10 ft. aisles with 286°F ceiling sprinklers*
D	*10 ft. aisles with 165°F ceiling sprinklers*

Fig. 4143e. Multiple Row Racks — 20 Ft. High Rack Storage — Sprinkler System Design Curves — Class I Commodities — Conventional Pallets



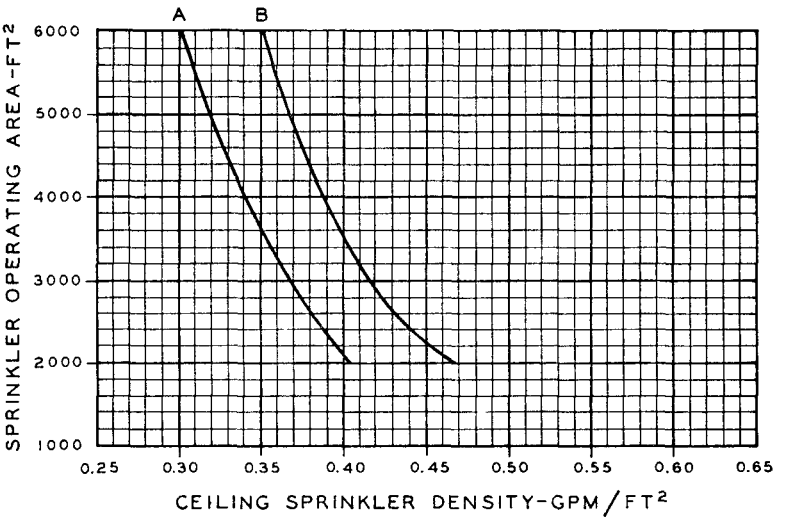
Curve	Legend
A	*10 ft. aisles with 286°F ceiling sprinklers and 165°F in-rack sprinklers*
B	*10 ft. aisles with 165°F ceiling sprinklers and 165°F in-rack sprinklers*
C	*10 ft. aisles with 286°F ceiling sprinklers*
D	*10 ft. aisles with 165°F ceiling sprinklers*

Fig. 4143f. Multiple Row Racks — 20 Ft. High Rack Storage — Sprinkler System Design Curves — Class II Commodities — Conventional Pallets



Curve	Legend
A	*10 ft. aisles with 286°F ceiling sprinklers and 165°F in-rack sprinklers*
B	*10 ft. aisles with 165°F ceiling sprinklers and 165°F in-rack sprinklers*
C	*10 ft. aisles with 286°F ceiling sprinklers*
D	*10 ft. aisles with 165°F ceiling sprinklers*

Fig. 4143g. Multiple Row Racks — 20 Ft. High Rack Storage — Sprinkler System Design Curves — Class III Commodities — Conventional Pallets



Curve	Legend	Curve	Legend
A	*— 10 ft. aisles with 286°F ceiling sprinklers and 165°F in-rack sprinklers*	*B*	*— 10 ft. aisles with 165°F ceiling sprinklers and 165°F in-rack sprinklers*

Fig. 4143h. Multiple Row Racks — 20 Ft. High Rack Storage — Sprinkler System Design Curves — Class IV Commodities — Conventional Pallets

413. System Division

4131. When sprinklers are installed in racks, separate gate valves and drains shall be provided for ceiling sprinklers and sprinklers in racks except for small in-rack installations of less than 20 sprinklers (see NFPA No. 13 — 1971, Paragraph 3063).

414. Ceiling Sprinklers

4141. Sprinkler spacing for ordinary hazard occupancies in NFPA No. 13 may apply to Class I commodities except as modified in 4143 of this Standard.

4142. Sprinkler spacing for High Piled Storage Occupancies in NFPA No. 13 — 1971, 4112 and 4132 may apply to Class II, III, and IV commodities except as modified in 4143 of this Standard.

4143. Sprinkler spacing may exceed 100 sq. ft., but not more than 130 sq. ft., in systems hydraulically designed in accordance with the design curves shown in Figs. No. 4143a through 4143h for densities below 0.25 gpm per sq. ft. Densities shall not be less than those shown on the design curves and the minimum operating pressure at any ceiling sprinkler in the design area shall be 12.5 psi.

4144. For the purpose of selecting sprinkler spacings in hydraulically designed sprinkler systems, to obtain a stipulated density, 12.5 psi and 60 psi shall be the minimum and maximum discharge pressures used at the calculation starting point.

4145. 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 curves shall be used for sprinklers with high temperature classification.

4146. 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 should extend 15 ft. beyond the area occupied by the racks.

415. Sprinklers in Racks

4151. When sprinklers are installed in racks, one level of sprinklers shall be installed in up to 25 ft. high storage on racks without solid shelves and design curves for combined ceiling and in-rack sprinklers shall be used. For solid shelves see Section 42.

4152. The line of sprinklers in racks shall be located at or above the midpoint, but not exceeding 2/3 the height of storage above the floor level and in the longitudinal space between rows of storage on racks.

4153. Sprinklers in racks shall be ordinary temperature classification with nominal ½-inch orifice size.

4154. Sprinklers in racks shall be hydraulically designed, based on the most hydraulically remote 6 sprinklers operating with Class I, II, and III commodities and 8 sprinklers operating with Class IV commodities and with a minimum operating pressure of 15 psi at any sprinkler in the racks. (See 4821 for total water demand for sprinklers in racks.)

4155. Maximum spacing of sprinklers on branch lines in double row racks 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.

4156. Maximum spacing of sprinklers on branch lines in multiple row racks shall not exceed 12 ft. for Class I, II, and III commodities and 8 ft. for Class IV commodities with area limitations of 100 sq. ft. per sprinkler for Class I, II, and III commodities, and 80 sq. ft. 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.)

4157. 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. Minimum pipe diameter shall be one inch.

4158. Water shields are not required where only one level of in-rack sprinklers is installed. Where more than one level of in-rack sprinklers are installed water shields shall be provided.

4159. With double row racks 20 ft. or less in height, without solid shelves, the elevation of sprinkler deflectors with respect to the storage is not a consideration. It is not necessary to distribute water across the top of material storage or into the aisles.

4160. The sprinklers installed in racks with storage up to 20 ft. high may be spaced without regard to rack uprights except as noted in 4161.

4161. With double row racks without solid shelves over 20 ft. up to and including 25 ft. high, with multiple row racks or with double row racks with solid shelves, a minimum 6-in. clear space shall be maintained between the sprinkler deflectors and the top of a tier of storage. Sprinklers in such racks shall be located a minimum of 2 ft. from rack uprights in a longitudinal direction.

42. Solid and Slatted Shelves

421. Slatted shelves shall be considered the same as solid shelves.

422. With storage no higher than 20 ft. sprinklers shall be installed at the ceiling and at one level in double row racks with solid shelves longer than 8 ft. but less than 10 ft. longitudinally and deeper than 4 ft. but less than 5 ft. that do not obstruct longitudinal or transverse flue spaces (see Fig. No. 332). Storage higher than 20 ft. in this configuration is beyond the scope of this standard.

423. Sprinklers shall be installed at the ceiling and at each level 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. No. 332).

43. Aisle Widths

431. Design curves for single and double row racks shall be selected corresponding to aisle width. For aisle widths between 4 ft. and 8 ft. a direct linear interpolation between curves may be made (see Appendix A431).

44. Bulkheads or Barriers

441. Bulkheads are not a substitute for sprinklers in racks. Their installation does not justify reduction in sprinkler densities or design operating areas as called for in the design curves. Bulkheads, or barriers, are not necessary with rack configurations covered by this standard.

45. Alarms

451. Central station, auxiliary, remote station, or proprietary sprinkler water-flow alarm should be provided. Local water-flow alarm is acceptable where standard recorded guard service is provided (see NFPA Nos. 71, 72A, 72B, 72C, and 72D).

46. High Expansion Foam

461. See Appendix A461.

47. Hose Connections

471. For first aid fire fighting, and for mop-up operations small (1½ in.) 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.

48. Water Demand

481. Sprinklers at Ceiling

4811. Sprinkler water demand for Class I, II, III, and IV commodities in double row racks or in portable racks arranged in the same manner as double row racks not more than two deep shall be determined from design curves shown in Figs. No. 4143a, 4143b, 4143c. and 4143d.

4812. Plastic Film Covered Commodity (See Appendix A4812).

4813. The sprinkler water demand shall be determined from the design curves shown in Figures 4143e, 4143f, 4143g, and 4143h, for each of the four classes of commodities when stored in multiple-row racks, either fixed or portable, which are arranged as follows:

> Depth not exceeding 16 feet (3 or 4 pallets), transverse flue spaces at least 6 inches wide and not over 4 feet apart, height of storage over 12 feet but not exceeding 20 feet, and aisles at least 10 feet wide.

One level of in-rack sprinklers is required for a Class IV commodity, in which case the ceiling density shall be determined from the curves in figure 4143h. Multiple-row racks and portable racks with a storage height of over 20 feet are beyond the scope of this Standard.

4814. Where solid wood flat bottom slave pallets are used, the densities indicated in the design curves, based on conventional pallets, shall be increased 20 percent for the given area.

4815. Where storage height is less than 25 ft. but more than 12 ft., the ceiling densities indicated in the design curves, based on 20 ft. nominal storage height, shall be modified in accordance with Fig. 4815.

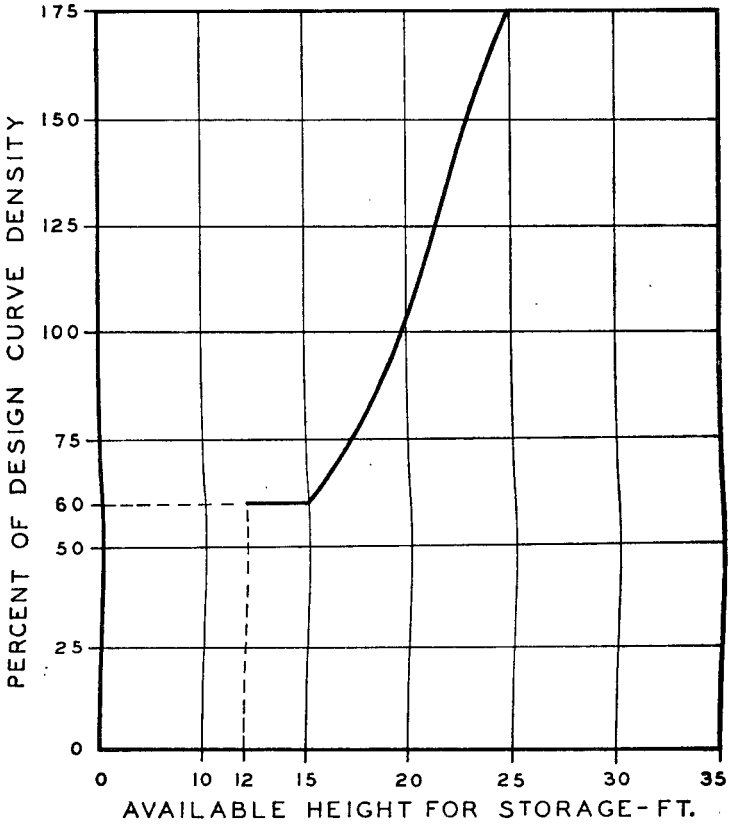


Fig. 4815

For storage heights over 20 ft. high up to and including 25 ft., percentages shown in the preceding table shall be applied to densities corresponding to design areas of application not exceeding 3000 sq. ft. Sprinklers in racks shall be installed for Class IV Commodities with storage heights exceeding 22 ft.

4816. 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 6000 sq. ft.

482. Sprinklers in Racks

4821. A water demand of 150 gallons per minute shall be added to the ceiling sprinkler water demand calculations for Class I, II, and III commodities and 200 gallons per minute shall be added for Class IV commodities.

483. Hose Streams

4831. For hose stream demand at least 500 gallons per minute shall be added to the sprinkler demand for Class I, II, and III commodities and at least 750 gallons per minute shall be added for Class IV commodities.

484. Duration of Water Supplies

4841. For double row racks the water supply duration should be at least 90 minutes for Class I, II and III Commodities and at least 2 hours for Class IV Commodities. For multiple row racks, water supply duration should be at least 3 hours for all classifications of commodity.

Chapter 5. Equipment

51. Mechanical Handling Equipment

511. Industrial Trucks

5111. Power-operated industrial trucks shall be of the type designated in Standard for Type Designations, Areas of Use, Maintenance and Operation of Powered Industrial Trucks, NFPA No. 505 — 1968, Part A, and their maintenance and operation shall be in accordance with NFPA No. 505, Parts B and C.

5112. Industrial trucks using LP-gas or liquid fuel shall be refueled outside of the storage building at a location designated for that purpose.

52. Building Service Equipment

521. Electrical equipment shall be installed in accordance with the provisions of the National Electrical Code, NFPA No. 70.

522. Heating, air-conditioning, refrigeration, lighting and other service equipment should be installed in accordance with applicable NFPA Codes, Standards, Recommended Practices, and Manuals.

Chapter 6. Building Maintenance and Operation

61. Building Operations Other Than Storage

611. 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. When welding or cutting operations are absolutely necessary, the precautions contained in NFPA No. 51B, Cutting and Welding Processes, shall be followed.

612. 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 ft. of the working area, and flame-proof 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.

613. Locomotives should not be allowed to enter the storage area.

614. Fumigation operations should comply with Standard for Fumigation, NFPA No. 57.

62. Waste Disposal

621. Approved type containers for rubbish and other trash materials should be provided as required. Containers should be emptied and contents removed from the premises at frequent intervals (see Standard for Incinerators and Rubbish Handling, NFPA No. 82).

63. Smoking

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

64. Maintenance and Inspection

641. Buildings should be maintained secure against the access of unauthorized persons.

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

643. Periodic inspections should be made of all fire protection equipment in conjunction with regular inspection of the premises. Unsatisfactory conditions should be immediately reported and necessary corrective measures taken promptly.

644. The sprinkler system and the water supplies should be checked and maintained in accordance with Care and Maintenance of Sprinkler Systems, NFPA No. 13A.

65. Plant Emergency Organization

651. Arrangements should be made to permit rapid entry into the premises in case of fire or other emergency of the municipal fire department, police department, or other personnel as may be summoned to deal with any emergency without delay.

652. A well-trained plant emergency organization should be provided to control emergency conditions that may arise.

653. The plant emergency organization should 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 still operating to effect final extinguishment

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

654. Special attention should be given to advance planning and training with respect to fire department response, access, and fire fighting.

655. A fire watch shall be maintained when the sprinkler system is not in service.

APPENDIX A. Introduction

A1. Application and Scope

This Standard uses as a basis the large scale fire test series conducted at the Factory Mutual Research Center, West Glocester, Rhode Island.

The test building is approximately 200 ft. x 250 ft. (50,000 sq. ft. in area), of fire resistive construction, and contains a volume of approximately 2.25 million cubic feet, the equivalent of a 100,000 sq. ft. building 22.5 ft. high. The test building has two primary heights beneath a single large ceiling. The east section is 30 ft. high and the west section is 60 ft. high.

The 20 ft. test series was conducted in the 30 ft. section with clearances from top of storage to ceiling nominally 10 ft.

Doors at the lower and intermediate levels and ventilation louvers at tops of walls were kept closed during the majority of the fire tests. This minimized effect of exterior conditions.

The entire test series was fully instrumented with thermocouples in rack members, simulated building column, bar joist, and at the ceiling.

Racks were constructed of steel vertical and horizontal members designed for 4,000 lb. loads. Vertical members were 8 ft. O.C. for conventional racks and 4 ft. O.C. for simulated automated racks. Simulated automated racks and slave pallets were used in the main central rack in the 4 ft. aisle tests. Conventional racks and conventional pallets were used in the main central rack in the 8 ft. aisle tests. The majority of the tests were conducted with 100 sq. ft. sprinkler spacing.

The test configuration in the 15 ft., 20 ft., and 25 ft. high tests covered an 1800 sq. ft. floor area, including aisles between racks. Tests which were utilized in producing this Standard limited fire damage to this area. Maximum water damage area anticipated in the Standard is 6000 sq. ft., the upper limit of the design curves.

The test data shows that as density is increased both the area of fire damage and sprinkler operation are reduced. The data also indicates that with sprinklers installed in the racks a reduction is gained in the area of fire damage and sprinkler operations, or water damage.

The following table illustrates these points. Information shown is taken from the 20 ft. high test series using the standard commodity.

Density GPM/Sq. Ft.		Fire Damage in Test Array %	Fire Damage in Test Array Sq. Ft.	Sprinkler Operation (165° F) Area — Sq. Ft.
0.30	(Ceiling only)	22	395	4500-4800
0.375	(Ceiling only)	17	306	1800
0.45	(Ceiling only)	9	162	700
0.20	(Ceiling only)	28-36	504-648	13,100-14,000
0.20	(Sprinklers at ceiling & in racks)	8	144	4100
0.30	(Sprinklers at ceiling & in racks)	7	126	700

These basic facts, the reduction in both fire damage and area of water application as sprinkler densities are increased or when sprinklers are installed in racks, should be considered carefully by those responsible for applying this Standard to the rack storage situation.

In the 25 ft. high test, a density of 0.55 gpm/sq. ft. produced 42% or 756 sq. ft. fire damage in the test array and a sprinkler wetted area of 1400 sq. ft. Lesser densities would not be expected to achieve the same limited degree of control. Therefore, if smaller areas of fire damage are to be achieved, sprinklers in racks should be considered.

Chapter A1. Classification of Storage

A11. A review of full scale fire tests run on the standard commodity (double tri-wall carton with metal liner), Hallmark products and 3-M products (abrasives, pressure sensitive tapes of plastic fiber, and paper, etc.) as well as a review of the considerable number of commodity tests conducted indicates a guide for commodity classifications. This guide is not related to any other method of classification of materials, therefore sound engineering judgement and analysis must be made of the commodity and the packaging when selecting a commodity classification.

Chapter A2. Building Construction

A221. None of the tests which were conducted with densities in accordance with the design curves produced critical temperatures in bar joists 12 ft. 6 in. from the ignition source. Therefore, with sprinkler systems designed in accordance with the curves, fireproofing of roof steel is not necessary.

A222. Temperatures in the test column were maintained below 1,000°F. in all tests where sprinklers in racks were used.

A223. Temperatures in the test column were maintained below 1,000°F. with densities of roof ceiling sprinklers only of 0.375 gal. per minute per sq. ft. with 8 ft. aisles and 0.45 gal. per sq. ft. with 4 ft. aisles using the standard commodity.

A241. Venting tests which were conducted as a part of the test program are not considered conclusive as to either the advantageous or detrimental effect of roof vents and draft curtains. Venting tests which have been conducted in other programs were without the benefit of sprinkler protection, and, as such, are not considered in this report which is dealing only with buildings protected by sprinklers. The design curves are based upon roof vents or draft curtains not being installed in the building.

Chapter A3. Storage Arrangements

A311. Type of racks covered in this Standard (see Figs. 331 and 332).

A3111. Conventional pallet racks — pallets rest on two beams parallel to the aisle. Any number of pallets can be supported by one pair of beams.

A3112. Automatic storage type rack — the pallet is supported by two rails running perpendicular to the aisle.

A3113. 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, and conventional or automatic racks with aisles less than 48 in.

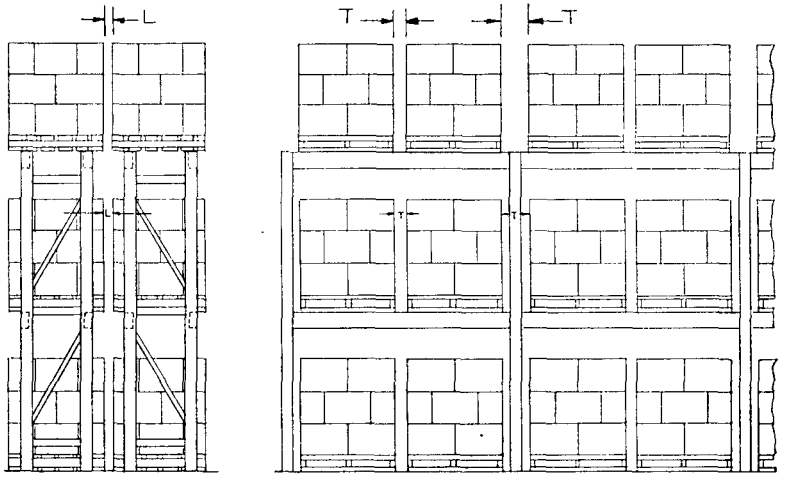
A3114. Solid shelving — conventional pallet rack with plywood shelves on the shelf beams. This is a special case (see Chapter 4).

A3115. 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.

A3116. Pallet depths in conventional or automatic racks are considered a nominal 48 in.

A331. Test No. 80 was conducted to determine the effect of closing back-to-back longitudinal 6 in. flue space in conventional pallet racks. Test results indicated fewer sprinklers operating than with the flue space open, and, as such, no minimum back-to-back clearance is necessary if the transverse flue space is maintained open.

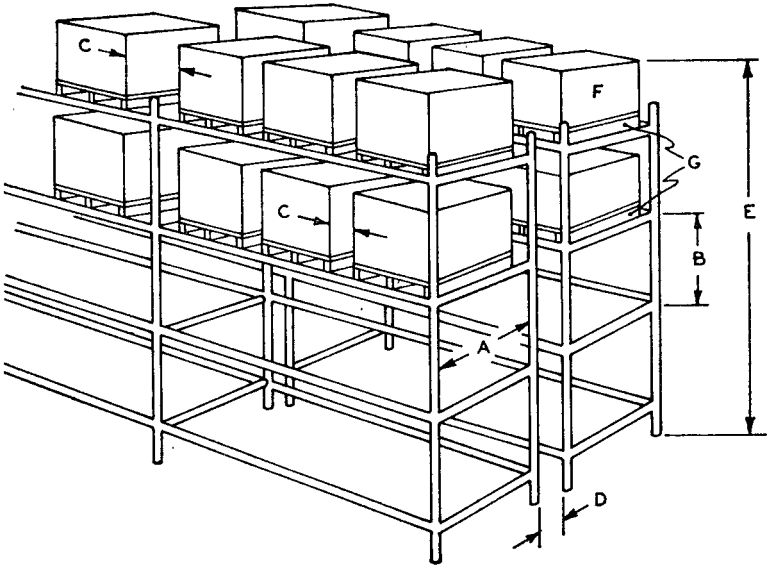
A35. Tests were conducted with deflector clearance of 10 ft. to top of storage with no adverse effects.



L — Longitudinal Flue Space

T — Transverse Flue Space

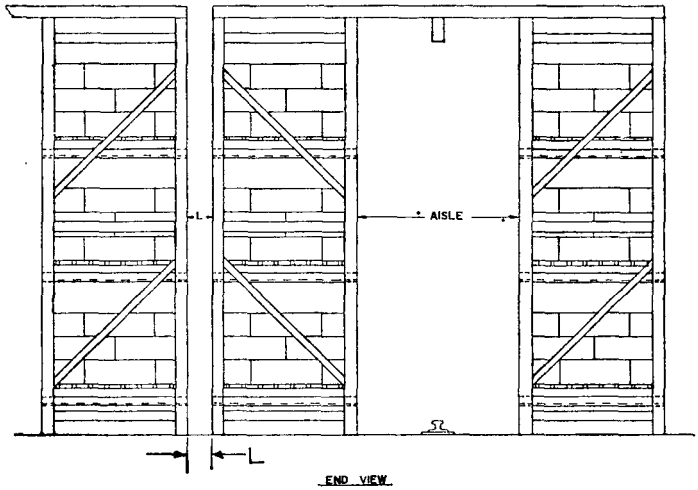
Fig. A3111a. Conventional Pallet Rack.



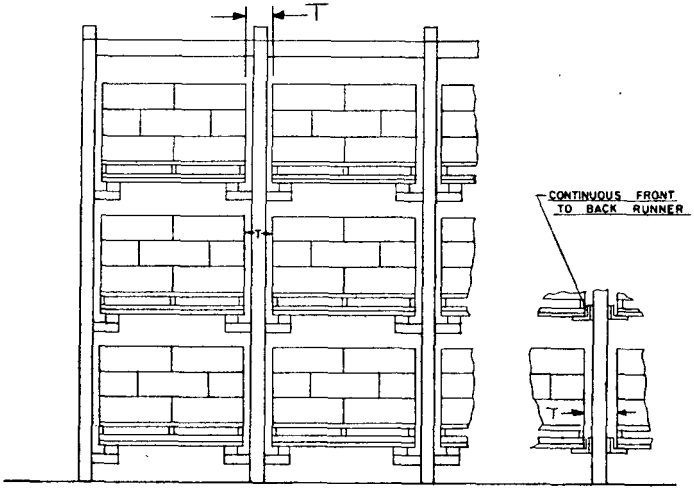
LEGEND

A — Shelf Width
B — Shelf Height
C — Transverse Flue Space
D — Longitudinal Flue Space
E — Storage Height
F — Commodity
G — Pallet

Fig. A3111b. Double Row Racks with Open Shelves.



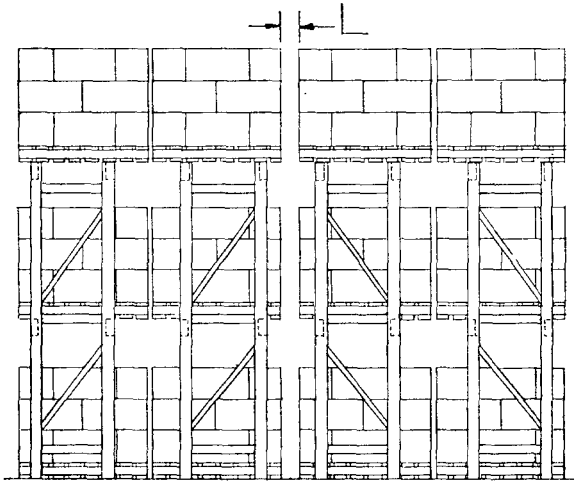
END VIEW



AISLE VIEW

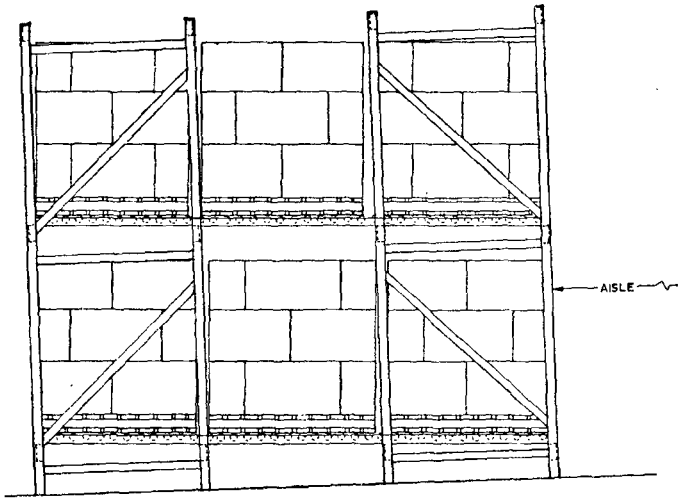
L — Longitudinal Flue Space T — Transverse Flue Space

Fig. A3112. Automatic Storage Type Rack.



L — Longitudinal Flue Space

Fig. A3113a. Multi-Row Rack to be Served by a Reach Truck.



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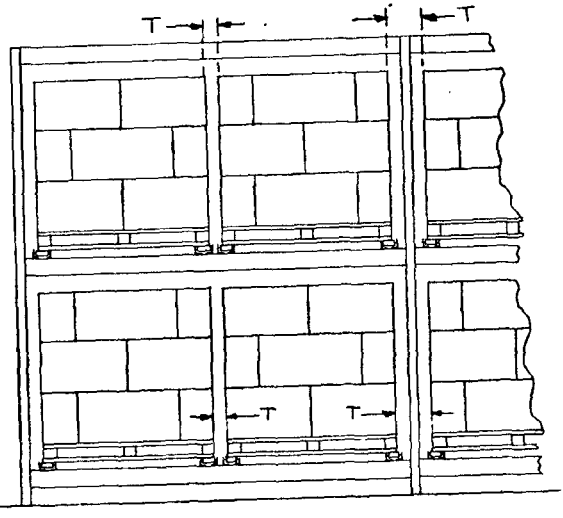
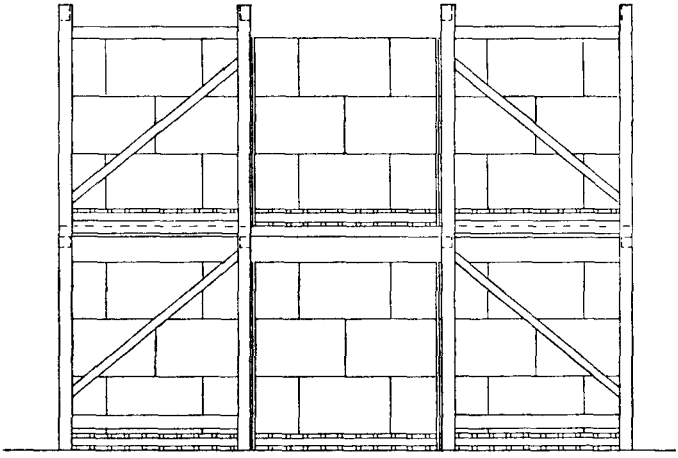


AISLE VIEW

L – Longitudinal Flue Space T – Transverse Flue Space

Fig. A3113b. Flow-Through Pallet Rack.



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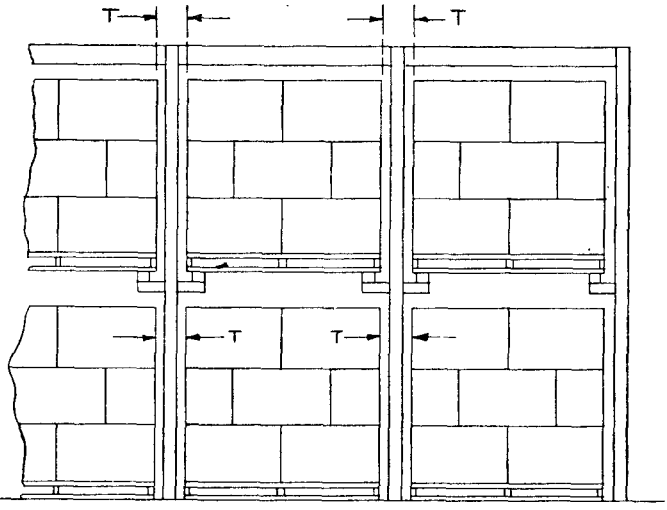
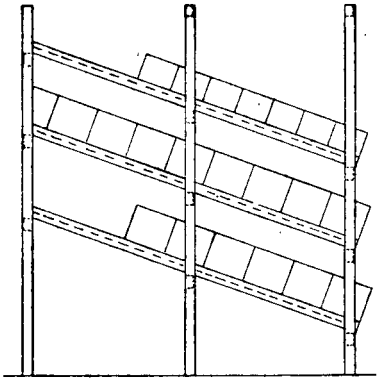


AISLE VIEW

T — Transverse Flue Space

Fig. A3113c. 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.



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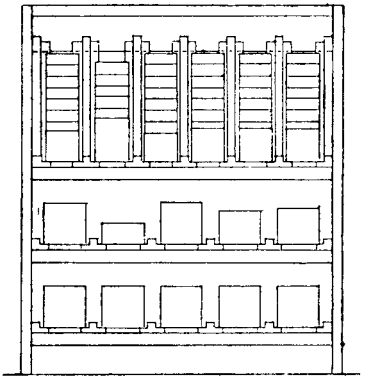
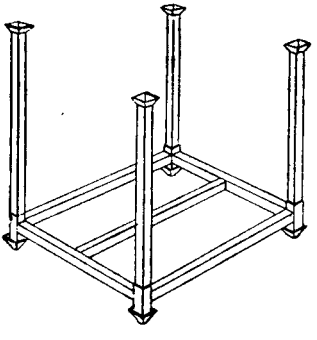
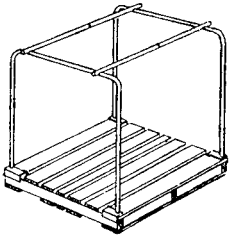


AISLE VIEW

Flow-Through Rack





PORTABLE RACKS

Fig. A3113d