



Second Revision No. 1041-NFPA 13-2017 [Global Comment]

SSD-AAA

Update metric conversions in NFPA 13 to match that as shown on the attached list and pdf of NFPA 13.

Supplemental Information

<u>File Name</u>	<u>Description</u>	<u>Approved</u>
13-SSD_metrics.pdf	Metric conversions SSD-AAA	
Metric_values_used_in_NFPA_13..docx		

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: National Fire Protection Assoc

Street Address:

City:

State:

Zip:

Submittal Date: Fri Oct 06 13:35:13 EDT 2017

Committee Statement

Committee Statement: The metric conversions in the attached list are considered to be “soft” or approximate conversions and are intended to consider trade sizes for pipe and other materials and have been appropriately rounded with the number of significant digits taken into account. The intent of this list is to provide for consistent use of metric conversions throughout the standard with the understanding that it is acceptable for an engineer, authority having jurisdiction, designer or, installer to use an exact conversion rather than an approximate conversion as used in the standard when necessary.

The attached list has been reviewed by the NFPA 13 Metric Task Group.

Response Message:

An assembly of fittings, pipe, flexible pipe, and/or couplings that permits movement in all directions to accommodate seismic differential movement across building seismic separation joints.

3.3.216 System Riser.

The aboveground horizontal or vertical pipe between the water supply and the mains (cross or feed) that contains a control valve (either directly or within its supply pipe), a pressure gauge, a drain, and a waterflow alarm device.

3.3.217 System Working Pressure.

The maximum anticipated static (nonflowing) or flowing pressure applied to sprinkler system components exclusive of surge pressures and exclusive of pressure from the fire department connection.

3.3.218 Sway Brace.

An assembly intended to be attached to the system piping to resist horizontal earthquake loads in two directions.

3.3.219 Thermal Barrier.

A material that limits the average temperature rise of the unexposed surface to not more than 250°F (121°C) above ambient for a specified fire exposure duration using the standard time–temperature curve of ASTM E119, *Standard Test Methods for Fire Tests of Building Construction and Materials*, or UL 263, *Standard for Fire Tests of Building Construction and Materials*.

3.3.220* Tiered Storage.

An arrangement in which bales are stored directly on the floor, two or more bales high.

3.3.221 Transverse Flue Space.

The space between rows of storage parallel to the direction of loading. (See Figure A.3.3.118.)

3.3.222 Type 1 Stair.

See 3.3.120.1.

3.3.223 Unit Load.

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

3.3.224 Unobstructed Construction.

See 3.3.43.2.

3.3.225 Upright Sprinkler.

See 3.3.206.3.6.

3.3.226 Vertical Roll Paper Storage.

See 3.3.183.4.

3.3.227 Waterflow Alarm Device.

An attachment to the sprinkler system that detects a predetermined water flow and is connected to a fire alarm system to initiate an alarm condition or is used to mechanically or electrically initiate a fire pump or local audible or visual alarm.

Chapter 4 General Requirements

4.1 Level of Protection.

4.1.1

A building, where protected by an automatic sprinkler system installation, shall be provided with sprinklers in all areas except where specific sections of this standard permit the omission of sprinklers.

4.1.2 Limited Area Systems.

4.1.2.1

When partial sprinkler systems are installed, the requirements of this standard shall be used insofar as they are applicable.

4.1.2.2

The authority having jurisdiction shall be consulted in each case.

4.2* Owner's Certificate.

The owner(s) of a building or structure where the fire sprinkler system is going to be installed or their authorized agent shall provide the sprinkler system installer with the following information prior to the layout and detailing of the fire sprinkler system [see Figure A.4.6(b)]:

- (1) Intended use of the building including the materials within the building and the maximum height of any storage
- (2) A preliminary plan of the building or structure along with the design concepts necessary to perform the layout and detail for the fire sprinkler system
- (3) *Any special knowledge of the water supply, including known environmental conditions that might be responsible for corrosion, including microbiologically influenced corrosion (MIC)

4.3* Classification of Hazard.

4.3.1 General.

4.3.1.1

Occupancy classifications for this standard shall relate to sprinkler design, installation, and water supply requirements only.

4.3.1.2

Occupancy classifications shall not be intended to be a general classification of occupancy hazards.

4.3.1.3

Commodity classification and storage arrangement referenced in 4.3.2 through 4.3.6 shall be determined in accordance with Sections 20.3 through 20.5 for miscellaneous and low-piled storage per 4.3.1.5 through 4.3.1.7.

4.3.1.4* Miscellaneous Storage.

4.3.1.4.1

Miscellaneous storage shall not constitute more than 10 percent of the building area or 4000 ft² (372 m²) of the sprinklered area, whichever is greater.

4.3.1.4.2

Miscellaneous storage shall not exceed 1000 ft² (93 m²) in one pile or area.

4.3.1.4.3

Miscellaneous storage shall be separated from other storage piles or areas by at least 25 ft (7.6 m).

4.3.1.5 Low-Piled Storage.

4.3.1.5.1

For storage of Class I through Class IV 12 ft (3.7 m) or less in height that does not meet the definition of *Miscellaneous Storage* that is on solid shelf racks, in-rack sprinklers shall be provided in accordance with 16.1.6, and ceiling sprinkler protection shall be provided in accordance with Chapter 1313.

4.3.1.5.2

For storage of Group A Plastics 5 ft (1.5 m) or less in height that does not meet the definition of *Miscellaneous Storage* that is on solid shelf racks, in-rack sprinklers shall be provided in accordance with 17.1.5, and ceiling sprinkler protection shall be provided in accordance with Chapter 13.

4.3.1.6 Miscellaneous Tire Storage.

4.3.1.6.1

Miscellaneous tire storage shall not exceed 2000 ft² (186 m²)

4.3.1.6.2

Miscellaneous tire storage piles on-tread, regardless of storage method, shall not exceed 25 ft (7.6 m) in the direction of the wheel holes.

4.3.1.7 In-Rack Sprinklers.

Miscellaneous and low-piled storage per 4.3.1.5 through 4.3.1.7 that require in-rack sprinklers shall follow Chapter 25 for their installation and design requirements.

4.3.2* Light Hazard.

The following shall be protected with light hazard occupancy criteria in this standard:

- (1) Spaces with low quantity and combustibility of contents

4.3.3* Ordinary Hazard (Group 1).

The following shall be protected with ordinary hazard group 1 occupancy criteria in this standard:

- (1) Spaces with moderate quantity and low combustibility of contents
- (2) Stockpiles of contents with low combustibility that do not exceed 8 ft (2.4 m)
- (3) Miscellaneous storage or storage facilities of solid-piled, palletized, bin box, shelf, rack, and back-to-back shelf storage of Class I commodities not exceeding 12 ft (3.7 m)
- (4) Miscellaneous storage or storage facilities of solid-piled, palletized, bin box, shelf, rack, and back-to-back shelf storage of Class II commodities not exceeding 10 ft (3.0 m)

4.3.4* Ordinary Hazard (Group 2).

The following shall be protected with ordinary hazard group 2 occupancy criteria in this standard:

- (1) Spaces with moderate to high quantity and combustibility of contents
- (2) Stockpiles of contents with moderate to high combustibility that do not exceed 12 ft (3.7 m)
- (3) Miscellaneous or low-piled storage of solid-piled, palletized, bin box, shelf, rack, and back-to-back shelf storage of Class II commodities more than 10 ft (3.0 m) and not exceeding 12 ft (3.7 m)
- (4) Miscellaneous or low-piled storage of solid-piled, palletized, bin box, shelf, rack, and back-to-back shelf storage of Class III commodities not exceeding 12 ft (3.7 m)
- (5) Miscellaneous or low-piled storage of solid-piled, palletized, bin box, shelf, rack, and back-to-back shelf storage of Class IV commodities not exceeding 10 ft (3.0 m)
- (6) Miscellaneous or low-piled storage of solid-piled, palletized, bin box, and shelf storage of Class IV commodities more than 10 ft (3.0 m) and not exceeding 12 ft (3.7 m) and a maximum ceiling height of 32 ft (9.8 m)
- (7) Miscellaneous or low-piled storage of solid-piled, palletized, bin box, shelf, rack, and back-to-back shelf storage of Group A commodities not exceeding 5 ft (1.5 m)
- (8) Miscellaneous storage of rack storage of Group A commodities more than 10 ft (3.0 m) and not exceeding 12 ft (3.7 m) and a maximum ceiling height of 32 ft (9.8 m) with the use of 1 level of in-rack sprinklers
- (9) Miscellaneous storage of rack storage of exposed expanded Group A commodities more than 5 ft (1.5 m) and not exceeding 10 ft (3.0 m) and a maximum ceiling height of 20 ft (5.1 m) with the use of 1 level of in-rack sprinklers
- (10) Miscellaneous tire storage stored on floor or in rack either on tread or on side not exceeding 5 ft (1.5 m)
- (11) Miscellaneous tire storage stored on a fixed single-row rack either on tread or on side more than 5 ft (1.5 m) and not exceeding 12 ft (3.7 m) and a maximum ceiling height of 32 ft (9.8 m) with the use of 1 level of in-rack sprinklers
- (12) Miscellaneous store of medium weight and heavyweight rolled paper stored on end not exceeding 10 ft (3.0 m) and a maximum ceiling height of 30 ft (9.1 m)

4.3.5* Extra Hazard (Group 1).

The following shall be protected with extra hazard group 1 occupancy criteria in this standard:

- (1) Spaces with very high quantity and combustibility of contents
- (2) Spaces where dust, lint, or other materials are present, introducing the probability of rapidly developing fires
- (3) Miscellaneous or low-piled storage of rack and back-to-back shelf storage of Class IV commodities more than 10 ft (3.0 m) and not exceeding 12 ft (3.7 m) and a maximum ceiling height of 32 ft (9.8 m),
- (4) Miscellaneous or low-piled storage of solid-piled, palletized, bin box, shelf, rack, and back-to-back shelf storage of cartoned Group A commodities more than 5 ft (1.5 m) and not exceeding 10 ft (3.0 m) and a maximum ceiling height of 15 ft (4.6 m)
- (5) Miscellaneous tire storage stored on floor on side or in single-row rack (portable and fixed) either on tread or on side more than 5 ft (1.5 m) and not exceeding 12 ft (3.7 m) and a maximum ceiling height of 32 ft (9.8 m)
- (6) Miscellaneous storage of tissue and lightweight rolled paper stored on end not exceeding 10 ft (3.0 m) and a maximum ceiling height of 30 ft (9.1 m)

4.3.6* Extra Hazard (Group 2).

The following shall be protected with extra hazard group 2 occupancy criteria in this standard:

- (1) Spaces with very high quantity and combustibility of contents
- (2) Spaces with substantial amounts of combustible or flammable liquids
- (3) Spaces where shielding of combustibles is extensive
- (4) Miscellaneous or low-piled storage of solid-piled, palletized, bin box, shelf, rack, and back-to-back shelf storage of cartoned Group A commodities more than 5 ft (1.5 m) and not exceeding 10 ft (3.0 m) and a maximum ceiling height of 20 ft (6.1 m)
- (5) Miscellaneous or low-piled storage of solid-piled, palletized, bin box, shelf, rack, and back-to-back shelf storage of cartoned Group A commodities more than 10 ft (3.0 m) and not exceeding
- (6) Miscellaneous or low-piled storage of solid-piled, palletized, bin box, shelf, and back-to-back shelf storage of cartoned Group A commodities more than 10 ft (3.0 m) and not exceeding 12 ft (3.7 m) and a maximum ceiling height of 32 ft (9.8 m)
- (7) Miscellaneous or low-piled storage of solid-piled, palletized, bin box, shelf, and back-to-back shelf storage of exposed Group A commodities more than 5 ft (1.5 m) and not exceeding 8 ft (2.4 m) and a maximum ceiling height of 28 ft (8.5 m)
- (8) Miscellaneous storage of solid-piled, palletized, bin box, shelf, rack, and back-to-back shelf storage of exposed Group A commodities more than 5 ft (1.5 m) and not exceeding 10 ft (3.0 m) and a maximum ceiling height of 15 ft (4.6 m)
- (9) Miscellaneous storage of solid-piled, palletized, bin box, shelf, rack, and back-to-back shelf storage of exposed unexpanded Group A commodities more than 5 ft (1.5 m) and not exceeding 10 ft (3.0 m) and a maximum ceiling height of 20 ft (6.1 m)
- (10) Miscellaneous storage of solid-piled, palletized, bin box, shelf, and back-to-back shelf storage of exposed Group A commodities more than 10 ft (3.0 m) and not exceeding 12 ft (3.7 m) and a maximum ceiling height of 17 ft (5.2 m)
- (11) Miscellaneous storage of rack storage of exposed Group A commodities more than 10 ft (3.0 m) and not exceeding 12 ft (3.7 m) and a maximum ceiling height of 17 ft (5.2 m)

4.3.7 High-Piled Storage.

Storage arrangements that do not meet the requirements of 4.3.2 through 4.3.6 shall be protected in accordance with Chapters 20 through 25.

4.3.8* Special Occupancy Hazards. (Reserved)

4.3.9

Where K-11.2 (160) or larger sprinklers are used with EH1 or EH2 design curves, the design area shall be permitted to be reduced by 25 percent but not below 2000 ft² (186 m²), regardless of temperature rating.

4.4 Hose Connections.

Hose connections shall not be required for the protection of miscellaneous storage.

4.5 System Protection Area Limitations.

4.5.1

The maximum floor area on any one floor to be protected by sprinklers supplied by any one sprinkler system riser or combined system riser shall be as follows:

- (1) Light hazard — 52,000 ft² (4830 m²)
- (2) Ordinary hazard — 52,000 ft² (4830 m²)
- (3) *Extra hazard — Hydraulically calculated — 40,000 ft² (3720 m²)
- (4) High-piled Storage — High-piled storage (as defined in 3.3.95) and storage covered by other NFPA standards — 40,000 ft² (3720 m²)
- (5) In-rack Storage — 40,000 ft² (3716 m²)

4.5.2

The floor area occupied by mezzanines shall not be included in the area limits of 4.5.1.

4.5.3

Where single systems protect extra hazard, high-piled storage, or storage covered by other NFPA standards, and ordinary or light hazard areas, the extra hazard or storage area coverage shall not exceed the floor area specified for that hazard and the total area coverage shall not exceed 52,000 ft² (4830 m²).

4.5.4

The area protected by a single in-rack system includes all of the floor area occupied by the racks, including aisles, regardless of the number of levels of in-rack sprinklers.

4.5.4.1

Multiple buildings attached by canopies, covered breezeways, common roofs, or a common wall(s) shall be permitted to be supplied by a single fire sprinkler riser.

4.5.4.2

The area protected by a single in-rack system shall include all of the floor area occupied by the racks, including aisles, regardless of the number of levels of in-rack sprinklers.

4.5.4.2.1

Multiple buildings attached by canopies, covered breezeways, common roofs, or a common wall(s) shall be permitted to be supplied by a single fire sprinkler riser.

4.5.4.3

The maximum system size shall comply with 4.5.1.

4.5.5* Detached Buildings.

4.5.5.1

Unless the requirements of 4.5.5.2 apply, detached buildings, regardless of separation distance, that do not meet the criteria of 4.5.4 shall be provided with separate fire sprinkler systems.

4.5.5.2

When acceptable to the authority having jurisdiction, detached structures shall be permitted to be supplied by the fire sprinkler system of an adjacent building.

4.6* Working Plans.

4.6.1*

Working plans shall be submitted for approval to the authority having jurisdiction before any equipment is installed or remodeled.

4.6.1.1

Working plan submittals shall include the following:

- (1) Working plans of the system(s), per 4.6.3
- (2) Hydraulic calculations where systems are required to be calculated
- (3) Data sheets for the system components where required by the AHJ
- (4) *Signed owner's certificate

4.6.1.2

Submittals shall be permitted to be in electronic format when approved by the authority having jurisdiction.

4.6.1.3

A copy of the approved plans shall be given to the owner or owner's representative.

4.6.2

Deviation from approved plans shall require permission of the authority having jurisdiction.

4.6.3

Working plans shall be drawn to an indicated scale, on sheets of uniform size, with a plan of each floor, and shall show those items from the following list that pertain to the design of the system:

- (1) Name of owner and occupant.
- (2) Location, including street address.
- (3) Point of compass.
- (4) Full height cross section or schematic diagram, including structural member information if required for clarity and including ceiling construction and method of protection for nonmetallic piping.
- (5) Ceiling/roof heights and slopes not shown in the full height cross section.
- (6) Location of partitions.
- (7) Location of fire walls.
- (8) Occupancy class of each area or room.
- (9) Location and size of concealed spaces, closets, attics, and bathrooms.
- (10) Any small enclosures in which no sprinklers are to be installed.
- (11) Size of city main in street and whether dead end or circulating; if dead end, direction and distance to nearest circulating main; and city main test results and system elevation relative to test hydrant.
- (12) Other sources of water supply, with pressure or elevation.
- (13) Make, type, model, and nominal K-factor of sprinklers, including sprinkler identification number.
- (14) Temperature rating and location of high-temperature sprinklers.
- (15) Total area protected by each system on each floor.
- (16) Number of sprinklers on each riser per floor.
- (17) Total number of sprinklers on each dry pipe system, preaction system, combined dry pipe–preaction system, or deluge system.
- (18) Approximate capacity in gallons of each dry pipe system.
- (19) Pipe type and schedule of wall thickness.

- (20) Nominal pipe size and cutting lengths of pipe (or center-to-center dimensions). Where typical branch lines prevail, it shall be necessary to size only one typical line.
- (21) Location and size of riser nipples.
- (22) Type of fittings and joints and location of all welds and bends. The contractor shall specify on drawing any sections to be shop welded and the type of fittings or formations to be used.
- (23) Type and locations of hangers, sleeves, braces, and methods of securing sprinklers when applicable.
- (24) All control valves, check valves, drain pipes, and test connections.
- (25) Size, location, and valve and piping arrangement for means to forward flow test at system demand.
- (26) Make, type, model, and size of alarm or dry pipe valve.
- (27) Make, type, model, and size of preaction or deluge valve.
- (28) Kind and location of alarm bells.
- (29) Size and location of standpipe risers, hose outlets, hand hose, monitor nozzles, and related equipment.
- (30) Private fire service main sizes, lengths, locations, weights, materials, point of connection to city main; the sizes, types and locations of valves, valve indicators, regulators, meters, and valve pits; and the depth that the top of the pipe is laid below grade.
- (31) Piping provisions for flushing.
- (32) Where the equipment is to be installed as an addition to an existing system, enough of the existing system indicated on the plans to make all conditions clear.
- (33) For hydraulically designed systems, the information on the hydraulic data nameplate.
- (34) A graphic representation of the scale used on all plans.
- (35) Name, address, and phone number(s) of contractor.
- (36) Hydraulic reference points shown on the plan that correspond with comparable reference points on the hydraulic calculation sheets.
- (37) The minimum rate of water application (density or flow or discharge pressure), the design area of water application, in-rack sprinkler demand, and the water required for hose streams both inside and outside.
- (38) The total quantity of water and the pressure required noted at a common reference point for each system.
- (39) Relative elevations of sprinklers, junction points, and supply or reference points.
- (40) If room design method is used, all unprotected wall openings throughout the floor protected.
- (41) Calculation of loads for sizing and details of sway bracing.
- (42) Zones of influence used in calculations for seismic bracing indicated on plans.
- (43) The setting for pressure-reducing valves.
- (44) Information about backflow preventers (manufacturer, size, type).
- (45) Information about listed antifreeze solution used (type and amount).
- (46) Size and location of hydrants showing size and number of outlets and if outlets are to be equipped with independent gate valves. Whether hose houses and equipment are to be provided, and by whom, shall be indicated. Static and residual hydrants that were used in flow tests shall be shown.
- (47) Utility plans and/or plumbing plans necessary to show connection from water supply to fire sprinkler system.

- (48) Size, location, and piping arrangement of fire department connections.
- (49) Ceiling/roof heights and slopes not shown in the full height cross section.
- (50) Edition year of NFPA 13 to which the sprinkler system is designed.

4.6.4

A signed copy of the owner's certificate and the working plan submittal shall include the manufacturer's installation instructions for any specially listed equipment, including descriptions, applications, and limitations for any sprinklers, devices, piping, or fittings.

4.6.5* Working Plans for Automatic Sprinkler Systems with Non-Fire Protection Connections.

4.6.5.1

Special symbols shall be used and explained for auxiliary piping, pumps, heat exchangers, valves, strainers, and the like, clearly distinguishing these devices and piping runs from those of the sprinkler system.

4.6.5.2

Model number, type, and manufacturer's name shall be identified for each piece of auxiliary equipment.

4.7 Water Supply Information.

4.7.1 Water Supply Capacity Information.

The following information shall be included:

- (1) Location and elevation of static and residual test gauge with relation to the riser reference point
- (2) Flow location
- (3) Static pressure, psi (bar)
- (4) Residual pressure, psi (bar)
- (5) Flow, gpm (L/min)
- (6) Date
- (7) Time
- (8) Name of person who conducted the test or supplied the information
- (9) Other sources of water supply, with pressure or elevation

4.7.1.1*

Where a waterflow test is used for the purposes of system design, the test shall be conducted no more than 12 months prior to working plan submittal unless otherwise approved by the authority having jurisdiction.

4.7.2 Water Supply Treatment Information.

The following information shall be included when water supply treatment is provided in accordance with 5.1.5:

- (1) Type of condition that requires treatment
- (2) Type of treatment needed to address the problem
- (3) Details of treatment plan

4.8* Additives.

Additives or chemicals intended to stop leaks, such as sodium silicate or derivatives of sodium silicate, brine, or similar acting chemicals, shall not be used in sprinkler systems.

4.9 Air, Nitrogen, or Other Approved Gas.

Where air is used to charge, maintain, or supervise sprinkler systems, nitrogen or other approved gas shall also be permitted to be used.

4.10* Support of Nonsprinkler System Components.

Sprinkler system components shall not be used to support nonsprinkler system components unless expressly permitted by this standard.

Chapter 5 Water Supplies

5.1 General.

5.1.1 Number of Supplies.

Every automatic sprinkler system shall have at least one automatic water supply.

5.1.2 Capacity.

Water supplies shall be capable of providing the required flow and pressure for the remote design area determined using the requirements and procedures as specified in Chapters 11 through 22 including hose stream allowance where applicable for the required duration.

5.1.3* Size of Fire Mains.

5.1.3.1

Except as provided in 5.1.3.2 or 5.1.3.3, no pipe smaller than 6 in. (150 mm) in diameter shall be installed as a private service main.

5.1.3.2

For mains that do not supply hydrants, sizes smaller than 6 in. (150 mm) shall be permitted to be used subject to the following restrictions:

- (1) The main supplies only automatic sprinkler systems, open sprinkler systems, water spray fixed systems, foam systems, or Class II standpipe systems.
- (2) Hydraulic calculations show that the main will supply the total demand at the appropriate pressure. Systems that are not hydraulically calculated shall have a main at least as large as the system riser.

5.1.3.3

Where a single main less than 4 in. (100 mm) in diameter serves both fire systems and other uses, the non-fire demand shall be added to the hydraulic calculations for the fire system at the point of connection unless provisions have been made to automatically isolate the non-fire demand during a fire event.

5.1.4 Underground Supply Pipe.

For pipe schedule systems, the underground supply pipe shall be at least as large as the system riser.

5.1.5* Water Supply Treatment.

5.1.5.1

Water supplies and environmental conditions shall be evaluated for the existence of microbes and conditions that contribute to microbiologically influenced corrosion (MIC). Where conditions are found that contribute to MIC, the owner(s) shall notify the sprinkler system installer and a plan shall be developed to treat the system using one of the following methods:

- (1) Install a water pipe that will not be affected by the MIC microbes
- (2) Treat all water that enters the system using an approved biocide
- (3) Implement an approved plan for monitoring the interior conditions of the pipe at established time intervals and locations
- (4) Install corrosion monitoring station and monitor at established intervals

5.1.5.2

Water supplies and environmental conditions shall be evaluated for conditions that contribute to unusual corrosive properties. Where conditions are found that contribute to unusual corrosive properties, the owner(s) shall notify the sprinkler system installer and a plan shall be developed to treat the system using one of the following methods:

- (1) Install a water pipe that is corrosion resistant

- (2) Implement an approved plan for monitoring the interior conditions of the pipe at established intervals and locations
- (3) Install corrosion monitoring station and monitor at established intervals
- (4) Fill dry-pipe or preaction systems with nitrogen as a supervisory gas to mitigate against corrosion.
- (5) When using a generator, use an approved nitrogen generator.

5.1.5.3

Where listed biocides and/or corrosion inhibitors are used, they shall be compatible with system components. Where used together, they shall also be compatible with each other.

5.1.6 Arrangement.

5.1.6.1 Connection Between Underground and Aboveground Piping.

5.1.6.1.1

The connection between the system piping and underground piping shall be made with a suitable transition piece and shall be properly strapped or fastened by approved devices.

5.1.6.1.2

Where required due to specific mechanical or environmental conditions, the transition piece shall be protected against possible damage from corrosive agents, solvent attack, or mechanical damage.

5.1.6.2* Connection Passing Through or Under Foundation Walls.

When system piping pierces a foundation wall below grade or is located under the foundation wall, clearance shall be provided to prevent breakage of the piping due to building settlement.

5.1.7* Meters.

Where meters are required by other authorities, they shall be listed.

5.1.8* Connection from Waterworks System.

5.1.8.1

The requirements of the public health authority having jurisdiction shall be determined and followed.

5.1.8.2

Where equipment is installed to guard against possible contamination of the public water system, such equipment and devices shall be listed for fire protection service.

5.2 Types.

5.2.1*

Water supplies for sprinkler systems shall be one of the following or any combination:

- (1) A connection to an approved public or private waterworks system in accordance with 5.2.2
- (2) A connection including a fire pump in accordance with 5.2.3
- (3) A connection to a water storage tank at grade or below grade installed in accordance with NFPA 22 and filled from an approved source
- (4) A connection to a pressure tank in accordance with 5.2.4 and filled from an approved source
- (5) A connection to a gravity tank in accordance with 5.2.5 and filled from an approved source
- (6) A penstock, flume, river, lake, pond, or reservoir in accordance with 5.2.6
- (7) *A source of recycled or reclaimed water where the building owner (or their agent) has analyzed the source of the water and the treatment process (if any) that the water undergoes before being made available to the sprinkler system and determined that any materials, chemicals, or contaminants in the water will not be detrimental to the components of the sprinkler system it comes in contact with

5.2.2* Connections to Waterworks Systems.

5.2.2.1

A connection to a reliable waterworks system shall be an acceptable water supply source.

5.2.2.2

The volume and pressure of a public water supply shall be determined from waterflow test data or other approved methods.

5.2.2.2.1

Where a waterflow test is conducted, the volume and pressure available for use for a fire protection system shall be determined in accordance with 5.2.2.2.1.1. If knowledge of the water supply is unavailable, the volume and pressure shall be determined in accordance with 5.2.2.2.1.2.

5.2.2.2.1.1*

Water supply adjustments shall be based on knowledge of the water supply and engineering judgment, taking into account daily and seasonal fluctuations, not extreme conditions.

5.2.2.2.1.2*

If knowledge of the water supply is unavailable, the following formula shall be used to determine volume and pressure:

$$P = (P_R - P_S) \left(\frac{Q}{Q_R} \right)^{1.85} + P_L \quad [5.2.2.2.1.2]$$

where:

P = pressure available from the water supply to use for a fire protection system that will be calculated for a given flow (Q)

P_R = residual pressure measured during the waterflow test while the flow Q_R was discharging from the water supply

P_S = static pressure measured during the waterflow test

Q = flow that will be used to calculate the available pressure from the water supply

Q_R = flow discharging from the water supply when P_R was measured

P_L = expected low static pressure at the location of the test results accounting for daily and seasonal fluctuations (not extreme conditions) obtained from the water utility

5.2.2.2.1.3

Where the water authority does not provide a value for P_L , the value of P_L shall be calculated from the following formula:

$$P_L = P_S(0.9) \quad [5.2.2.2.1.3]$$

5.2.3* Pumps.

A single automatically controlled fire pump installed in accordance with NFPA 20 shall be an acceptable water supply source.

5.2.4 Pressure Tanks.

5.2.4.1 Acceptability.

5.2.4.1.1

A pressure tank installed in accordance with NFPA 22 shall be an acceptable water supply source.

5.2.4.1.2

Pressure tanks shall be provided with an approved means for automatically maintaining the required air pressure.

5.2.4.1.3

Where a pressure tank is the sole water supply, an approved trouble alarm shall also be provided to indicate low air pressure and low water level with the alarm supplied from an electrical branch circuit independent of the air compressor.

5.2.4.1.4

Pressure tanks shall not be used to supply other than sprinklers and hand hose attached to sprinkler piping.

5.2.4.2 Capacity.

5.2.4.2.1

In addition to the requirements of 5.1.2, the water capacity of a pressure tank shall include the extra capacity needed to fill dry pipe or preaction systems where installed.

5.2.4.2.2

The total volume shall be based on the water capacity plus the air capacity required by 5.2.4.3.

5.2.4.3* Water Level and Air Pressure.

5.2.4.3.1

Pressure tanks shall be kept with a sufficient supply of water to meet the demand of the fire protection system as calculated in Chapter 23 for the duration required by Chapter 11, Chapter 12, or Chapter 22.

5.2.4.3.2

The pressure shall be sufficient to push all of the water out of the tank while maintaining the necessary residual pressure (required by Chapter 23) at the top of the system.

5.2.5 Gravity Tanks.

An elevated tank installed in accordance with NFPA 22 shall be an acceptable water supply source.

5.2.6 Penstocks, Flumes, Rivers, or Lakes.

Water supply connections from penstocks, flumes, rivers, lakes, or reservoirs shall be arranged to avoid mud and sediment and shall be provided with approved double removable screens or approved strainers installed in an approved manner.

Chapter 6 Installation Underground Piping

6.1* Piping.

[24:10.1]

6.1.1*

All piping used in private fire service mains shall be in accordance with 6.1.1.1, 6.1.1.2 or 6.1.1.3.

[24:10.1.1]

6.1.1.1 Listing.

Piping manufactured in accordance with **Table 6.1.1.1** shall be permitted to be used. [24:10.1.1.1]

Table 6.1.1.1 Manufacturing Standards for Underground Pipe

Materials and Dimensions		Standard
Ductile Iron		

Chapter 19 Design Approaches and Calculations

19.1 General.

Chapter 19 shall be utilized for design approaches and calculation procedures.

19.2 General Design Approaches.

The requirements of Section 19.2 shall apply to all sprinkler systems unless modified by a specific section of Chapter 11 or Chapter 12.

19.2.1

A building or portion thereof shall be permitted to be protected in accordance with any applicable design approach at the discretion of the designer.

19.2.2* Adjacent Hazards or Design Methods.

For buildings with two or more adjacent hazards or design methods, the following shall apply:

(1) Where areas are not physically separated by a draft curtain, barrier, or partition capable of delaying heat from a fire in one area from fusing sprinklers in the adjacent area, the required sprinkler protection for the more demanding design basis shall extend 15 ft (4.6 m) beyond its perimeter.

(2) The requirements of 19.2.2(1) shall not apply where the areas are separated by a draft curtain, or barrier located above an aisle, where the aisle has a minimum 2 ft (600 mm) horizontal separation from the adjacent hazard on each side, or a partition that is capable of delaying heat from a fire in one area from fusing sprinklers in the adjacent area.

(3) The requirements of 19.2.2(1) shall not apply to the extension of more demanding criteria from an upper ceiling level to beneath a lower ceiling level where the difference in height between the ceiling levels is at least 2 ft (600 mm), located above an aisle, where the aisle has a minimum 2 ft (600 mm) horizontal separation from the adjacent hazard on each side.

19.2.3

For hydraulically calculated systems, the total system water supply requirements for each design basis shall be determined in accordance with the procedures of Section 19.6 unless modified by a section of Chapter 11 or Chapter 12.

19.2.4 Water Demand.

19.2.4.1*

The water demand requirements shall be determined from the following:

- (1) Occupancy hazard fire control approach and special design approaches of Chapter 11
- (2) Storage design approaches of Chapter 12 through Chapter 20
- (3) Special occupancy approaches of Chapter 22

19.2.4.2*

The minimum water demand requirements for a sprinkler system shall be determined by adding the hose stream allowance to the water demand for sprinklers.

19.2.5 Water Supplies.

19.2.5.1

The minimum water supply shall be available for the minimum duration specified in Chapter 11.

19.2.5.2*

Tanks shall be sized to supply the equipment that they serve.

19.2.5.3*

Pumps shall be sized to supply the equipment that they serve.

19.2.6 Hose Allowance.

19.2.6.1 Systems with Multiple Hazard Classifications.

For systems with multiple hazard classifications, the hose stream allowance and water supply duration shall be in accordance with one of the following:

(1) The water supply requirements for the highest hazard classification within the system shall be used.

(2) The water supply requirements for each individual hazard classification shall be used in the calculations for the design area for that hazard.

(3) *For systems with multiple hazard classifications where the higher classification only lies within single rooms less than or equal to 400 ft² (37 m²) in area with no such rooms adjacent, the water supply requirements for the principal occupancy shall be used for the remainder of the system.

19.2.6.2*

Water allowance for outside hose shall be added to the sprinkler requirement at the connection to the city main or a private fire hydrant, whichever is closer to the system riser.

19.2.6.3

Where inside hose connections are planned or are required, the following shall apply:

(1) A total water allowance of 50 gpm (190 L/min) for a single hose connection installation shall be added to the sprinkler requirements.

(2) A total water allowance of 100 gpm (380 L/min) for a multiple hose connection installation shall be added to the sprinkler requirements.

(3) The water allowance shall be added in 50 gpm (190 L/min) increments beginning at the most remote hose connection, with each increment added at the pressure required by the sprinkler system design at that point.

19.2.6.3.1

Where the system is a combined sprinkler/standpipe system (Class I or Class III) and the building is fully sprinklered in accordance with NFPA 13, no inside hose demand shall be required at any of the standpipe outlets.

19.2.6.4*

When hose valves for fire department use are attached to wet pipe sprinkler system risers in accordance with 16.15.2, the following shall apply:

(1) The sprinkler system demand shall not be required to be added to standpipe demand as determined from NFPA 14.

(2) Where the combined sprinkler system demand and hose stream allowance of Table 19.3.3.1.2 exceeds the requirements of NFPA 14, this higher demand shall be used.

(3) For partially sprinklered buildings, the sprinkler demand, not including hose stream allowance, as indicated in Figure 19.3.3.1.1 shall be added to the requirements given in NFPA 14.

19.2.7* High Volume Low Speed (HVLS) Fans.

The installation of HVLS fans in buildings equipped with sprinklers, including ESFR sprinklers, shall comply with the following:

(1) The maximum fan diameter shall be 24 ft (7.3 m).

(2) The HVLS fan shall be centered approximately between four adjacent sprinklers.

(3) The vertical clearance from the HVLS fan to sprinkler deflector shall be a minimum of 3 ft (0.9 m).

(4) All HVLS fans shall be interlocked to shut down immediately upon a waterflow alarm. Where the building is protected with a fire alarm system, this interlock shall be in accordance with the requirements of NFPA 72.

19.3 Occupancy Hazard Fire Control Approach for Spray Sprinklers.

19.3.1 General.

19.3.1.1*

The water demand requirements shall be determined by either the pipe schedule method in accordance with 19.3.2 or the hydraulic calculation method in accordance with 19.3.3.

19.3.1.2 Occupancy Classifications.

19.3.1.2.1

Occupancy classifications for this standard shall relate to sprinkler installations and their water supplies only.

19.3.1.2.2

Occupancy classifications shall not be used as a general classification of occupancy hazards.

19.3.1.2.3

Occupancies or portions of occupancies shall be classified according to the quantity and combustibility of contents, the expected rates of heat release, the total potential for energy release, the heights of stockpiles, and the presence of flammable and combustible liquids, using the definitions contained in Section 4.3.2 through Section 4.3.7.

19.3.1.2.4

Classifications shall be as follows:

- (1) Light hazard
- (2) Ordinary hazard (Groups 1 and 2)
- (3) Extra hazard (Groups 1 and 2)
- (4) Special occupancy hazard (*see Chapter 22*)

19.3.2 Water Demand Requirements — Pipe Schedule Method.

19.3.2.1

Table 19.3.2.1 shall be used in determining the minimum water supply requirements for light and ordinary hazard occupancies protected by systems with pipe sized according to the pipe schedules of Section 19.9.

Table 19.3.2.1 Water Supply Requirements for Pipe Schedule Sprinkler Systems

Occupancy Classification	Minimum Residual Pressure Required		Acceptable Flow at Base of Riser (Including Hose Stream Allowance)		Duration (minutes)
	psi	bar	gpm	L/min	
Light hazard	15	1	500–750	1900–2850	30–60
Ordinary hazard	20	1.4	850–1500	3200–5700	60–90

19.3.2.2

Pressure and flow requirements for extra hazard occupancies shall be based on the hydraulic calculation methods of 19.3.3.

19.3.2.3

The pipe schedule method shall be permitted as follows:

- (1) Additions or modifications to existing pipe schedule systems sized according to the pipe schedules of Section 19.9
- (2) Additions or modifications to existing extra hazard pipe schedule systems
- (3) New systems of 5000 ft² (465 m²) or less
- (4) New systems exceeding 5000 ft² (465 m²) where the flows required in Table 19.3.2.1 are available at a minimum residual pressure of 50 psi (3.4 bar) at the highest elevation of sprinkler

19.3.2.4

Table 19.3.2.1 shall be used in determining the minimum water supply requirements.

19.3.2.5

The lower duration value of Table 19.3.2.1 shall be acceptable only where the sprinkler system waterflow alarm device(s) and supervisory device(s) are electrically supervised and such supervision is monitored at an approved, constantly attended location.

19.3.2.6* Residual Pressure.

19.3.2.6.1

The residual pressure requirement of Table 19.3.2.1 shall be met at the elevation of the highest sprinkler.

19.3.2.6.2 Friction Loss Due to Backflow Prevention Valves.

19.3.2.6.2.1

When backflow prevention valves are installed on pipe schedule systems, the friction losses of the device shall be accounted for when determining acceptable residual pressure at the top level of sprinklers.

19.3.2.6.2.2

The friction loss of this device [in psi (bar)] shall be added to the elevation loss and the residual pressure at the top row of sprinklers to determine the total pressure needed at the water supply.

19.3.2.7

The lower flow figure of Table 19.3.2.1 shall be permitted only where the building is of noncombustible construction or the potential areas of fire are limited by building size or compartmentation such that no open areas exceed 3000 ft² (280 m²) for light hazard or 4000 ft² (370 m²) for ordinary hazard.

19.3.3 Water Demand Requirements — Hydraulic Calculation Methods.

19.3.3.1 General.

19.3.3.1.1

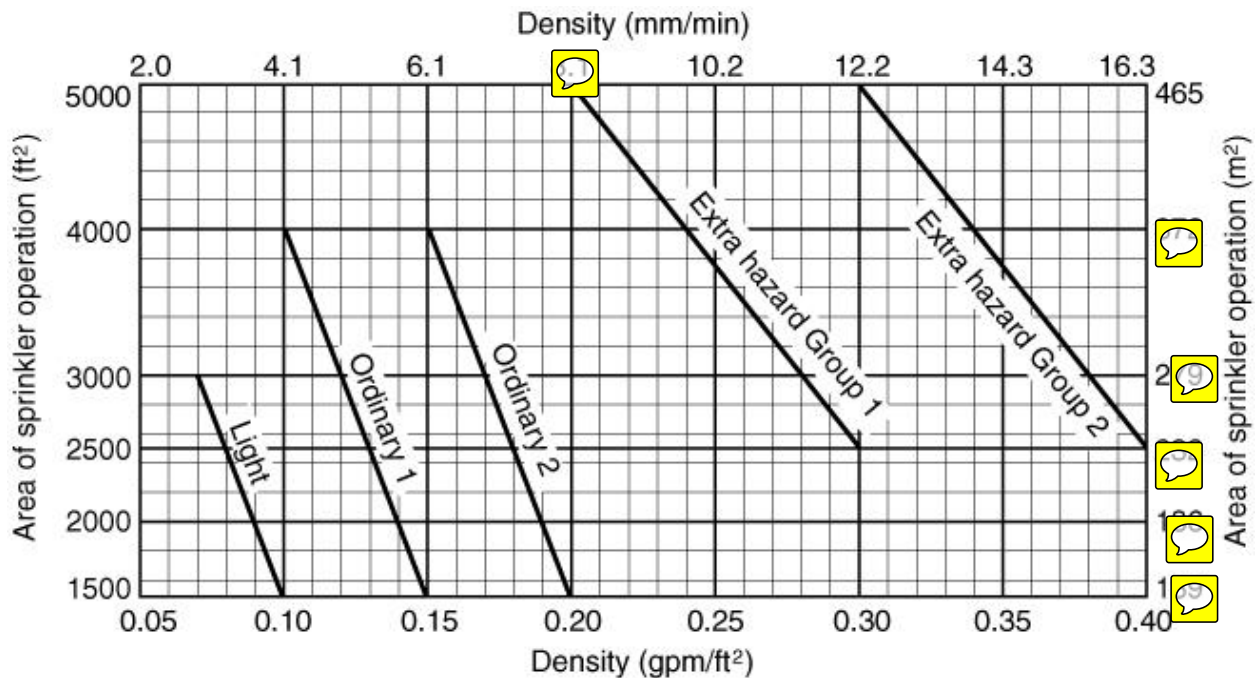
The water demand for sprinklers shall be determined only from one of the following, at the discretion of the designer:

- (1) Density/area curves of Figure 19.3.3.1.1 in accordance with the density/area method of

19.3.3.2

- (2) The room that creates the greatest demand in accordance with the room design method of 19.3.3.3
- (3) Special design areas in accordance with 19.3.3.4

Figure 19.3.3.1.1 Density/Area Curves.



19.3.3.1.2

The minimum water supply shall be available for the minimum duration specified in Table 19.3.3.1.2.

Table 19.3.3.1.2 Hose Stream Allowance and Water Supply Duration Requirements for Hydraulically Calculated Systems

Occupancy	Inside Hose		Total Combined Inside and Outside Hose		Duration (minutes)
	gpm	L/min	gpm	L/min	
Light hazard	0, 50, or 100	0, 190, or 380	100	380	30
Ordinary hazard	0, 50, or 100	0, 190, or 380	250	950	60–90
Extra hazard	0, 50, or 100	0, 190, or 380	500	1900	90–120

19.3.3.1.2.1

The maximum design area for miscellaneous and low-piled storage shall be 3000 ft² (279 m²).

19.3.3.1.3

The lower duration values in Table 19.3.3.1.2 shall be permitted where the sprinkler system waterflow alarm device(s) and supervisory device(s) are electrically supervised and such supervision is monitored at an approved, constantly attended location.

19.3.3.1.4 Restrictions.

When either the density/area method or room design method is used, the following shall apply:

- (1) *For areas of sprinkler operation less than 1500 ft² (139 m²) used for light and ordinary hazard occupancies, the density for 1500 ft² (139 m²) shall be used.
- (2) For areas of sprinkler operation less than 2500 ft² (232 m²) for extra hazard occupancies, the density for 2500 ft² (232 m²) shall be used.

19.3.3.1.5 Unsprinklered Combustible Concealed Spaces.

19.3.3.1.5.1*

When using the density/area or room design method, unless the requirements of 19.3.3.1.5.2 are met for buildings having unsprinklered combustible concealed spaces, as described in 9.2.1 and 9.3.19, the minimum area of sprinkler operation for that portion of the building shall be 3000 ft² (280 m²).

(A)

The design area of 3000 ft² (280 m²) shall be applied only to the sprinkler system or portions of the sprinkler system that are adjacent to the qualifying combustible concealed space.

(B)

The term *adjacent* shall apply to any sprinkler system protecting a space above, below, or next to the qualifying concealed space except where a barrier with a fire resistance rating at least equivalent to the water supply duration completely separates the concealed space from the sprinklered area.

19.3.3.1.5.2

The following unsprinklered concealed spaces shall not require a minimum area of sprinkler operation of 3000 ft² (279 m²):

- (1) Noncombustible and limited-combustible concealed spaces with minimal combustible loading having no access. The space shall be considered a concealed space even with small openings such as those used as return air for a plenum.
- (2) Noncombustible and limited-combustible concealed spaces with limited access and not permitting occupancy or storage of combustibles. The space shall be considered a concealed space even with small openings such as those used as return air for a plenum.
- (3) Combustible concealed spaces filled entirely with noncombustible insulation.
- (4) *Light or ordinary hazard occupancies where noncombustible or limited-combustible ceilings are directly attached to the bottom of solid wood joists or solid limited-combustible construction or noncombustible construction so as to create enclosed joist spaces 160 ft³ (4.5 m³) or less in volume, including space below insulation that is laid directly on top or within the ceiling joists in an otherwise sprinklered concealed space.
- (5) Concealed spaces where rigid materials are used and the exposed surfaces comply with one of the following in the form in which they are installed in the space:
 - (a) The surface materials have a flame spread index of 25 or less and the materials have been demonstrated to not propagate fire more than 10.5 ft (3.2 m) when tested in accordance with ASTM E84, *Standard Test Method for Surface Burning Characteristics of Building Materials*, or ANSI/UL 723, *Standard for Test for Surface Burning Characteristics of Building Materials*, extended for an additional 20 minutes in the form in which they are installed in the space or
 - (b) The surface materials comply with the requirements of ASTM E2768, *Standard Test Method for Extended Duration Surface Burning Characteristics of Building Materials (30 min Tunnel Test)*.
- (6) Concealed spaces in which the exposed materials are constructed entirely of fire-retardant-treated wood as defined by NFPA 703.
- (7) Concealed spaces over isolated small rooms not exceeding 55 ft² (5.1 m²) in area.
- (8) Vertical pipe chases under 10 ft² (0.9 m²), provided that in multifloor buildings the chases are firestopped at each floor using materials equivalent to the floor construction, and where such pipe chases contain no sources of ignition, piping shall be noncombustible, and pipe penetrations at each floor shall be properly sealed.
- (9) Exterior columns under 10 ft² (0.9 m²) in area formed by studs or wood joists, supporting exterior canopies that are fully protected with a sprinkler system.
- (10) *Light or ordinary hazard occupancies where noncombustible or limited-combustible ceilings are attached to the bottom of composite wood joists either directly or on to metal channels not exceeding 1 in. (25 mm) in depth, provided the adjacent joist channels are firestopped into volumes not exceeding 160 ft³

(4.5 m³) using materials equivalent to ½ in. (13 mm) gypsum board, and at least 3½ in. (90 mm) of batt insulation is installed at the bottom of the joist channels when the ceiling is attached utilizing metal channels.

(11) Cavities within unsprinklered wall spaces.

19.3.3.2 Density/Area Method.

19.3.3.2.1 Water Supply.

19.3.3.2.1.1

The water supply requirement for sprinklers only shall be calculated from the density/area curves of Figure 19.3.3.1.1 or from Chapter 22 where density/area criteria are specified for special occupancy hazards.

19.3.3.2.1.2

When using Figure 19.3.3.1.1, the calculations shall satisfy any single point on the appropriate density/area curve.

19.3.3.2.1.3

When using Figure 19.3.3.1.1, it shall not be necessary to meet all points on the selected curves.

19.3.3.2.2 Sprinklers.

19.3.3.2.2.1

The densities and areas provided in Figure 19.3.3.1.1 shall be for use only with spray sprinklers.

19.3.3.2.2.2

Quick-response sprinklers shall not be permitted for use in extra hazard occupancies or other occupancies where there are substantial amounts of flammable liquids or combustible dusts.

19.3.3.2.2.3

For extended coverage sprinklers, the minimum design area shall be that corresponding to the hazard in Figure 19.3.3.1.1 or the area protected by five sprinklers, whichever is greater.

19.3.3.2.2.4

Extended coverage sprinklers shall be listed with and designed for the minimum flow corresponding to the density for the hazard as specified in Figure 19.3.3.1.1.

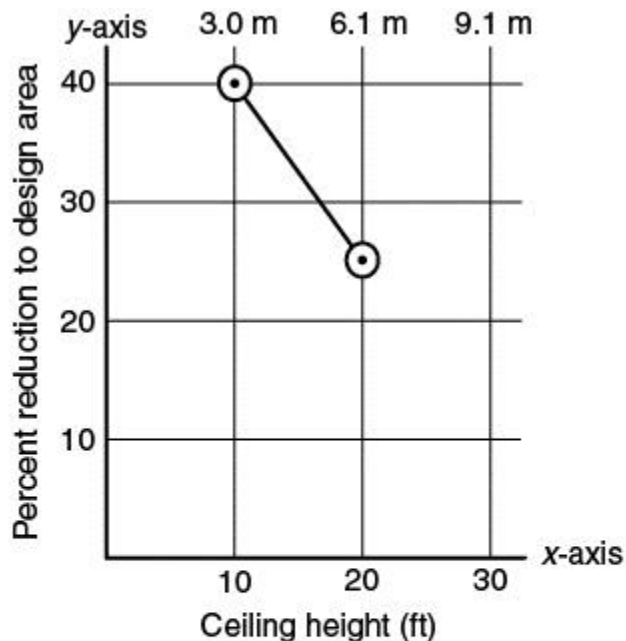
19.3.3.2.3 Quick-Response Sprinklers.

19.3.3.2.3.1

Where listed quick-response sprinklers, including extended coverage quick-response sprinklers, are used throughout a system or portion of a system having the same hydraulic design basis, the system area of operation shall be permitted to be reduced without revising the density as indicated in Figure 19.3.3.2.3.1 when all of the following conditions are satisfied:

- (1) Wet pipe system
- (2) Light hazard or ordinary hazard occupancy
- (3) 20 ft (6.1 m) maximum ceiling height
- (4) No unprotected ceiling pockets as allowed by 10.2.9 and 11.2.7 exceeding 32 ft² (3.0 m²)
- (5) No unprotected areas above cloud ceilings as allowed by 9.2.7

Figure 19.3.3.2.3.1 Design Area Reduction for Quick-Response Sprinklers.



Note: $y = \frac{-3x}{2} + 55$ for U.S. Customary Units

Note: $y = -4.8x + 54.6$ for S.I. Units

For ceiling height ≥ 10 ft and ≤ 20 ft, $y = \frac{-3x}{2} + 55$

For ceiling height < 10 ft, $y = 40$

For ceiling height > 20 , $y = 0$

For SI units, 1 ft = 0.31 m.

19.3.3.2.3.2

The number of sprinklers in the design area shall never be less than five.

19.3.3.2.3.3

Where quick-response sprinklers are used on a sloped ceiling or roof, the maximum ceiling or roof height shall be used for determining the percent reduction in design area.

19.3.3.2.4 Sloped Ceilings.

The system area of operation shall be increased by 30 percent without revising the density when the following types of sprinklers are used on sloped ceilings with a pitch exceeding 1 in 6 (a rise of 2 units in a run of 12 units, a roof slope of 16.7 percent) in nonstorage applications:

- (1) Spray sprinklers, including extended coverage sprinklers listed in accordance with 11.2.1(4), and quick-response sprinklers
- (2) CMSA sprinklers

19.3.3.2.5* Dry Pipe and Double Interlock Preaction Systems.

For dry pipe systems and double interlock preaction systems, the area of sprinkler operation shall be increased by 30 percent without revising the density.

19.3.3.2.6 High-Temperature Sprinklers.

Where high-temperature sprinklers are used for extra hazard occupancies, the area of sprinkler operation shall be permitted to be reduced by 25 percent without revising the density, but not to less than 2000 ft² (186 m²). 

19.3.3.2.7

Where K-11.2 (160) or larger sprinklers are used with EH1 or EH2 design curves from Figure 13.2.1, the design area shall be permitted to be reduced by 25 percent but not below 2000 ft² (186 m²), regardless of temperature rating. 

19.3.3.2.8* Multiple Adjustments.

19.3.3.2.8.1

Where multiple adjustments to the area of operation are required to be made in accordance with 19.3.3.2.3, 19.3.3.2.4, 19.3.3.2.5, or 19.3.3.2.6, these adjustments shall be compounded based on the area of operation originally selected from Figure 19.3.3.1.1.

19.3.3.2.8.2

If the building has unsprinklered combustible concealed spaces, the rules of 19.3.3.1.4 shall be applied after all other modifications have been made.

19.3.3.3 Room Design Method.

19.3.3.3.1*

The water supply requirements for sprinklers only shall be based upon the room that creates the greatest demand.

19.3.3.3.2

The density selected shall be that from Figure 19.3.3.1.1 corresponding to the occupancy hazard classification and room size.

19.3.3.3.3

To utilize the room design method, all rooms shall be enclosed with walls having a fire-resistance rating equal to the water supply duration indicated in Table 19.3.3.1.2.

19.3.3.3.4

If the room is smaller than the area specified in Figure 19.3.3.1.1, the provisions of 19.3.3.1.4(1) and 19.3.3.1.4(2) shall apply.

19.3.3.3.5

Minimum protection of openings shall be as follows:

(1) Light hazard — Nonrated automatic or self-closing doors.

(2) Light hazard with no opening protection — Where openings are not protected, calculations shall include the sprinklers in the room plus two sprinklers in the communicating space nearest each such unprotected opening unless the communicating space has only one sprinkler, in which case calculations shall be extended to the operation of that sprinkler. The selection of the room and communicating space sprinklers to be calculated shall be that which produces the greatest hydraulic demand. For light hazard occupancies with unprotected openings in walls, a minimum lintel of depth of 8 in. (200 mm) is required for openings and the opening shall not exceed 8 ft (2.4 m) in width. It shall be permitted to have a single opening of 36 in. (900 mm) or less without a lintel, provided there are no other openings to adjoining spaces.

(3) Ordinary and extra hazard — Automatic or self-closing doors with appropriate fire resistance ratings for the enclosure.

19.3.3.3.6

Where the room design method is used and the area under consideration is a corridor protected by a single row of sprinklers with protected openings in accordance with 19.3.3.3.5, the maximum number of sprinklers that needs to be calculated is five or, when extended coverage sprinklers are installed, all sprinklers contained within 75 linear feet (23 linear meters) of the corridor.

19.3.3.3.7

Where the area under consideration is a corridor protected by a single row of sprinklers with unprotected openings, in a light hazard occupancy, the design area shall include all sprinklers in the corridor to a maximum of five or, when extended coverage sprinklers are installed, all sprinklers within 75 linear feet (23 linear meters) of the corridor.

19.3.3.4 Special Design Areas.

19.3.3.4.1

Where the design area consists of a building service chute supplied by a separate riser, the maximum number of sprinklers that needs to be calculated is three, each with a minimum discharge of 15 gpm (57 L/min).

19.3.3.4.2*

Where an area is to be protected by a single line of sprinklers, the design area shall include all sprinklers on the line up to a maximum of seven.

19.3.3.4.3

Sprinklers in ducts as described in Section 8.9 and 9.3.9 shall be hydraulically designed to provide a discharge pressure of not less than 7 psi (0.5 bar) at each sprinkler with all sprinklers within the duct flowing.

19.3.3.4.4 Stair Towers.

Stair towers, or other construction with incomplete floors, if piped on independent risers, shall be treated as one area with reference to pipe sizes.

19.4 Special Design Approaches.

19.4.1 Residential Sprinklers.

19.4.1.1*

The design area shall be the area that includes the four adjacent sprinklers that produce the greatest hydraulic demand.

19.4.1.2*

Unless the requirements of 19.3.3.1.5.2 are met for buildings having unsprinklered combustible concealed spaces, as described in 9.2.1 and 9.3.19, the minimum design area of sprinkler operation for that portion of the building shall be eight sprinklers.

19.4.1.2.1*

The design area of eight sprinklers shall be applied only to the portion of the residential sprinklers that are adjacent to the qualifying combustible concealed space.

19.4.1.2.2

The term *adjacent* shall apply to any sprinkler system protecting a space above, below, or next to the qualifying concealed space except where a barrier with a fire resistance rating at least equivalent to the water supply duration completely separates the concealed space from the sprinklered area.

19.4.1.3

Unless the requirements of 19.4.1.4 are met, the minimum required discharge from each design area sprinkler shall be the greater of the following:

- (1) In accordance with minimum flow rates indicated in the sprinkler listings
- (2) In rooms or compartments greater than 800 ft² (74.3 m²) calculated based on delivering a minimum of 0.1 gpm/ft² (4.1 mm/min) over the design area in accordance with the provisions of 9.5.2.1
- (3) In rooms or compartments 800 ft² (74.3 m²) or less calculated based on delivering a minimum of 0.1 gpm/ft² (4.1 mm/min) over the room or the compartment using the area of the room divided by the number of sprinklers in the room

19.4.1.4

For modifications or additions to existing systems equipped with residential sprinklers, the listed discharge criteria less than 0.1 gpm/ft² (4.1 mm/min) shall be permitted to be used.

19.4.1.4.1

Where replacing residential sprinklers manufactured prior to 2003 that are no longer available from the manufacturer and that are installed using a design density less than 0.05 gpm/ft² (2.04 mm/min), a residential sprinkler with an equivalent K-factor ($\pm$ 5 percent) shall be permitted to be used provided the currently listed coverage area for the replacement sprinkler is not exceeded.

19.4.1.5

Where areas such as attics, basements, or other types of occupancies are outside of dwelling units but within the same structure, these areas shall be protected as a separate design basis in accordance with Section 19.2.

19.4.1.6

Hose stream allowance and water supply duration requirements shall be in accordance with those for light hazard occupancies in Table 19.3.3.1.2.

19.4.2 Exposure Protection.

19.4.2.1*

Piping shall be hydraulically calculated in accordance with Section 19.6 to furnish a minimum of 7 psi (0.5 bar) at any sprinkler with all sprinklers facing the exposure operating.

19.4.2.2

Where the water supply feeds other fire protection systems, it shall be capable of furnishing total demand for such systems as well as the exposure system demand.

19.4.3 Water Curtains.

19.4.3.1

Sprinklers in a water curtain such as described in 9.3.5 or 9.3.13.2 shall be hydraulically designed to provide a discharge of 3 gpm per lineal foot (37 L/min per lineal meter) of water curtain, with no sprinklers discharging less than 15 gpm (57 L/min).

19.4.3.2

For water curtains employing automatic sprinklers, the number of sprinklers calculated in this water curtain shall be the number in the length corresponding to the length parallel to the branch lines in the area determined by 19.6.4.2.

19.4.3.3

For a deluge system water curtain providing proscenium opening protection in accordance with 19.15.17.2, the water curtain shall be calculated to supply all of the open sprinklers attached thereto.

19.4.3.4 Sprinklers Under Roof or Ceiling in Combustible Concealed Spaces of Wood Joist or Wood Truss Construction with Members 3 ft (0.9 m) or Less on Center and Slope Having Pitch of 4 in 12 or Greater.

19.4.3.4.1

Where sprinkler spacing does not exceed 8 ft (2.4 m) measured perpendicular to the slope, the minimum sprinkler discharge pressure shall be 7 psi (0.5 bar).

19.4.3.4.2

Where sprinkler spacing exceeds 8 ft (2.4 m) measured perpendicular to the slope, the minimum sprinkler discharge pressure shall be 20 psi (1.4 bar).

19.4.3.4.3

Hose stream allowance and water supply duration requirements shall be in accordance with those for light hazard occupancies in Table 19.3.3.1.2.

19.4.3.5

If a single fire can be expected to operate sprinklers within the water curtain and within the design area of a hydraulically calculated system, the water supply to the water curtain shall be added to the water demand of the hydraulic calculations and shall be balanced to the calculated area demand.

19.4.4 Sprinkler-Protected Glazing.

Where the sprinkler-protected glazing is required to comply with 9.3.15, the water supply duration for the design area that includes the window sprinklers shall be not less than the required rating of the assembly.

19.4.4.1

For sprinkler-protected glazing, the number of sprinklers calculated for the glazing shall be the number in the length corresponding to the length parallel to the branch lines in the area determined by 19.6.4.2.

19.4.4.2

If a single fire can be expected to operate sprinklers for the sprinkler-protected glazing and within the design area of a hydraulically calculated system, the water supply to the sprinkler-protected glazing shall be added to the water demand of the hydraulic calculations and shall be balanced to the calculated area demand.

19.4.4.3

Hydraulic design calculations shall include a design area selected to include ceiling sprinklers adjacent to the sprinkler-protected glazing.

19.5 Deluge Systems.

Open sprinkler and deluge systems shall be hydraulically calculated according to applicable standards.

19.6 Hydraulic Calculation Procedures.

19.6.1* General.

19.6.1.1

A calculated system for a building, or a calculated addition to a system in an existing sprinklered building, shall supersede the rules in this standard governing pipe schedules, except that all systems shall continue to be limited by area.

19.6.1.2

Pipe sizes shall be no less than 1 in. (25 mm) nominal for black or galvanized steel piping and $\frac{3}{4}$ in. (20 mm) nominal for copper tubing or brass, stainless steel, or nonmetallic piping listed for fire sprinkler service unless permitted by 28.5 and 28.6.

19.6.1.3

The size of pipe, number of sprinklers per branch line, and number of branch lines per cross main shall otherwise be limited only by the available water supply.

19.6.1.4*

Unless required by other NFPA standards, the velocity of water flow shall not be limited when hydraulic calculations are performed using the Hazen–Williams or Darcy Weisbach formulas.

19.6.1.5

However, sprinkler spacing and all other rules covered in this and other applicable standards shall be observed.

19.6.1.6

Hydraulic calculations shall extend to the effective point of the water supply where the characteristics of the water supply are known.

19.6.2 Formulas.

19.6.2.1 Friction Loss Formula.

19.6.2.1.1

Pipe friction losses shall be determined on the basis of the Hazen–Williams formula, as follows:

$$p = \frac{4.52Q^{1.85}}{C^{1.85}d^{4.87}} \quad [19.4.2.1.1]$$

where:

p = frictional resistance (psi/ft of pipe)

Q = flow (gpm)

C = friction loss coefficient

d = actual internal diameter of pipe (in.)

19.6.2.1.2

For SI units, the following equation shall be used:

$$p_m = 6.05 \left(\frac{Q_m^{1.85}}{C^{1.85}d_m^{4.87}} \right) 10^5 \quad [19.4.2.1.2]$$

where:

p_m = frictional resistance (bar/m of pipe)

Q_m = flow (L/min)

C = friction loss coefficient

d_m = actual internal diameter (mm)

19.6.2.1.3

For antifreeze systems greater than 40 gal (150 L) in size, the friction loss shall also be calculated using the Darcy–Weisbach formula:

$$\Delta P = 0.000216 f \frac{l \rho Q^2}{d^5} \quad [19.4.2.1.3]$$

where:

ΔP = friction loss (psi)

f = friction loss factor from Moody diagram

l = length of pipe or tube (ft)

ρ = density of fluid (lb/ft³)

Q = flow in pipe or tube (gpm)

d = inside diameter of tube (in.)

19.6.2.2 Velocity Pressure Formula.

Velocity pressure shall be determined on the basis of the following formula:

$$P_v = \frac{0.001123Q^2}{D^4} \quad [19.4.2.2]$$

where:

P_v = velocity pressure (psi) (SI, 1 psi = 0.0689 bar)

Q = flow (gpm) (SI, 1 gal = 3.785 L)

D = inside diameter (in.) (SI, 1 in. = 25.4 mm)

19.6.2.3 Normal Pressure Formula.

Normal pressure (P_n) shall be determined on the basis of the following formula:

$$P_n = P_t - P_v \quad [19.4.2.3]$$

where:

P_n = normal pressure

P_t = total pressure [psi (bar)]

P_v = velocity pressure [psi (bar)]

19.6.2.4 Hydraulic Junction Points.

19.6.2.4.1

Pressures at hydraulic junction points shall balance within 0.5 psi (0.03 bar).

19.6.2.4.2

The highest pressure at the junction point, and the total flows as adjusted, shall be carried into the calculations.

19.6.2.4.3

Pressure balancing shall be permitted through the use of a K-factor developed for branch lines or portions of systems using the formula in 19.6.2.5.

19.6.2.5 K-Factor Formula.

K-factors, flow from an orifice, or pressure from an orifice shall be determined on the basis of the following formula:

$$K_n = \frac{Q}{\sqrt{P}} \quad [19.4.2.5]$$

where:

K_n = equivalent K at a node

Q = flow at the node

P = pressure at the node

19.6.3 Equivalent Pipe Lengths of Valves and Fittings.

19.6.3.1 Pipe and Fittings.

19.6.3.1.1

Table 19.6.3.1.1 shall be used to determine the equivalent length of pipe for fittings and devices unless manufacturer's test data indicate that other factors are appropriate.

Table 19.6.3.1.1 Equivalent Schedule 40 Steel Pipe Length Chart

Fittings and Valves Expressed in Equivalent Feet (Meters) of Pipe															
Fittings and Valves	1/2 in.	3/4 in.	1 in.	1 1/4 in.	1 1/2 in.	2 in.	2 1/2 in.	3 in.	3 1/2 in.	4 in.	5 in.	6 in.	8 in.	10 in.	12 in.
	(15 mm)	(20 mm)	(25 mm)	(32 mm)	(40 mm)	(50 mm)	(65 mm)	(80 mm)	(90 mm)	(100 mm)	(125 mm)	(150 mm)	(200 mm)	(250 mm)	(300 mm)
45° elbow	—	1 (0.3)	1 (0.3)	1 (0.3)	2 (0.6)	2 (0.6)	3 (0.9)	3 (0.9)	3 (0.9)	4 (1.2)	5 (1.5)	7 (2.1)	9 (2.7)	11 (3.3)	13 (4)
90° standard elbow	1 (0.3)	2 (0.6)	2 (0.6)	3 (0.9)	4 (1.2)	5 (1.5)	6 (1.8)	7 (2.1)	8 (2.4)	10 (3)	12 (3.7)	14 (4.3)	18 (5.5)	22 (6.7)	27 (8.2)
90° long-turn elbow	0.5 (0.2)	1 (0.3)	2 (0.6)	2 (0.6)	2 (0.6)	3 (0.9)	4 (1.2)	5 (1.5)	5 (1.5)	6 (1.8)	8 (2.4)	9 (2.7)	13 (4)	16 (4.9)	18 (5.5)
Tee or crosses (flow turned 90°)	3 (0.9)	4 (1.2)	5 (1.5)	6 (1.8)	8 (2.4)	10 (3)	12 (3.7)	15 (4.6)	17 (5.2)	20 (6.1)	25 (7.6)	30 (9.1)	35 (10.7)	50 (15.2)	60 (18.3)
Butterfly valve	—	—	—	—	—	6 (1.8)	7 (2.1)	10 (3)	—	12 (3.7)	9 (2.7)	10 (3)	12 (3.7)	19 (5.8)	21 (6.4)
Gate valve	—	—	—	—	—	1 (0.3)	1 (0.3)	1 (0.3)	1 (0.3)	2 (0.6)	2 (0.6)	3 (0.9)	4 (1.2)	5 (1.5)	6 (1.8)
Vanetype flow switch	—	—	6 (1.8)	9 (2.7)	10 (3)	14 (4.3)	17 (5.2)	22 (6.7)	—	30 (9.1)	—	16 (4.9)	22 (6.7)	29 (8.8)	36 (11)
Swing check*	—	—	5 (1.5)	7 (2.1)	9 (2.7)	11 (3.3)	14 (4.3)	16 (4.9)	19 (5.8)	22 (6.7)	27 (8.2)	33 (9.7)	41 (13.7)	53 (16.8)	65 (19.8)

Note: Information on 1/2 in. pipe is included in this table only because it is allowed under 8.15.19.4 and 8.15.19.5.

*Due to the variation in design of swing check valves, the pipe equivalents indicated in this table are considered average.

19.6.3.1.2

For saddle-type fittings having friction loss greater than that shown in Table 19.6.3.1.1, the increased friction loss shall be included in hydraulic calculations.

19.6.3.1.3 Equivalent Length Modifier.

19.6.3.1.3.1

For internal pipe diameters different from Schedule 40 steel pipe [Schedule 30 for pipe diameters 8 in. (200 mm) and larger], the equivalent length shown in Table 19.6.3.1.1 shall be multiplied by a factor derived from the following formula:

$$\left(\frac{\text{Actual inside diameter}}{\text{Schedule 40 steel pipe inside diameter}} \right)^{4.87} = \text{Factor} \quad [19.4.3.1.3.1]$$

19.6.3.1.3.2

The factor thus obtained shall be further modified as required by Table 19.6.3.1.1. This table shall apply to other types of pipe listed in Table 19.6.3.1.1 only where modified by factors from 19.6.3.1.1 and 19.6.3.2.

19.6.3.2 C Factors.

Table 19.6.3.1.1 shall be used with a Hazen–Williams *C* factor of 120 only.

19.6.3.2.1

For other values of *C*, the values in Table 19.6.3.1.1 shall be multiplied by the factors indicated in Table 19.6.3.2.1.

Table 19.6.3.2.1 C Value Multiplier

Value of <i>C</i>	100	130	140	150
Multiplying factor	0.713	1.16	1.33	1.51

Note: These factors are based upon the friction loss through the fitting being independent of the *C* factor available to the piping.

19.6.3.3 Valves.

Specific friction loss values or equivalent pipe lengths for alarm valves, dry pipe valves, deluge valves, strainers, and other devices shall be made available to the authority having jurisdiction.

19.6.3.4

Hydraulic design calculations shall include a design area selected to include ceiling sprinklers adjacent to the water curtain.

19.6.3.5 Differing Values.

Specific friction loss values or equivalent pipe lengths for listed fittings not in Table 7.4.1 shall be used in hydraulic calculations where these losses or equivalent pipe lengths are different from those shown in Table 19.6.3.1.1.

19.6.4* Calculation Procedure.

19.6.4.1*

For all systems the design area shall be the hydraulically most demanding based on the criteria of Chapter 11, Chapter 12, or the special design approaches in accordance with the requirements of Chapter 22.

19.6.4.1.1 Room Design Method.

Where the design is based on the room design method, the calculation shall be based on the room and communicating space, if any, that is hydraulically the most demanding.

19.6.4.2 Density/Area Method.

19.6.4.2.1*

Where the design is based on the density/area method, the design area shall be a rectangular area having a dimension parallel to the branch lines at least 1.2 times the square root of the area of sprinkler operation (A) used, which shall permit the inclusion of sprinklers on both sides of the cross main.

19.6.4.2.2

Any fractional sprinkler shall be carried to the next higher whole sprinkler.

19.6.4.2.3

In systems having branch lines with an insufficient number of sprinklers to fulfill the 1.2 requirement, the design area shall be extended to include sprinklers on adjacent branch lines supplied by the same cross main.

19.6.4.2.4*

Where the available floor area for a specific area/density design criteria, including any extension of area as required by 19.2.2 and Section 20.10, is less than the required minimum design area, the design area shall be permitted to only include those sprinklers within the available design area.

19.6.4.2.5

Where the total design discharge from these operating sprinklers is less than the minimum required discharge determined by multiplying the required design density times the required minimum design area, an additional flow shall be added at the point of connection of the branch line to the cross main furthest from the source to increase the overall demand, not including hose stream allowance, to the minimum required discharge.

19.6.4.3 CMSA Sprinkler Method.

19.6.4.3.1

For CMSA sprinklers, the design area shall be a rectangular area having a dimension parallel to the branch lines at least 1.2 times the square root of the area protected by the number of sprinklers to be included in the design area. The design area protected by the number of sprinklers to be used by the 1.2 rule shall be based on the maximum allowable area per sprinkler.

19.6.4.3.2

Any fractional sprinkler shall be carried to the next higher whole sprinkler.

19.6.4.3.3

In systems having branch lines with an insufficient number of sprinklers to fulfill the 1.2 requirement, the design area shall be extended to include sprinklers on adjacent branch lines supplied by the same cross main.

19.6.4.4 ESFR Sprinkler Method.

For ESFR sprinklers, the design area shall consist of the most hydraulically demanding area of 12 sprinklers, consisting of four sprinklers on each of three branch lines, unless other specific numbers of design sprinklers are required in other sections of this standard.

19.6.4.5* Gridded Systems.

19.6.4.5.1

For gridded systems, the designer shall verify that the hydraulically most demanding area is being used.

19.6.4.5.2

A minimum of two additional sets of calculations shall be submitted to demonstrate peaking of demand area friction loss when compared to areas immediately adjacent on either side along the same branch lines, unless the requirements of 19.6.4.5.3 are met.

19.6.4.5.3

Computer programs that show the peaking of the demand area friction loss shall be acceptable based on a single set of calculations.

19.6.4.6 Design Densities.

19.6.4.6.1*

System piping shall be hydraulically designed using design densities and areas of operation in accordance with 19.3.3.2 or Chapter 12 as required for the occupancies or hazards involved.

19.6.4.6.2*

The density shall be calculated on the basis of floor area of sprinkler operation. Where sprinklers are installed under a sloped ceiling, the area used for this calculation shall be the horizontal plane below the sprinklers.

19.6.4.6.3

The area covered by any sprinkler used in hydraulic design and calculations shall be the horizontal distances measured between the sprinklers on the branch line and between the branch lines in accordance with 9.5.2.

19.6.4.6.4

Where sprinklers are installed above and below a ceiling or in a case where more than two areas are supplied from a common set of branch lines, the branch lines and supplies shall be calculated to supply the largest water demand.

19.6.4.6.5*

For sloped ceiling applications, the area of sprinkler application for density calculations shall be based upon the projected horizontal area.

19.6.4.7* Design Area Sprinklers.

19.6.4.7.1

Each sprinkler in the design area and the remainder of the hydraulically designed system shall discharge at a flow rate at least equal to the stipulated minimum water application rate (density) multiplied by the area of sprinkler operation.

19.6.4.7.1.1

Where sprinklers are required to discharge a specific flow or pressure rather than a density, each sprinkler in the design area shall discharge at a flow or pressure at least equal to the minimum required.

19.6.4.7.2*

Where the design area is equal to or greater than the area in Table 19.6.4.7.2 for the hazard being protected by the sprinkler system, the discharge for sprinklers protecting small compartments 55 ft² (5.1 m²) or less, such as closets, washrooms, and similar compartments that are in the design area, shall be permitted to be omitted from the hydraulic calculations.

Table 19.6.4.7.2 Minimum Design Area

Occupancy Hazard Classification	Minimum Design Area to Omit Discharge from Sprinklers in Small Compartments in Design Area [ft ² (m ²)]
Light hazard—wet pipe system	1500 (139) 
Light hazard—dry pipe system	1950 (181) 
Ordinary hazard—wet pipe system	1500 (139) 
Ordinary hazard—dry pipe system	1950 (181) 
Extra hazard—wet pipe system	2500 (232) 
Extra hazard—dry pipe system	3250 (300)

19.6.4.7.2.1

The sprinklers in these small compartments shall be capable of discharging the minimum density appropriate for the hazard they protect in accordance with Figure 19.3.3.1.1.

19.6.4.7.2.2

The requirements of 19.6.4.7.2 shall only apply where the area of application is equal to or greater than the area shown in Table 19.6.4.7.2 for the appropriate hazard classification (including a 30 percent increase for dry pipe systems).

19.6.4.7.3

The requirements of 19.6.4.7.1.1 to include every sprinkler in the design area shall not apply where sprinklers are provided above and below obstructions such as wide ducts or tables.

19.6.4.7.3.1

Sprinklers under the obstruction shall not be required to be included in the hydraulic calculation of the ceiling sprinklers.

19.6.4.7.3.2

Where the piping to sprinklers under obstructions follows the same sizing pattern as the branch lines, no additional hydraulic calculations shall be required for sprinklers under obstructions.

19.6.4.7.4

Water demand of sprinklers installed in concealed spaces shall not be required to be added to the ceiling demand.

19.6.4.7.5

Calculations shall begin at the hydraulically most remote sprinkler.

19.6.4.7.6

The calculated pressure at each sprinkler shall be used to determine the discharge flow rate for that particular sprinkler.

19.6.4.7.7

Where sprinklers are installed under a sloped ceiling, the area shall be calculated on a horizontal plane below the sprinklers.

19.6.4.8 Friction Loss.

19.6.4.8.1

Pipe friction loss shall be calculated in accordance with the Hazen–Williams formula with C values from Table 19.6.4.8.1, as follows:

- (1) Pipe, fittings, and devices such as valves, meters, flow switches in pipes 2 in. (50 mm) or less in size, and strainers shall be included, and elevation changes that affect the sprinkler discharge shall be calculated.
- (2) Tie-in drain piping shall not be included in the hydraulic calculations.
- (3) The loss for a tee or a cross shall be calculated where flow direction change occurs based on the equivalent pipe length of the piping segment in which the fitting is included.
- (4) The tee at the top of a riser nipple shall be included in the branch line, the tee at the base of a riser nipple shall be included in the riser nipple, and the tee or cross at a cross main–feed main junction shall be included in the cross main.
- (5) Fitting loss for straight-through flow in a tee or cross shall not be included.
- (6) The loss of reducing elbows based on the equivalent feet value of the smallest outlet shall be calculated.
- (7) The equivalent feet value for the standard elbow on any abrupt 90-degree turn, such as the screw-type pattern shall be used.

- (8) The equivalent feet value for the long-turn elbow on any sweeping 90-degree turn, such as a flanged, welded, or mechanical joint-elbow type shall be used. (See Table 19.6.3.1.1.)
- (9) Friction loss shall be excluded for the fitting directly connected to a sprinkler.
- (10) Losses through a pressure-reducing valve shall be included based on the normal inlet pressure condition. Pressure loss data from the manufacturer's literature shall be used.

Table 19.6.4.8.1 Hazen–Williams C Values

Pipe or Tube	C Value*
Unlined cast or ductile iron	100
Black steel (dry systems including preaction)	100
Black steel (wet systems including deluge)	120
Galvanized steel (dry systems including preaction)	100
Galvanized steel (wet systems including deluge)	120
Plastic (listed) all	150
Cement-lined cast- or ductile iron	140
Copper tube, brass or stainless steel	150
Asbestos cement	140
Concrete	140

*The authority having jurisdiction is permitted to allow other C values.

19.6.4.8.2*

For antifreeze systems greater than 40 gal (150 L) in size, the pipe friction loss shall be calculated using the Darcy-Weisbach equation shown in 19.6.2.1.3 using a Moody diagram and ϵ -factors that are representative of aged pipe otherwise following the methodology presented in 19.6.4.8.1.

19.6.4.9* Orifice Plates.

19.6.4.9.1

Orifice plates shall not be used for balancing the system.

19.6.4.9.2

Unless the requirements of 19.6.4.9.3 or 19.6.4.9.4 are met, mixing of sprinklers of different K-factors by reducing the K-factor of adjacent sprinklers on the same branch line leading back to the main for the purpose of minimizing sprinkler over discharge shall not be permitted.

19.6.4.9.3

Sprinklers with different K-factors shall be acceptable for special use such as exposure protection, small rooms or enclosures, or directional discharge. (See 3.3.196 for definition of small rooms.)

19.6.4.9.4

Extended-coverage and residential sprinklers with a different K-factor shall be acceptable for part of the protection area where installed in accordance with their listing.

19.6.4.10* Pressures.

19.6.4.10.1

When calculating flow from an orifice, the total pressure (P_t) shall be used, unless the calculation method of 19.6.4.10.2 is utilized.

19.6.4.10.2

Use of the normal pressure (P_n) calculated by subtracting the velocity pressure from the total pressure shall be permitted. Where the normal pressure is used, it shall be used on all branch lines and cross mains where applicable.

19.6.4.10.3

Flow from a sprinkler shall be calculated using the nominal K-factor except that the manufacturer's adjusted K-factors shall be utilized for dry-type sprinklers.

19.6.4.11 Minimum Operating Pressure.

19.6.4.11.1

Minimum operating pressure of any sprinkler shall be 7 psi (0.5 bar).

19.6.4.11.2

Where a higher minimum operating pressure for the desired application is specified in the listing of the sprinkler, this higher pressure shall be required.

19.6.4.12 Maximum Operating Pressure.

For extra hazard occupancies, palletized, solid-piled, bin box, back-to-back shelf storage, shelf storage, or rack storage, the maximum operating pressure of any sprinkler shall be 175 psi (12 bar).

19.6.5 In-Rack Sprinklers.

19.6.5.1

Pipes to in-rack sprinklers shall be sized by hydraulic calculations.

19.6.5.2

Water demand of sprinklers installed in racks or water curtains shall be added to the ceiling sprinkler water demand at the point of connection. Demands shall be balanced to the higher pressure. (See Chapter 8.)

19.7 Hose Allowance.

Water allowance for outside hose shall be added to the sprinkler and inside hose requirement at the connection to the city water main or a yard hydrant, whichever is closer to the system riser.

19.8 Hydraulic Calculation Forms.

19.8.1 General.

Hydraulic calculations shall be prepared on form sheets that include a summary sheet, detailed worksheets, and a graph sheet. [See Figure A.19.8.2(a), Figure A.19.8.3, and Figure A.19.8.4 for copies of typical forms.]

19.8.2* Summary Sheet.

The summary sheet shall contain the following information, where applicable:

- (1) Date
- (2) Location
- (3) Name of owner and occupant
- (4) Building number or other identification
- (5) Description of hazard (for storage applications, the commodity classification, storage height, and rack configuration shall be included)
- (6) Name and address of contractor or designer
- (7) Name of approving agency
- (8) System design requirements, as follows:
 - (a) Design area of water application, ft² (m²).

(b) Minimum rate of water application (density), gpm/ft² (mm/min). Where sprinklers are listed with minimum water application in gpm (L/min) or pressure in psi (bar), the minimum rate of water application shall be indicated in gpm (L/min) or pressure, psi (bar).

(c) Area per sprinkler, ft² (m²).

(9) Total water requirements as calculated, including allowance for inside hose, outside hydrants, and water curtain and exposure sprinklers

(10) Allowance for in-rack sprinklers, gpm (L/min)

(11) Limitations (dimension, flow, and pressure) on extended coverage or other listed special sprinklers

19.8.3* Detailed Worksheets.

Detailed worksheets or computer printout sheets shall contain the following information:

- (1) Sheet number
- (2) Sprinkler description and discharge constant (*K*)
- (3) Hydraulic reference points
- (4) Flow in gpm (L/min)
- (5) Pipe size
- (6) Pipe lengths, center-to-center of fittings
- (7) Equivalent pipe lengths for fittings and devices
- (8) Friction loss in psi/ft (bar/m) of pipe
- (9) Total friction loss between reference points
- (10) In-rack sprinkler demand balanced to ceiling demand
- (11) Elevation head in psi (bar) between reference points
- (12) Required pressure in psi (bar) at each reference point
- (13) Velocity pressure and normal pressure if included in calculations
- (14) Notes to indicate starting points or reference to other sheets or to clarify data shown
- (15) *Diagram to accompany gridded system calculations to indicate flow quantities and directions for lines with sprinklers operating in the remote area
- (16) Combined K-factor calculations for sprinklers on drops, armovers, or sprigs where calculations do not begin at the sprinkler

19.8.4* Graph Sheet.

A graphic representation of the complete hydraulic calculation shall be plotted on semiexponential graph paper ($Q^{1.85}$) and shall include the following:

- (1) Water supply curve
- (2) Sprinkler system demand
- (3) Hose allowance (where applicable)
- (4) In-rack sprinkler demand (where applicable)

19.8.5 Hydraulic Reports.

19.8.5.1* General.

19.8.5.1.1

Hydraulic calculations shall be prepared on form sheets that include a summary sheet, a graph sheet, a water supply analysis, a node analysis, and detailed worksheets.

19.8.5.1.2

The data shall be presented in the order shown in Figure 19.8.5.1.2(a) through Figure 19.8.5.1.2(d).

Figure 19.8.5.1.2(a) Summary Sheet.

DRAFT

**HYDRAULIC CALCULATIONS
for**

Project name: _____

Location: _____

Drawing no.: _____ Date: _____

Design

Remote area number: _____

Remote area location: _____

Occupancy classification: _____

Density: _____ gpm/ft² (mm/min)

Area of application: _____ ft² (m²)

Coverage per sprinkler: _____ ft² (m²)

Type of sprinklers calculated: _____

No. of sprinklers calculated: _____

In-rack demand: _____

Hose streams: _____

Total water required (including hose streams): _____ gpm (mm/min) @ _____ psi (bar)

Type of system: _____

Volume of dry or preaction system: _____ gal (l)

Water supply information

Date: _____

Location: _____

Source: _____

Name of contractor: _____

Address: _____

Phone number: _____

Name of designer: _____

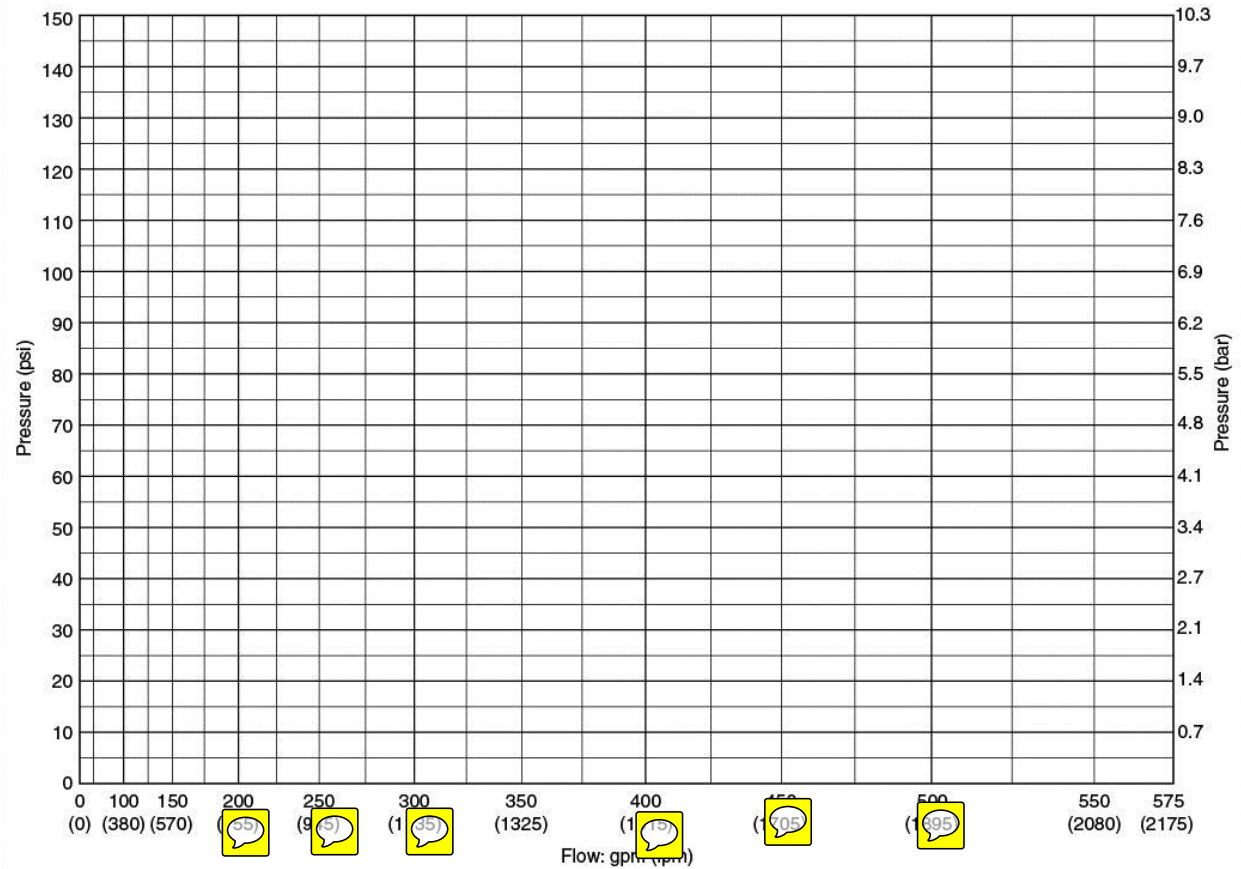
Authority having jurisdiction: _____

Notes: (Include peaking information or gridded systems here.) _____

Figure 19.8.5.1.2(b) Graph Sheet.

FLOW TEST SUMMARY SHEET $N^{1.85}$

Contract name and number: _____



Notes: _____

Figure 19.8.5.1.2(c) Supply and Node Analysis Sheet.

SUPPLY ANALYSIS						
Node at Source	Static Pressure	Residual Pressure	Flow	Available Pressure	Total Demand	Required Pressure
Data	Data	Data	Data	Data	Data	Data

NODE ANALYSIS					
Node Tag	Elevation	Node Type	Pressure at Node	Discharge at Node	Notes
Data	Data	Data	Data	Data	Data
Data	Data	Data	Data	Data	Data
Data	Data	Data	Data	Data	Data
Data	Data	Data	Data	Data	Data
Data	Data	Data	Data	Data	Data
Data	Data	Data	Data	Data	Data
Data	Data	Data	Data	Data	Data
Data	Data	Data	Data	Data	Data
Data	Data	Data	Data	Data	Data
Data	Data	Data	Data	Data	Data
Data	Data	Data	Data	Data	Data
Data	Data	Data	Data	Data	Data
Data	Data	Data	Data	Data	Data
Data	Data	Data	Data	Data	Data
Data	Data	Data	Data	Data	Data
Data	Data	Data	Data	Data	Data

© 2018 National Fire Protection Association

NFPA 13

Figure 19.8.5.1.2(d) Detailed Worksheet.

Job name: _____ Sheet number: _____

PIPE INFORMATION

Node 1	Elev 1 (ft) (m)	K- Factor	Flow added — this step (<i>q</i>)	Nominal ID	Fittings— quantity and length	<i>L</i> ft (m)	<i>C</i> Factor	total (<i>P_t</i>)	Notes
Node 2			Total flow (<i>Q</i>)	Actual ID		<i>F</i> ft (m)	<i>P_f</i> per foot (m) (psi) (bar)	elev (<i>P_e</i>)	
						<i>T</i> ft (m)		frict (<i>P_f</i>)	
data 1	data 1	data 1	data 1	data	data	data	data	data 1	data
data 2	data 2		data	data	data	data	data	data	
					data	data		data	
data 1	data 1	data 1	data 1	data	data	data	data	data 1	data
data 2	data 2		data	data	data	data	data	data	
					data	data		data	
data 1	data 1	data 1	data 1	data	data	data	data	data 1	data
data 2	data 2		data	data	data	data	data	data	
					data	data		data	
data 1	data 1	data 1	data 1	data	data	data	data	data 1	data
data 2	data 2		data	data	data	data	data	data	
					data	data		data	
data 1	data 1	data 1	data 1	data	data	data	data	data 1	data
data 2	data 2		data	data	data	data	data	data	
					data	data		data	
data 1	data 1	data 1	data 1	data	data	data	data	data 1	data
data 2	data 2		data	data	data	data	data	data	
					data	data		data	
data 1	data 1	data 1	data 1	data	data	data	data	data 1	data
data 2	data 2		data	data	data	data	data	data	
					data	data		data	

© 2018 National Fire Protection Association NFPA 13

19.8.5.2 Summary Sheet.

The summary sheet as shown in Figure 19.8.5.1.2(a) shall contain the following information, where applicable:

- (1) Project name and date
- (2) Location (including street address)
- (3) Owner or expected occupant of space being designed
- (4) Name, address, and phone number of installing contractor
- (5) Name and phone number of designer
- (6) Authority having jurisdiction
- (7) Standard or document system is being designed to, including the edition of the document
- (8) Design area number and location
- (9) Drawing or sheet number where design area is located
- (10) Occupancy or commodity classification and information
- (11) For storage applications (including miscellaneous), additional information including storage height, ceiling height, storage configuration, aisle width, orientation of upright or pendent, sprinkler K-factor and sprinkler temperature, and the table and or curve utilized in the design
- (12) System type, including the system volume with type of protection system indicated in the notes
- (13) Sprinkler type, including coverage and response type
- (14) Slope of roof or ceiling within the design area
- (15) System design requirements, as follows:
 - (a) Design area of application, ft² (m²)
 - (b) Minimum rate of water application (density), gpm/ft² (mm/min)
 - (c) Area per sprinkler, ft² (m²)
 - (d) Number of sprinklers calculated
- (16) Total water requirements as calculated, including allowance for inside hose, outside hydrants, water curtain, and exposure sprinklers, and allowance for in-rack sprinklers, gpm (L/min)
- (17) Ceiling height if used for quick response sprinkler reduction
- (18) Elevation of highest calculated sprinkler
- (19) Water supply information, including the following:
 - (a) Date and time of test
 - (b) Location of the test and flow hydrant(s)
 - (c) Source of the water for the flow test
 - (d) Elevation of the test hydrant relative to the finished floor
 - (e) Size of fire pump, gpm @ psi
 - (f) Size of on-site water tank
- (20) Notes that include peaking information for calculations performed by a computer program, type of preaction system, limitations (dimension, flow, and pressure) on extended-coverage or other listed special sprinklers, system type, including the system volume

19.8.5.3 Graph Sheet.

A graphic representation of the complete hydraulic calculation shall be plotted on semiexponential graph paper ($Q^{1.85}$) as shown in Figure 19.8.5.1.2(b) and shall include the following:

- (1) Water supply curve
- (2) Sprinkler system demand
- (3) Hose demand (where applicable)
- (4) In-rack sprinkler demand (where applicable)
- (5) Additional pressures supplied by a fire pump or other source (when applicable)

19.8.5.4 Supply Analysis.

Information summarized from the graph sheet as shown in Figure 19.8.5.1.2(c) shall include the following:

- (1) Node tag at the source
- (2) Static pressure [psi (bar)] available at the source
- (3) Residual pressure [psi (bar)] available at the source
- (4) Total flow [gpm (L/min)] available at the source
- (5) Available pressure [psi (bar)] at the source when the total calculated demand is flowing
- (6) Total calculated demand [gpm (L/min)] at the source
- (7) Required pressure [psi (bar)] when flowing total calculated demand

19.8.5.5 Node Analysis.

Organized information as shown in Figure 19.8.5.1.2(c) regarding the node tags given to each hydraulic reference point on the system as indicated on the shop drawings shall include the following information:

- (1) Node tag for each specific point on the system used in the hydraulic calculations
- (2) Elevation in ft (m) of each node tag
- (3) K-factor of flowing nodes (such as sprinklers)
- (4) Hose allowance in gpm (L/min) requirements for the node tag
- (5) Pressure in psi (bar) at the node
- (6) Discharge in gpm (L/min) calculated at the node
- (7) Notes that indicate any special requirements for the node

19.8.5.6 Detailed Worksheets.

Detailed worksheets as shown in Figure 19.8.5.1.2(d) or computer printout sheets shall contain the following information:

- (1) Sheet number
- (2) Hydraulic reference points used in each step
- (3) Elevation in ft (m) at each hydraulic reference point
- (4) Sprinkler description and discharge constant (K) for the flowing reference point
- (5) Flow in gpm (L/min) for the flowing reference point (when applicable)
- (6) Total flow in gpm (L/min) through each step
- (7) Nominal pipe size in in. (mm)
- (8) Actual internal diameter of pipe in in. (mm)
- (9) Quantity and length in ft (m) of each type of fitting and device
- (10) Pipe lengths in ft (m), center-to-center of fittings
- (11) Equivalent pipe lengths in ft (m) of fittings and devices for the step

- (12) Total equivalent length in ft (m) of pipes and fitting for the step
- (13) C-factor used in each step
- (14) Friction loss in psi/ft (bar/m) of pipe
- (15) Sum of the pressures from the previous step (starting pressure at beginning)
- (16) Elevation head in psi (bar) between reference points
- (17) Total friction loss in psi (bar) between reference points
- (18) Required pressure in psi (bar) at each reference point
- (19) Notes and other information shall include the following:
 - (a) Velocity pressure and normal pressure if included in calculations
 - (b) In-rack sprinkler demand balanced to ceiling demand
 - (c) Notes to indicate starting points or reference to other sheets or to clarify data shown
 - (d) Diagram to accompany gridded system calculations to indicate flow quantities and directions for lines with sprinklers operating in the remote area
 - (e) Combined K-factor calculations for sprinklers on drops, armovers, or sprigs where calculations do not begin at the sprinkler
 - (f) The pressure [psi/(bar)] loss assigned the backflow device when included on a system
 - (g) Friction factor and Reynolds number when the Darcy–Weisbach equation is used

19.9 Pipe Schedules.

Pipe schedules shall not be used, except in existing systems and in new systems or extensions to existing systems described in Chapter 11. Water supplies shall conform to 19.3.2.

19.9.1* General.

19.9.1.1

The pipe schedule sizing provisions shall not apply to hydraulically calculated systems.

19.9.1.2

Sprinkler systems having sprinklers with K-factors other than 5.6 nominal, listed piping material other than that covered in Table 7.3.1.1, extra hazard Group 1 and Group 2 systems, and exposure protection systems shall be hydraulically calculated.

19.9.1.3

The number of automatic sprinklers on a given pipe size on one floor shall not exceed the number given in 19.9.2, 19.9.3, or 19.9.4 for a given occupancy.

19.9.1.4* Size of Risers.

Each system riser shall be sized to supply all sprinklers on the riser on any one floor as determined by the standard schedules of pipe sizes in 19.9.2, 19.9.3, or 19.9.4.

19.9.1.5 Slatted Floors, Large Floor Openings, Mezzanines, and Large Platforms.

Buildings having slatted floors or large unprotected floor openings without approved stops shall be treated as one area with reference to pipe sizes, and the feed mains or risers shall be of the size required for the total number of sprinklers.

19.9.1.6 Stair Towers.

Stair towers, or other construction with incomplete floors, if piped on independent risers, shall be treated as one area with reference to pipe sizes.

19.9.2 Schedule for Light Hazard Occupancies.

19.9.2.1 Branch Lines.

19.9.2.1.1

Unless permitted by 19.9.2.1.2 or 19.9.2.1.3, branch lines shall not exceed eight sprinklers on either side of a cross main.

19.9.2.1.2

Where more than eight sprinklers on a branch line are necessary, lines shall be permitted to be increased to nine sprinklers by making the two end lengths 1 in. (25 mm) and 1¼ in. (32 mm), respectively, and the sizes thereafter standard.

19.9.2.1.3

Ten sprinklers shall be permitted to be placed on a branch line, making the two end lengths 1 in. (25 mm) and 1¼ in. (32 mm), respectively, and feeding the tenth sprinkler by a 2½ in. (65 mm) pipe.

19.9.2.2 Pipe Sizes.

19.9.2.2.1

Pipe sizes shall be in accordance with Table 19.9.2.2.1.

Table 19.9.2.2.1 Light Hazard Pipe Schedules

Steel		Copper	
1 in. (25 mm)	2 sprinklers	1 in. (25 mm)	2 sprinklers
1¼ in. (32 mm)	3 sprinklers	1¼ in. (32 mm)	3 sprinklers
1½ in. (40 mm)	5 sprinklers	1½ in. (40 mm)	5 sprinklers
2 in. (50 mm)	10 sprinklers	2 in. (50 mm)	12 sprinklers
2½ in. (65 mm)	30 sprinklers	2½ in. (65 mm)	40 sprinklers
3 in. (80 mm)	60 sprinklers	3 in. (80 mm)	65 sprinklers
3½ in. (90 mm)	100 sprinklers	3½ in. (90 mm)	115 sprinklers
4 in. (100 mm)	See Section 8.2	4 in. (100 mm)	See Section 8.2

19.9.2.2.2

Each area requiring more sprinklers than the number specified for 3½ in. (90 mm) pipe in Table 19.9.2.2.1 and without subdividing partitions (not necessarily fire walls) shall be supplied by mains or risers sized for ordinary hazard occupancies.

19.9.2.3

Where sprinklers are installed above and below ceilings in accordance with Figure 19.9.2.3(a) through Figure 19.9.2.3(c), and such sprinklers are supplied from a common set of branch lines or separate branch lines from a common cross main, such branch lines shall not exceed eight sprinklers above and eight sprinklers below any ceiling on either side of the cross main.

Figure 19.9.2.3(a) Arrangement of Branch Lines Supplying Sprinklers Above and Below Ceiling.

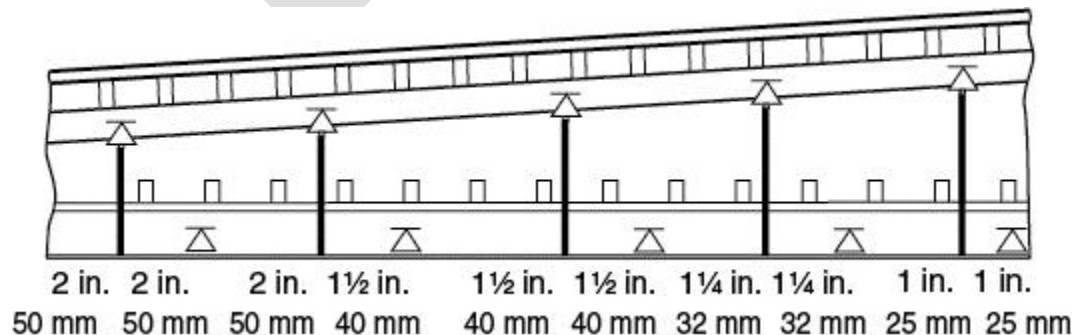


Figure 19.9.2.3(b) Sprinkler on Riser Nipple from Branch Line in Lower Fire Area.

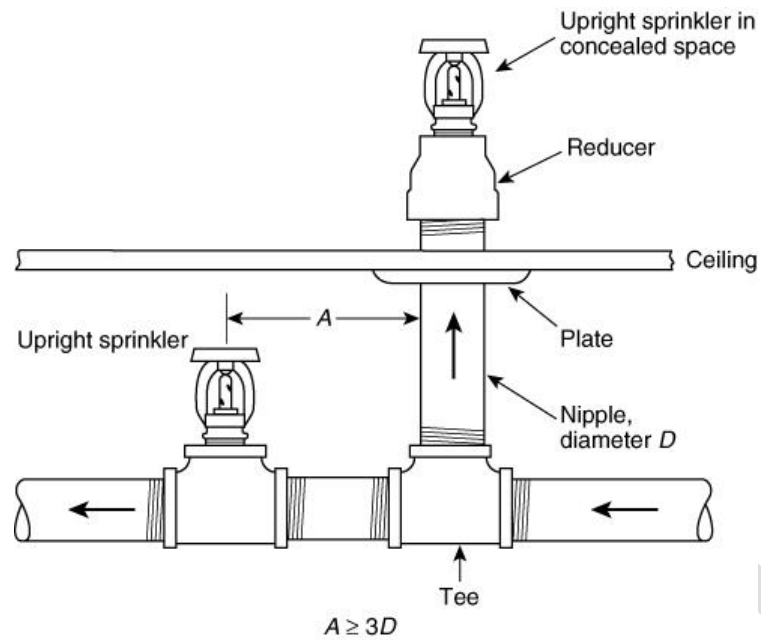
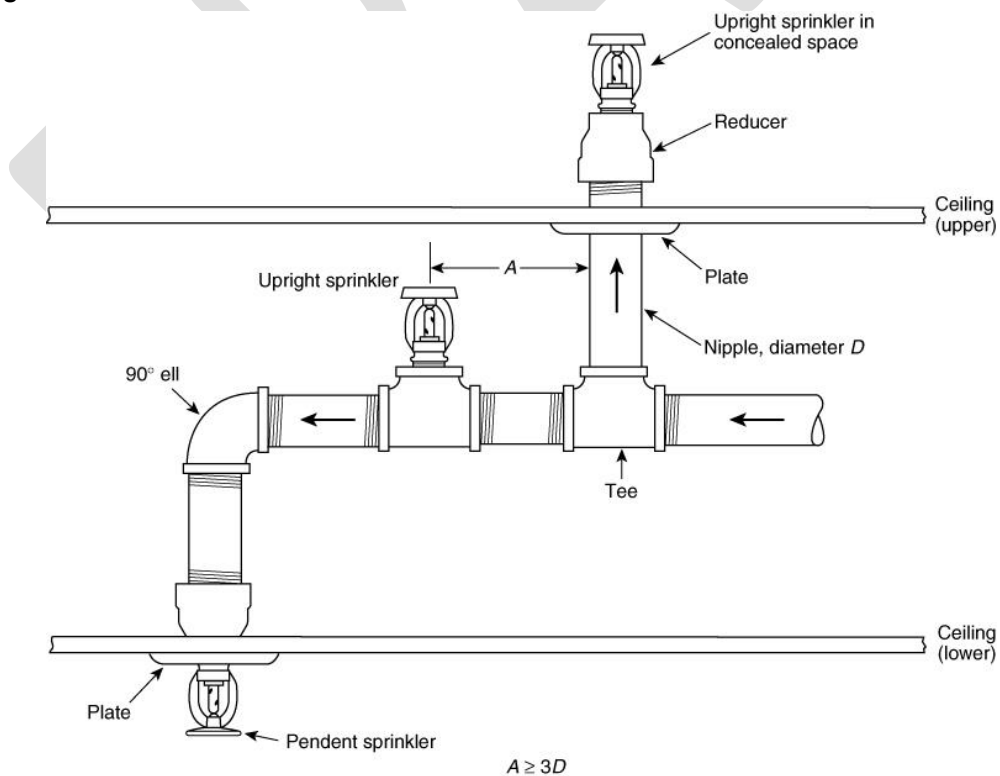


Figure 19.9.2.3(c) Arrangement of Branch Lines Supplying Sprinklers Above, Between, and Below Ceilings.



19.9.2.4

Unless the requirements of 19.9.2.5 are met, pipe sizing up to and including 2 ½ in. (65 mm) shall be as shown in Table 19.9.2.4 utilizing the greatest number of sprinklers to be found on any two adjacent levels.

Table 19.9.2.4 Number of Sprinklers Above and Below Ceiling

Steel		Copper	
1 in. (25 mm)	2 sprinklers	1 in. (25 mm)	2 sprinklers
1¼ in. (32 mm)	4 sprinklers	1¼ in. (32 mm)	4 sprinklers
1½ in. (40 mm)	7 sprinklers	1½ in. (40 mm)	7 sprinklers
2 in. (50 mm)	15 sprinklers	2 in. (50 mm)	18 sprinklers
2½ in. (65 mm)	50 sprinklers	2½ in. (65 mm)	65 sprinklers

19.9.2.5

Branch lines and cross mains supplying sprinklers installed entirely above or entirely below ceilings shall be sized in accordance with Table 19.9.2.2.1.

19.9.2.6*

Where the total number of sprinklers above and below a ceiling exceeds the number specified in Table 19.9.2.4 for 2½ in. (65 mm) pipe, the pipe supplying such sprinklers shall be increased to 3 in. (75 mm) and sized thereafter according to the schedule shown in Table 19.9.2.2.1 for the number of sprinklers above or below a ceiling, whichever is larger.

19.9.3 Schedule for Ordinary Hazard Occupancies.**19.9.3.1**

Unless permitted by 19.9.3.2 or 19.9.3.3, branch lines shall not exceed eight sprinklers on either side of a cross main.

19.9.3.2

Where more than eight sprinklers on a branch line are necessary, lines shall be permitted to be increased to nine sprinklers by making the two end lengths 1 in. (25 mm) and 1¼ in. (32 mm), respectively, and the sizes thereafter standard.

19.9.3.3

Ten sprinklers shall be permitted to be placed on a branch line, making the two end lengths 1 in. (25 mm) and 1¼ in. (32 mm), respectively, and feeding the tenth sprinkler by a 2½ in. (65 mm) pipe.

19.9.3.4

Pipe sizes shall be in accordance with Table 19.9.3.4.

Table 19.9.3.4 Ordinary Hazard Pipe Schedule

Steel		Copper	
1 in. (25 mm)	2 sprinklers	1 in. (25 mm)	2 sprinklers
1¼ in. (32 mm)	3 sprinklers	1¼ in. (32 mm)	3 sprinklers
1½ in. (40 mm)	5 sprinklers	1½ in. (40 mm)	5 sprinklers
2 in. (50 mm)	10 sprinklers	2 in. (50 mm)	12 sprinklers
2½ in. (65 mm)	20 sprinklers	2½ in. (65 mm)	25 sprinklers
3 in. (80 mm)	40 sprinklers	3 in. (80 mm)	45 sprinklers
3½ in. (90 mm)	65 sprinklers	3½ in. (90 mm)	75 sprinklers
4 in. (100 mm)	100 sprinklers	4 in. (100 mm)	115 sprinklers

Steel		Copper	
5 in. (125 mm)	160 sprinklers	5 in. (125 mm)	180 sprinklers
6 in. (150 mm)	275 sprinklers	6 in. (150 mm)	300 sprinklers
8 in. (200 mm)	See Section 8.2	8 in. (200 mm)	See Section 8.2

19.9.3.5

Where the distance between sprinklers on the branch line exceeds 12 ft (3.7 m) or the distance between the branch lines exceeds 12 ft (3.7 m), the number of sprinklers for a given pipe size shall be in accordance with Table 19.9.3.5.

Table 19.9.3.5 Number of Sprinklers — Greater Than 12 ft (3.7 m) Separations

Steel		Copper	
2½ in. (65 mm)	15 sprinklers	2½ in. (65 mm)	20 sprinklers
3 in. (80 mm)	30 sprinklers	3 in. (80 mm)	35 sprinklers
3½ in. (90 mm)	60 sprinklers	3½ in. (90 mm)	65 sprinklers

Note: For other pipe and tube sizes, see Table 22.5.3.4.

19.9.3.6

Where sprinklers are installed above and below ceilings and such sprinklers are supplied from a common set of branch lines or separate branch lines supplied by a common cross main, such branch lines shall not exceed eight sprinklers above and eight sprinklers below any ceiling on either side of the cross main.

19.9.3.7

Pipe sizing up to and including 3 in. (76 mm) shall be as shown in Table 19.9.3.7 in accordance with Figure 19.9.2.3(a), Figure 19.9.2.3(b), and Figure 19.9.2.3(c) utilizing the greatest number of sprinklers to be found on any two adjacent levels.

Table 19.9.3.7 Number of Sprinklers Above and Below a Ceiling

Steel		Copper	
1 in. (25 mm)	2 sprinklers	1 in. (25 mm)	2 sprinklers
1¼ in. (32 mm)	4 sprinklers	1¼ in. (32 mm)	4 sprinklers
1½ in. (40 mm)	7 sprinklers	1½ in. (40 mm)	7 sprinklers
2 in. (50 mm)	15 sprinklers	2 in. (50 mm)	18 sprinklers
2½ in. (65 mm)	30 sprinklers	2½ in. (65 mm)	40 sprinklers
3 in. (80 mm)	60 sprinklers	3 in. (80 mm)	65 sprinklers

19.9.3.8

Branch lines and cross mains supplying sprinklers installed entirely above or entirely below ceilings shall be sized in accordance with Table 19.9.3.4 or Table 19.9.3.5.

19.9.3.9*

Where the total number of sprinklers above and below a ceiling exceeds the number specified in Table 19.9.3.7 for 3 in. (80 mm) pipe, the pipe supplying such sprinklers shall be increased to 3½ in. (90 mm) or larger and sized thereafter according to the schedule shown in Table 19.9.2.2.1 or Table 19.9.3.4 for the number of sprinklers above or below a ceiling, whichever is larger.

19.9.3.10

Where the distance between the sprinklers protecting the occupied area exceeds 12 ft (3.7 m) or the distance between the branch lines exceeds 12 ft (3.7 m), the branch lines shall be sized in accordance

with either Table 19.9.3.5, taking into consideration the sprinklers protecting the occupied area only, or Table 19.9.3.7, whichever requires the greater size of pipe.

19.9.4* Extra Hazard Occupancies.

Extra hazard occupancies shall be hydraulically calculated.

Chapter 20 General Requirements for Storage

20.1 General.

This chapter shall provide the necessary steps for identifying commodity, storage arrangements, storage heights, and clearances as well as general protection criteria for storage conditions relative to Chapters 21 to 24.

20.1.1

Miscellaneous and low-piled storage, meeting the criteria of Chapter 4, shall be protected in accordance with the relative occupancy hazard criteria reference in that section.

20.2

Protection of storage shall follow the following criteria:

- (1) Identify the storage commodity class in accordance with Sections 20.3 and 20.4.
- (2) Identify the method of storage in accordance with Section 20.5.
- (3) Establish storage height, building height, and associated clearances in accordance with Section 20.6.
- (4) Define the general protection criteria that are common to all storage protection options in accordance with Sections 20.7 through 20.15.
- (5) Select the appropriate system/sprinkler technology for protection criteria (Chapters 21 through 24).
- (6) Design and install system in accordance with the remainder of this document.

20.3* Classification of Commodities.

20.3.1

Commodity classification and the corresponding protection requirements shall be determined based on the makeup of individual storage units, pallet load, or module held together in some manner and normally transported by material-handling equipment.

20.3.1.1

The type and amount of materials used as part of the product and its primary packaging as well as the storage pallet shall be considered in the classification of the commodity.

20.3.1.2

When specific test data of commodity classification by a nationally recognized testing agency are available, the data shall be permitted to be used in determining classification of commodities.

20.3.2 Pallet Types.

20.3.2.1 General.

When loads are palletized, the use of wood or metal pallets, or listed pallets equivalent to wood, shall be assumed in the classification of commodities.

20.3.2.2 Plastic Pallet.

A pallet having any portion of its construction consisting of a plastic material that has not been listed as equivalent to wood shall increase the class of commodity determined for a storage load in accordance with 20.3.2.2.1 or 20.3.2.2.2.

20.3.2.2.1* Unreinforced Plastic Pallets.

Plastic pallets that have no secondary reinforcing shall be treated as unreinforced plastic pallets.

20.3.2.2.1.1

For Class I through Class IV commodities, when unreinforced polypropylene or unreinforced high-density polyethylene plastic pallets are used, the classification of the commodity unit shall be increased one class.

20.3.2.2.1.2

Unreinforced polypropylene or unreinforced high-density polyethylene plastic pallets shall be marked with a permanent symbol to indicate that the pallet is unreinforced.

20.3.2.2.2 Reinforced Plastic Pallet.

A plastic pallet incorporating a secondary reinforcing material (such as steel or fiberglass) within the pallet shall be considered a reinforced plastic pallet.

20.3.2.2.2.1*

For Class I through Class IV commodities, when reinforced polypropylene or reinforced high-density polyethylene plastic pallets are used, the classification of the commodity unit shall be increased two classes except for Class IV commodity, which shall be increased to a cartoned nonexpanded Group A plastic commodity.

20.3.2.2.2.2

Pallets shall be assumed to be reinforced if no permanent marking or manufacturer's certification of nonreinforcement is provided.

20.3.2.2.3

No increase in the commodity classification shall be required for Group A plastic commodities stored on plastic pallets.

20.3.2.2.4

For ceiling-only sprinkler protection, the requirements of 20.3.2.2.1 and 20.3.2.2.2.1 shall not apply where plastic pallets are used and where the sprinkler system uses spray sprinklers with a minimum K-factor of K-16.8 (240).

20.3.2.3

The requirements of 20.3.2.2.1 through 20.3.2.4 shall not apply to nonwood pallets that have demonstrated a fire hazard that is equal to or less than wood pallets and are listed as such.

20.3.2.4

For Class I through Class IV commodities stored on plastic pallets when other than wood, metal, or polypropylene or high-density polyethylene plastic pallets are used, the classification of the commodity unit shall be determined by specific testing conducted by a national testing laboratory or shall be increased two classes.

20.3.2.5 Slave Pallet.

Where solid, flat-bottom, combustible pallets are used in combination with CMDA sprinklers, Section 20.xxxx shall apply. (See *Figure A.3.9.1.10*.)

20.3.3 Open-Top Container.

A container of any shape that is entirely or partially open on the top and arranged so as to allow for the collection of discharging sprinkler water cascading through the storage array shall be considered outside the protection criteria of rack storage protection outlined in Chapters 21 through 24.

20.3.4 Solid Unit Load of Unexpanded Plastic (Either Cartoned or Exposed).

A load that does not have voids (air) within the load and that burns only on the exterior of the load and that water from sprinklers will reach most surfaces available to burn shall allow a reduction in design density of CMDA sprinklers. [See *Table 15.2.2.5(a)(2)*.]

20.3.5 Encapsulation.

20.4* Commodity Classes.

20.4.1* Class I.

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

- (1) Placed directly on wood pallets
- (2) Placed in single-layer corrugated cartons, with or without single-thickness cardboard dividers, with or without pallets
- (3) Shrink-wrapped or paper-wrapped as a unit load with or without pallets

20.4.2* Class II.

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

20.4.3* Class III.

20.4.3.1

A Class III commodity shall be defined as a product fashioned from wood, paper, natural fibers, or Group C plastics with or without cartons, boxes, or crates and with or without pallets.

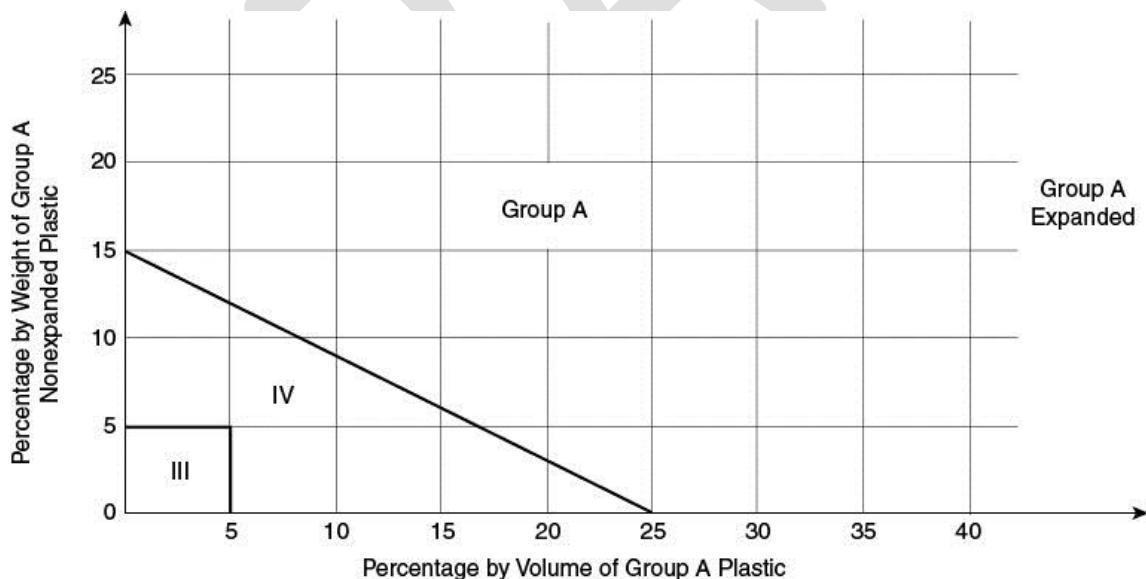
20.4.3.2

A Class III commodity shall be permitted to contain a limited amount (5 percent or less by weight of nonexpanded plastic or 5 percent or less by volume of expanded plastic) of Group A or Group B plastics.

20.4.3.3

Class III commodities containing a mix of both Group A expanded and nonexpanded plastics shall comply with Figure 20.4.3.3(a) where they are within cartons, boxes, or crates or with Figure 20.4.3.3(b) where they are exposed.

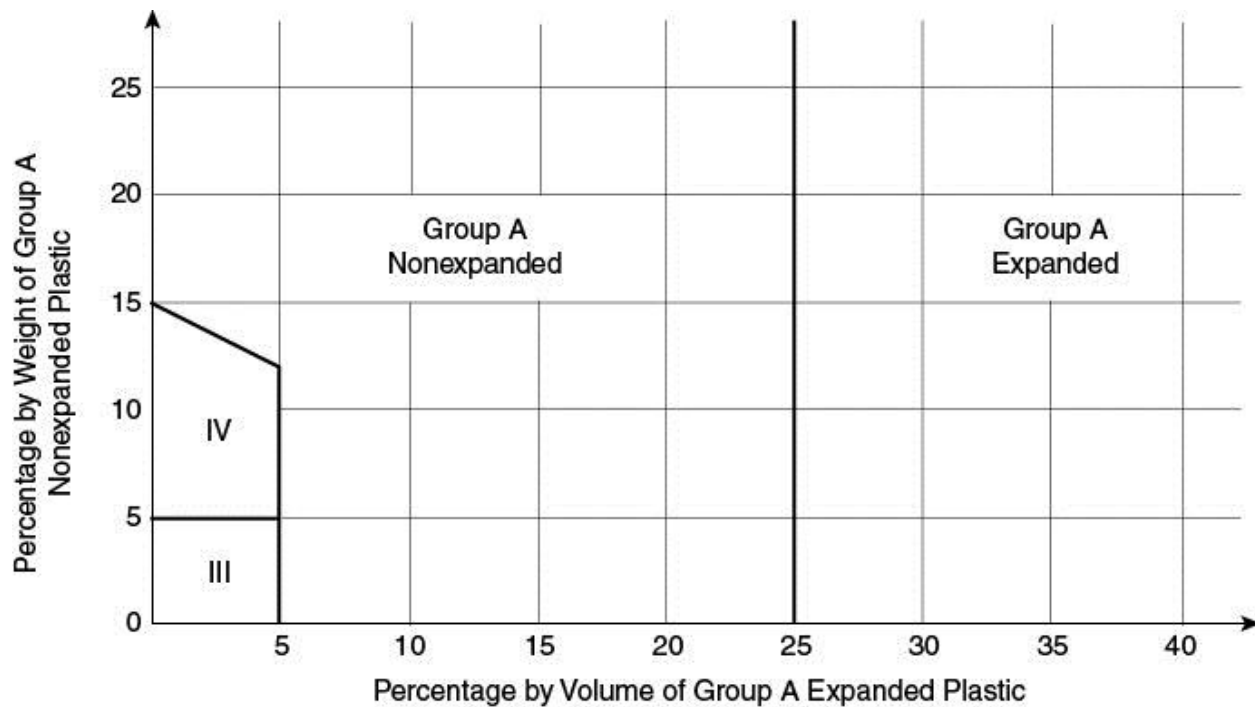
Figure 20.4.3.3(a) Commodities Containing a Mixture of Expanded and Nonexpanded Group A Plastics.



III - Class III Commodity. Refer to 5.6.2 if a plastic pallet is used.

IV - Class IV Commodity. Refer to 5.6.2 if a plastic pallet is used.

Figure 20.4.3.3(b) Exposed Commodities Containing a Mixture of Expanded and Nonexpanded Group A Plastics.



III - Class III Commodity. Refer to 5.6.2 if a plastic pallet is used.

IV - Class IV Commodity. Refer to 5.6.2 if a plastic pallet is used.

20.4.4* Class IV.

20.4.4.1

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

- (1) Constructed partially or totally of Group B plastics
- (2) Consists of free-flowing Group A plastic materials
- (3) Cartoned, or within a wooden container, that contains greater than 5 percent and up to 15 percent by weight of Group A unexpanded plastic
- (4) Cartoned, or within a wooden container, that contains greater than 5 percent and up to 25 percent by volume of expanded Group A plastics
- (5) Cartoned, or within a wooden container, that contains a mix of Group A expanded and unexpanded plastics and complies with Figure 20.4.3.3(a)
- (6) Exposed, that contains greater than 5 percent and up to 15 percent by weight of Group A unexpanded plastic
- (7) Exposed, that contains a mix of Group A expanded and unexpanded plastics and complies with Figure 20.4.3.3(b)

20.4.4.2

The remaining materials shall be permitted to be metal, wood, paper, natural or synthetic fibers, or Group B or Group C plastics.

20.4.5* Classification of Plastics, Elastomers, and Rubber.

Plastics, elastomers, and rubber shall be classified as Group A, Group B, or Group C.

20.4.5.1* Group A.

The following materials shall be classified as Group A:

- (1) ABS (acrylonitrile-butadiene-styrene copolymer)
- (2) Acetal (polyformaldehyde)
- (3) Acrylic (polymethyl methacrylate)
- (4) Butyl rubber
- (5) Cellulosics (cellulose acetate, cellulose acetate butyrate, ethyl cellulose)
- (6) EPDM (ethylene-propylene rubber)
- (7) FRP (fiberglass-reinforced polyester)
- (8) Natural rubber
- (9) Nitrile-rubber (acrylonitrile-butadiene-rubber)
- (10) Nylon (nylon 6, nylon 6/6)
- (11) PET (thermoplastic polyester)
- (12) Polybutadiene
- (13) Polycarbonate
- (14) Polyester elastomer
- (15) Polyethylene
- (16) Polypropylene
- (17) Polystyrene
- (18) Polyurethane
- (19) PVC (polyvinyl chloride — highly plasticized, with plasticizer content greater than 20 percent) (rarely found)
- (20) PVF (polyvinyl fluoride)
- (21) SAN (styrene acrylonitrile)
- (22) SBR (styrene-butadiene rubber)

20.4.5.2*

Group A plastics shall be further subdivided as either expanded or nonexpanded.

20.4.5.3

A Group A expanded plastic commodity shall be defined as a product, with or without pallets, that meets one of the following criteria:

- (1) Cartoned, or within a wooden container, that contains greater than 40 percent by volume of Group A expanded plastic
- (2) Exposed, that contains greater than 25 percent by volume of Group A expanded plastic

20.4.5.4

A Group A nonexpanded plastic commodity shall be defined as a product, with or without pallets, that meets one of the following criteria:

- (1) Cartoned, or within a wooden container, that contains greater than 15 percent by weight of Group A unexpanded plastic
- (2) Cartoned, or within a wooden container, that contains greater than 25 percent and up to 40 percent by volume of Group A expanded plastic
- (3) Cartoned, or within a wooden container, that contains a mix of Group A unexpanded and expanded plastics, in compliance with Figure 20.4.3.3(a)

- (4) Exposed, that contains greater than 15 percent by weight of Group A unexpanded plastic
- (5) Exposed, that contains greater than 5 percent and up to 25 percent by volume of Group A expanded plastic
- (6) Exposed, that contains a mix of Group A unexpanded and expanded plastics, in compliance with Figure 20.4.3.3(b)

20.4.5.5

The remaining materials shall be permitted to be noncombustible, wood, paper, natural or synthetic fibers, or Group A, Group B, or Group C plastics.

20.4.6 Group B.

The following materials shall be classified as Group B:

- (1) Chloroprene rubber
- (2) Fluoroplastics (ECTFE — ethylene-chlorotrifluoro-ethylene copolymer; ETFE — ethylene-tetrafluoroethylene-copolymer; FEP — fluorinated ethylene-propylene copolymer)
- (3) Silicone rubber

20.4.7 Group C.

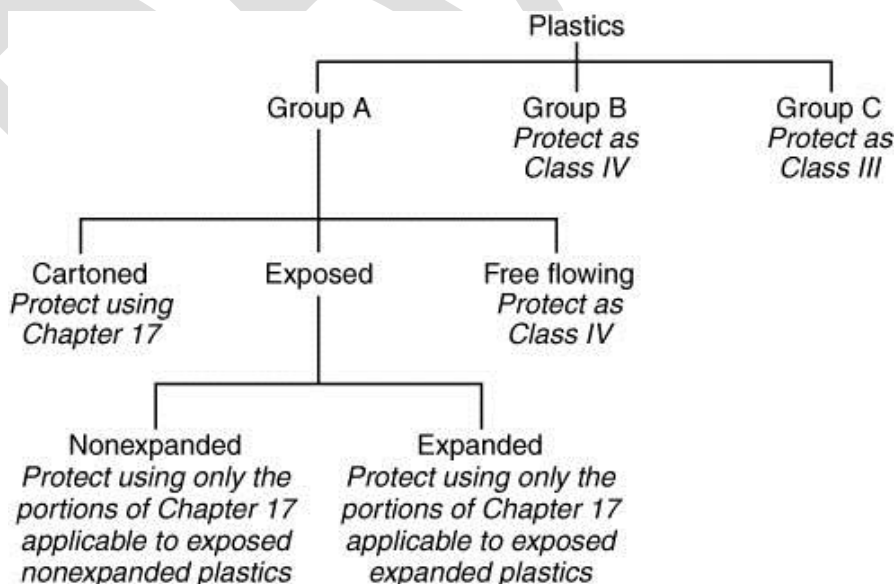
The following materials shall be classified as Group C:

- (1) Fluoroplastics (PCTFE — polychlorotrifluoroethylene; PTFE — polytetrafluoroethylene)
- (2) Melamine (melamine formaldehyde)
- (3) Phenolic
- (4) PVC (polyvinyl chloride — flexible — PVCs with plasticizer content up to 20 percent)
- (5) PVDC (polyvinylidene chloride)
- (6) PVDF (polyvinylidene fluoride)
- (7) Urea (urea formaldehyde)

20.4.8*

Plastic commodities shall be protected in accordance with Figure 20.4.8. (See Section C.21.)

Figure 20.4.8 Decision Tree.



20.4.8.1

Group B plastics and free-flowing Group A plastics shall be protected the same as Class IV commodities.

20.4.8.2

Group C plastics shall be protected the same as Class III commodities.

20.4.9 Rubber Tires.

Pneumatic tires for passenger automobiles, aircraft, light and heavy trucks, trailers, farm equipment, construction equipment (off-the-road), and buses shall be protected as rubber tire storage in accordance with Chapters 20 through 24.

20.4.10* Classification of Rolled Paper Storage.

For the purposes of this standard, the classifications of paper described in 20.4.10.1 through 20.4.10.4 shall apply and shall be used to determine the sprinkler system design criteria in accordance with Chapters 20 through 24.

20.4.10.1 Heavyweight Class.

Heavyweight class shall be defined so as to include paperboard and paper stock having a basis weight [weight per 1000 ft² (92.9 m²)] of 20 lb (9.1 kg).

20.4.10.2 Mediumweight Class.

Mediumweight class shall be defined so as to include all the broad range of papers having a basis weight [weight per 1000 ft² (92.9 m²)] of 10 lb to 20 lb (4.5 kg to 9.1 kg).

20.4.10.3 Lightweight Class.

Lightweight class shall be defined so as to include all papers having a basis weight [weight per 1000 ft² (92.9 m²)] of 10 lb (4.5 kg).

20.4.10.4 Tissue.

20.4.10.4.1

Tissue shall be defined so as to include the broad range of papers of characteristic gauzy texture, which, in some cases, are fairly transparent.

20.4.10.4.2

For the purposes of this standard, tissue shall be defined as the soft, absorbent type, regardless of basis weight — specifically, crepe wadding and the sanitary class including facial tissue, paper napkins, bathroom tissue, and toweling.

20.4.11* Plastic Motor Vehicle Components.

Group A plastic automotive components and associated packaging material consisting of exposed, expanded Group A plastic dunnage, instrument panels, and plastic bumper fascia shall be permitted to be protected as defined in Chapter 23.

20.4.12 Retail Display/Storage of Up to Cartoned Group A Plastics.

Group A plastics combined with Class I through IV in a retail/storage environment (big box retail) that combines customer picking areas with storage above within the retail area shall be permitted to be protected in accordance with retail display/storage of up to cartoned group A plastics in Chapters 20 to 23.

20.4.12.1 Baled Cotton.

A natural seed fiber wrapped and secured in industry-accepted materials, usually consisting of burlap, woven polypropylene, or sheet polyethylene, and secured with steel, synthetic or wire bands, or wire; also includes linters (lint removed from the cottonseed) and motes (residual materials from the ginning process) shall be protected as baled cotton in accordance with Chapter 21. (See Table A.3.9.6.1.)

20.4.13 Carton Records Storage.

A Class III commodity consisting predominantly of paper records in cardboard cartons shall be permitted to be protected as cartoned record storage in accordance with Chapters 21 or 23.

20.4.14 Mixed Commodities.

20.4.14.1

Protection requirements shall not be based on the overall commodity mix in a fire area.

20.4.14.2

Unless the requirements of 20.4.14.3 or 20.4.14.4 are met, mixed commodity storage shall be protected by the requirements for the highest classified commodity and storage arrangement.

20.4.14.3

The protection requirements for the lower commodity class shall be permitted to be utilized where all of the following are met:

- (1) Up to 10 pallet loads of a higher hazard commodity, as described in 20.4 and 20.4.5, shall be permitted to be present in an area not exceeding 40,000 ft² (3720 m²).
- (2) The higher hazard commodity shall be randomly dispersed with no adjacent loads in any direction (including diagonally).
- (3) Where the ceiling protection is based on Class I or Class II commodities, the allowable number of pallet loads for Class IV or Group A plastics shall be reduced to five.

20.4.14.4 Mixed Commodity Segregation.

The protection requirements for the lower commodity class shall be permitted to be utilized in the area of lower commodity class, where the higher hazard material is confined to a designated area and the area is protected to the higher hazard in accordance with the requirements of this standard.

20.5 Storage Arrangement.

20.5.1

General storage arrangements defined in this section shall be used to select the appropriate protection criteria in Chapters 21 through 24.

20.5.1.1

Other storage arrangements not covered by this section shall be considered outside the scope of this standard.

20.5.2 Palletized Storage.

On floor storage of commodities on pallets or other storage aids that form horizontal spaces between tiers of storage shall be considered as palletized storage.

20.5.2.1 Closed Array.

Where the vertical flues between pallet loads are 6 in. (152 mm) or less, the arrangement shall be considered closed array.

20.5.2.2 Open Array.

Where the vertical flues between pallet loads are greater than 6 in. (152 mm), the arrangement shall be considered open array.

20.5.2.3 Pile Stability, Stable Piles.

Those arrays where collapse, spillage of contents, or leaning of stacks across flue spaces is not likely to occur soon after initial fire development shall be considered as stable piles.

20.5.2.4* Pile Stability, Unstable Piles.

Those arrays where collapse, spillage of contents, or leaning of stacks across flue spaces occurs soon after initial fire development shall be considered as unstable piles.

20.5.3 Solid-Piled Storage.

Storage of commodities stacked on each other shall be considered as solid piled storage.

20.5.3.1 Closed Array.

Where solid piled storage has vertical flues between the piles of 6 in. (152 mm) or less, the storage arrangement shall be considered as closed array.

20.5.3.2 Open Array.

Where solid piled storage has vertical flues between the piles that are greater than 6 in. (152 mm), the storage arrangement shall be considered as open array.

20.5.3.3 Pile Stability, Stable Piles.

Those arrays where collapse, spillage of content, or leaning of stacks across flue spaces is not likely to occur soon after initial fire development shall be considered as stable piles.

20.5.3.4* Pile Stability, Unstable Piles.

Those arrays where collapse, spillage of contents, or leaning of stacks across flue spaces occurs soon after initial fire development shall be considered as unstable piles.

20.5.4 Bin Box Storage.

Storage in five-sided wood, metal, or cardboard boxes with open face on the aisles in which boxes are self-supporting or supported by a structure so designed that little or no horizontal or vertical space exists around boxes shall be considered as bin box storage.

20.5.5 Shelf Storage.

Storage on structures up to and including 30 in. (0.76 m) deep and separated by aisles at least 30 in. (0.76 m) wide shall be considered as shelf storage.

20.5.6 Back-to-Back Shelf Storage.

Two solid or perforated shelves up to 30 in. (0.76 m) depth each, not exceeding a total depth of 60 in. (1.52 m), separated by a longitudinal vertical barrier such as plywood, particleboard, sheet metal, or equivalent, with a maximum 0.25 in. (6.4 mm) diameter penetrations and no longitudinal flue space and a maximum storage height of 15 ft (4.57 m) shall be considered as back-to-back storage.

20.5.7 Movable Racks.

Racks on fixed rails or guides that can be moved back and forth only in a horizontal, two-dimensional plane shall be protected as movable racks.

20.5.7.1

Rack storage in movable racks shall be protected in the same manner as multiple-row racks.

20.5.8* Rack Storage.

General rack storage shall include any combination of vertical, horizontal, and diagonal members that supports stored materials in accordance with 20.5.7.

20.5.8.1 Open Rack.

Racks without shelving or with shelving in racks that are fixed in place with shelves having a solid surface and a shelf area equal to or less than 20 ft² (1.9 m²) or with shelves having a wire mesh, slatted surface, or other material with openings representing at least 50 percent of the shelf area, including the horizontal area of rack members and where the flue spaces are maintained, shall be protected as open rack.

20.5.8.2 Shelving.

20.5.8.2.1 Rack Shelf Area.

The area of the horizontal surface of a shelf in a rack defined by perimeter aisle(s) or nominal 6 in. (152 mm) flue spaces on all four sides, or by the placement of loads that block openings that would otherwise serve as the required flue spaces, shall be considered to determine the rack shelf area.

20.5.8.2.2 Slatted Shelf Rack.

A rack where shelves are fixed in place with a series of narrow individual solid supports used as the shelf material and spaced apart with regular openings shall be protected as a slatted shelf rack.

20.5.8.2.3 Solid Shelf Rack.

A rack that is not defined as an open rack where shelves are fixed in place with a solid, slatted, or wire mesh barrier used as the shelf material and having limited openings in the shelf area shall be protected as a solid shelf rack.

20.5.8.2.4 Solid Shelving.

The area of a shelf shall be measured by perimeter aisle or flue space on all four sides or by the placement of loads that block openings that would otherwise serve as the required flue spaces.

20.5.8.2.4.1

Shelving material that is less than 50 percent open, or placement of loads that block openings that would otherwise serve as the required flue spaces, greater than 20 ft² (1.9 m²) in area shall be treated as solid shelf racks.

20.5.8.2.4.2

Where multiple-row racks of any height have no longitudinal flue or where double-row racks with storage up to 25 ft (7.6 m) in height have no longitudinal flue, the situation shall not be considered solid shelves where transverse flues exist at maximum 5 ft (1.5 m) intervals, and additional in-rack sprinklers shall not be required in accordance with 16.1.6.1 and 16.1.6.2.

20.5.8.3 Aisles.

20.5.8.3.1

Aisles required by Chapters 21 through 25 shall not be obstructed unless Chapters 21 through 25 include specific guidance allowing obstructions over the aisle.

20.5.8.3.2 Aisle Width.

The horizontal dimension between the face of the loads in racks under consideration shall determine the aisle width for protection criteria.

20.5.8.4 Flues.

20.5.8.4.1 Longitudinal Flue Space.

The space between rows of storage perpendicular to the direction of loading with a width not exceeding 24 in. (610 mm) between storage shall be considered as the longitudinal flue.

20.5.8.4.1.1

For Class I through IV and Group A plastic in double-row and multiple-row open racks, a longitudinal flue space shall not be required for storage up to and including 25 ft (7.6 m). (See Section C.13.)

20.5.8.4.1.2

For Class I through IV and Group A plastic nominal 6 in. (152.4 mm) longitudinal flue spaces shall be provided in double-row racks for storage over 25 ft (7.6 m).

20.5.8.4.2 Transverse Flue Space.

The space between rows of storage parallel to the direction of loading shall be considered as the transverse flue. (See Figure A.3.9.3.6.)

20.5.8.4.2.1

Nominal 6 in. (150 mm) transverse flue spaces between loads and at rack uprights shall be maintained in single-row, double-row, and multiple-row racks.

20.5.8.4.2.2

Random variations in the width of flue spaces or in their vertical alignment shall be permitted.

20.5.8.5 Bulkhead.

A vertical barrier across the rack shall be considered a bulkhead.

20.5.8.6 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 shall be considered a horizontal barrier.

20.5.8.7 Single-Row Racks.

Racks that have no longitudinal flue space and that have a depth up to 6 ft (1.8 m) with aisles having a width of at least 3.5 ft (1.1 m) between loads on racks shall be protected as single-row racks.

20.5.8.8 Double-Row Racks.

Racks less than or equal to 12 ft (3.7 m) in depth or single-row racks placed back to back having an aggregate depth up to 12 ft (3.7 m), with aisles having an aisle width of at least 3.5 ft (1.1 m) between loads on racks shall be protected as double-row racks.

20.5.8.9 Multiple-Row Racks.

Racks greater than 12 ft (3.7 m) in depth or single- or double-row racks separated by aisles less than 3.5 ft (1.1 m) wide having an overall width greater than 12 ft (3.7 m) shall be protected as multiple-row racks.

20.5.8.10 Movable Racks.

Racks on fixed rails or guides that can be moved back and forth only in a horizontal, two-dimensional plane shall be protected as movable racks.

20.5.8.11 Portable Racks.

Racks that are not fixed in place and can be arranged in any number of configurations shall be protected as portable racks.

20.5.9 Rubber Tires.

Paragraphs 20.5.9.1 through 20.5.9.7 cover the general terms of rubber tire storage that identify which type of protection criteria shall be used in Chapters 21 to 24.

20.5.9.1 Banded Tires.

When tires are strapped together, they shall be considered as banded.

20.5.9.2 Horizontal Channel.

Any uninterrupted space in excess of 5 ft (1.5 m) in length between horizontal layers of stored tires shall be considered as the horizontal channel.

20.5.9.3 Laced Tire Storage.

Tires stored where the sides of the tires overlap, creating a woven or laced appearance, shall be considered as laced tire storage. [See Figure A.3.9.4.9(g).]

20.5.9.4 On-Side Tire Storage.

Tires stored horizontally or flat shall be considered as on-side storage.

20.5.9.5 On-Tread Tire Storage.

Tires stored vertically or on their treads shall be considered as on-tread storage.

20.5.9.6 Palletized Tire Storage.

Storage on portable racks of various types utilizing a conventional pallet as a base shall be considered as palletized storage.

20.5.9.7 Pyramid Tire Storage.

On-floor storage in which tires are formed into a pyramid to provide pile stability shall be considered as pyramid storage.

20.5.9.8 Water Supplies.

Total water supplies shall be capable of providing flow for automatic sprinklers, hose streams, and foam systems (if provided) for the duration required in Table 20.12.2.6.

20.5.10 Roll Paper.

Paragraphs 20.5.9.1 through 20.5.9.11 cover the general terms of roll paper that identify which type of protection criteria shall be used in Chapters 21 through 24.

20.5.10.1 Paper.

Storage of all kinds of felted sheets made from natural fibrous materials, usually vegetable but sometimes mineral or animal, and formed on a fine wire screen from water suspension, where stored in rolled form shall be protected as roll paper storage.

20.5.10.2 Closed Array (Paper).

Where a vertical storage arrangement in which the distances between columns in both directions are short [not more than 2 in. (50 mm) in one direction and 1 in. (25 mm) in the other], the storage array shall be considered as closed array.

20.5.10.3 Open Array (Paper).

Where a vertical storage arrangement in which the distance between columns in both directions is lengthy (all vertical arrays other than closed or standard), the storage array shall be considered as open array.

20.5.10.4 Standard Array (Paper).

Where a vertical storage arrangement in which the distance between columns in one direction is short [1 in. (25 mm) or less] and is in excess of 2 in. (50 mm) in the other direction, the storage array shall be considered as standard array.

20.5.10.5 Banded Roll Paper Storage.

Where rolls are provided with a circumferential steel strap [$\frac{3}{8}$ in. (9.5 mm) or wider] at each end of the roll, the rolls shall be considered banded.

20.5.10.6 Column.

A single vertical stack of rolls shall be considered a column.

20.5.10.7 Core.

The central tube around which paper is wound to form a roll shall be considered as the core.

20.5.10.8 Horizontal Roll Paper Storage.

Rolls stored with the cores in the horizontal plane (on-side storage) shall be considered as horizontal storage.

20.5.10.9 Vertical Roll Paper Storage.

Rolls stored with the cores in the vertical plane (on-end storage) shall be considered as vertical storage.

20.5.10.10 Wrapped Roll Paper Storage.

Rolls provided with a complete heavy kraft covering around both sides and ends shall be considered as wrapped storage.

20.5.10.11 Roll Paper Storage Height.

The maximum vertical distance above the floor at which roll paper is normally stored shall be considered as the storage height.

20.5.10.12 Protection Criteria for Roll Paper Storage.

20.5.10.13

Wet pipe systems shall be used in tissue storage areas.

20.5.10.13.1

The water supply design shall include the demand of the automatic sprinkler system plus the hose stream allowance plus, where provided, the high-expansion foam system for the duration specified in Table 20.12.2.6.

20.5.10.14

Horizontal storage of heavyweight or mediumweight paper shall be protected as a closed array.

20.5.10.15

Mediumweight paper shall be permitted to be protected as heavyweight paper where wrapped completely on the sides and both ends, or where wrapped on the sides only with steel bands. Wrapping material shall be either a single layer of heavyweight paper with a basis weight of 40 lb (18.1 kg) or two layers of heavyweight paper with a basis weight of less than 40 lb (18.1 kg).

20.5.10.16

Lightweight paper or tissue paper shall be permitted to be protected as mediumweight paper where wrapped completely on the sides and both ends, or where wrapped on the sides only with steel bands. Wrapping material shall be either a single layer of heavyweight paper with a basis weight of 40 lb (18.1 kg) or two layers of heavyweight paper with a basis weight of less than 40 lb (18.1 kg).

20.5.10.17

For purposes of sprinkler system design criteria, lightweight class paper shall be protected as tissue.

20.5.11 Plastic Motor Vehicle Components.

Group A plastic automotive components and associated packaging material consisting of exposed, expanded Group A plastic dunnage, instrument panels, and plastic bumper fascia shall be permitted to be protected as defined in Chapter 23.

20.5.11.1

Automotive components covered in this section shall not include the storage of air bags, tires, and seats on portable racks. Paragraphs 20.5.11.1 through 20.5.11.3 cover the general terms of plastic motor vehicle components that identify which protection criteria shall be used in Chapter 23.

20.5.11.2 Automotive Components on Portable Racks.

Instrument panels, windshields, metal and plastic gasoline tanks, heater housings, door panels, interior trim, bumper fascia, wiring harnesses, sheet metal, body components, engines, driveline components, steering mechanisms, auxiliary motors, and lighting, all with or without expanded Group A plastic dunnage, shall be permitted to be protected as automotive components in Chapter 23.

20.5.11.3 Closed Array.

Where portable racks have vertical flues between the racks that are 6 in. (152 mm) or less, the storage arrangement shall be considered as closed array.

20.5.12 Retail Display/Storage.

Paragraph 20.5.7.1 covers the general terms of retail display/storage that identify which type of protection criteria shall be used in Chapters 21 through 24.

20.5.13 Baled Cotton Storage.

Paragraph 20.5.13.1 covers the general terms of baled cotton storage that identify which type of protection criteria shall be used in Chapter 21.

20.5.13.1 Tiered Storage.

An arrangement in which bales are stored directly on the floor, two or more bales high, shall be considered as tiered storage.

20.5.14 Cartoned Record Storage.

Paragraphs 20.5.14.1 and 20.5.14.2 cover the general terms of cartoned record storage that identify which type of rack and shelving criteria shall be used in Chapters 21 through 24.

20.5.14.1 Cartoned Records Storage.

The protection criteria in Chapter 21 for cartoned records storage shall be based on a Class III commodity consisting predominantly of paper records in cardboard cartons.

20.5.14.2* Catwalk.

For the purposes of cartoned records storage, catwalks shall be considered a storage aid consisting of either open metal grating or solid horizontal barriers supported from a rack storage system that is utilized as a walkway for access to storage at elevated levels.

20.6 Building Construction and Storage: Heights and Clearance.

20.6.1 Ceiling Slope.

The sprinkler system criteria specified in Chapter 12 and Chapters 14 through 20 are intended to apply to buildings with ceiling slopes not exceeding 2 in 12 (16.7 percent) unless modified by a specific section in Chapter 12 and Chapters 14 through 20.

20.6.2* Building and Storage Height.

20.6.2.1

The maximum building height shall be measured to the underside of the roof deck or ceiling in the storage area or in accordance with 20.13.1.1 through 20.6.2.4.2.

20.6.2.2

For corrugated metal deck roofs up to 3 in. (75 mm) in depth, the maximum roof height shall be measured from floor to the bottom of the deck.

20.6.2.3

For decks deeper than 3 in. (75 mm), the maximum roof height shall be measured to the highest point on the deck.

20.6.2.4

For ceilings that have insulation installed directly against underside of the ceiling or roof structure, the maximum roof height shall be measured to the bottom of insulation and shall be in accordance with 20.13.1.3.1 or 20.13.1.3.2.

20.6.2.4.1

For insulation that is installed directly against the ceiling or roof structure and is installed flat and parallel to the ceiling or roof structure, the maximum roof height shall be measured to the underside of the insulation.

20.6.2.4.2

For insulation that is installed in a manner that causes it to deflect or sag down from the ceiling or roof structure, the maximum roof height shall be measured as half of the distance of the deflection from the insulation high point to the insulation low point. If the deflection or sag in the insulation exceeds 6 in. (150 mm), the maximum roof height shall be measured to the high point of the insulation.

20.6.2.5*

Where the building height changes within a compartment, the sprinklers directly over the storage shall be capable of protecting storage directly beneath.

20.6.2.5.1

Where a barrier to heat and smoke in accordance with 20.10.1(2) or 20.10.1(3) is not present, the sprinkler criteria 15 ft (4.6 m) into the perimeter of the lower ceiling area shall be the same as the sprinkler protection for the high ceiling area.

20.6.2.6

ESFR sprinklers shall be used only in buildings equal to, or less than, the height of the building for which they have been listed.

20.6.3 Storage Height.

20.6.3.1

The sprinkler system design shall be based on the storage height that routinely or periodically exists in the building and creates the greatest water demand.

20.6.3.2

Where storage is placed above doors, the storage height shall be calculated from the base of storage above the door.

20.6.4 Clearance to Ceiling.

20.6.4.1*

The clearance to ceiling shall be measured in accordance with 20.6.4.1.1 through 20.6.4.1.3.

20.6.4.1.1

For corrugated metal deck roofs up to 3 in. (75 mm) in depth, the clearance to ceiling shall be measured from the top of storage to the bottom of the deck.

20.6.4.1.2

For corrugated metal deck roofs deeper than 3 in. (75 mm), the clearance to ceiling shall be measured to the highest point on the deck.

20.6.4.1.3

For ceilings that have insulation attached directly to underside of the ceiling or roof structure, the clearance to ceiling shall be measured from the top of storage to the bottom of the insulation and shall be in accordance with 20.6.4.1.3(A) or 20.6.4.1.3(B).

(A)

For insulation that is attached directly to the ceiling or roof structure and is installed flat and parallel to the ceiling or roof structure, the clearance to ceiling shall be measured from the top of storage to the underside of the insulation.

(B)

For insulation that is installed in a manner that causes it to deflect or sag down from the ceiling or roof structure, the clearance to ceiling shall be measured from the top of storage to a point half of the distance of the deflection from the insulation high point to the insulation low point. If the deflection or sag in the insulation exceeds 6 in. (150 mm), the clearance to ceiling shall be measured from the top of storage to the high point of the insulation.

20.6.4.2

Protection of Class I-IV commodities with excessive clearance from the top of storage to the ceiling sprinkler deflectors shall be in accordance with Table 20.6.4.2.

Table 20.6.4.2 Class I Through Class IV Commodities

Storage Configuration	Where the clearance to ceiling exceeds	Protection is based upon the storage height that would result in a clearance to ceiling of...	In-rack Sprinklers*
Palletized, solid-piled, bin box, shelf, or back-to-back shelf storage	20 ft (6.1 m)	20 ft (6.1 m)	N/A
Rack storage up to and including 25 ft (7.6 m) in height	20 ft (6.1 m)	20 ft (6.1 m)	Permitted as alternative to presumed clearance of 20 ft (6.1 m)
Rack storage over 25 ft (7.6 m) in height	10 ft (3.1 m)	10 ft (3.1 m)	Permitted as alternative to presumed clearance of 10 ft (3.1 m)

*When applying the supplemental in-rack sprinkler option, the ceiling density is based upon the given storage height with an assumed acceptable clearance to ceiling. Provide one level of supplemental, quick response in-rack sprinklers located directly below the top tier of storage and at every flue space intersection.

20.6.4.3

Protection of Plastic and Rubber commodities with excessive clearance from the top of storage to the ceiling sprinkler deflectors shall be in accordance with Table 20.6.4.3.

Table 20.6.4.3 Plastics and Rubber Commodities

Storage Configuration	Where the clearance to ceiling exceeds	Protection is based upon the storage height that would result in a clearance to ceiling of...	In-rack Sprinklers*
Palletized, solid-piled, bin box, shelf, or back-to-back shelf storage	20 ft (6.1 m)	20 ft (6.1 m)	N/A
Rack storage up to and including 25 ft (7.6 m) in height	10 ft (3.1 m)	10 ft (3.1 m)	Permitted as alternative to presumed clearance of 10 ft (3.1 m)
Rack storage over 25 ft (7.6 m) in height	10 ft (3.1 m)	N/A	Required

*If in-rack sprinklers are required for the actual storage height with an acceptable clearance to ceiling, in-rack sprinklers are installed as indicated by that criteria. Provide one level of supplemental, quick response in-rack sprinklers located directly below the top tier of storage and at every flue space intersection.

20.6.4.4

For spray sprinkler CMDA criteria where the clearance to ceiling exceeds those identified in Table 20.6.4.4, the requirements of 20.6.4.5 through 20.6.4.10 shall apply.

Table 20.6.4.4 Maximum Clearance from Top of Storage to Ceiling for CMDA Protection Criteria

Commodity	Class I to IV	Group A Plastic
Palletized, Solid-Piled, Bin Box, Shelf, or Back-to-Back Shelf Storage	20 ft (6.1 m)	20 ft (6.1 m)
Rack Storage up to 25 ft (7.6 m)	20 ft (6.1 m)	10 ft (3.1 m)
Rack Storage > 25 ft (7.6 m)	10 ft (3.1 m)	10 ft (3.1 m)

20.6.4.5

Where the clearance to ceiling exceeds 20 ft (6.1 m) for palletized, solid-piled, bin box, shelf, or back-to-back shelf storage, the protection shall be based on the storage height that would result in a clearance to ceiling of 20 ft (6.1 m).

20.6.4.6

Where the clearance to ceiling exceeds 20 ft (6.1 m) for rack storage of Class I through IV storage up to and including 25 ft (7.6 m) in height, the protection shall be based upon the storage height that would result in a clearance to ceiling of 20 ft (6.1 m) or providing one level of supplemental, quick-response in-rack sprinklers in accordance with Chapter 25.

20.6.4.7

Where the clearance to ceiling exceeds 10 ft (3.0 m) for rack storage of Class I to IV above 25 ft (7.6 m) in height or Group A plastic up to 25 ft (7.6 m) in height, protection shall be based upon the storage height that would result in a clearance to ceiling of 10 ft (3.0 m) or providing one level of supplemental, quick-response in-rack sprinklers in accordance with Chapter 25.

20.6.4.8

Where the clearance exceeds 10 ft (3.0 m) for rack storage of Group A plastic above 25 ft (7.6 m) in height, protection shall be based on providing one level of supplemental, quick-response in-rack sprinklers in accordance with Chapter 25.

20.6.4.9

When applying the supplemental in-rack sprinkler option, the ceiling density shall be based upon the given storage height with an assumed acceptable clearance to ceiling.

20.6.4.10

If in-rack sprinklers are required for the actual storage height with an acceptable clearance to ceiling, in-rack sprinklers shall be installed as indicated by that criteria.

20.6.5 Roof Vents and Draft Curtains.

See Section C.6.

20.6.6 Clearance from Deflector to Storage.

20.6.6.1

Unless the requirements of 20.6.6.2 through 20.6.6.5 are met, the clearance between the deflector and the top of storage or contents of the room shall be 18 in. (450 mm) or greater.

20.6.6.2*

Manually operated roof vents or automatic roof vents with operating elements that have a higher temperature classification than the automatic sprinklers shall be permitted.

20.6.6.3

Early suppression fast-response (ESFR) sprinklers shall not be used in buildings with automatic heat or smoke vents unless the vents use a high-temperature rated, standard-response operating mechanism.

20.6.6.4

Where other standards specify greater clearance to storage minimums, they shall be followed.

20.6.6.5

A minimum clearance to storage of 36 in. (900 mm) shall be permitted for special sprinklers.

20.6.6.6*

Draft curtains shall not be used within ESFR sprinkler systems.

20.6.6.6.1

Draft curtains separating ESFR sprinklers at system breaks or from control mode sprinklers or between hazards shall be permitted. (See 14.2.5.)

20.6.6.6.2

Where ESFR sprinkler systems are installed adjacent to sprinkler systems with standard-response sprinklers, a draft curtain of noncombustible construction and at least 2 ft (600 mm) in depth shall be required to separate the two areas.

20.6.6.6.3

A clear aisle of at least 4 ft (1.2 m) centered below the draft curtain shall be maintained for separation.

20.6.6.7

A minimum clearance to storage of less than 18 in. (450 mm) between the top of storage and ceiling sprinkler deflectors shall be permitted where proven by successful large-scale fire tests for the particular hazard.

20.6.6.8

The clearance from the top of storage to sprinkler deflectors shall be not less than 36 in. (900 mm) where rubber tires are stored.

20.6.7* High Volume Low Speed (HVLS) Fans.

20.6.7.1

The installation of HVLS fans in buildings equipped with sprinklers, including ESFR sprinklers, shall comply with the following:

- (1) The maximum fan diameter shall be 24 ft (7.3 m).
- (2) The HVLS fan shall be centered approximately between four adjacent sprinklers.
- (3) The vertical clearance from the HVLS fan to sprinkler deflector shall be a minimum of 3 ft (914 mm).
- (4) All HVLS fans shall be interlocked to shut down immediately upon a waterflow alarm.
- (5) Where the building is protected with a fire alarm system, this interlock shall be in accordance with the requirements of NFPA 72.

20.7 Unsprinklered Combustible Concealed Spaces.

20.7.1*

When using the density/area method or room design method, unless the requirements of 20.7.2 are met for buildings having unsprinklered combustible concealed spaces as described in 17.4.1 and 9.3.19, the minimum area of sprinkler operation for that portion of the building shall be 3000 ft² (280 m²).

20.7.1.1

The design area of 3000 ft² (280 m²) shall be applied only to the sprinkler system or portions of the sprinkler system that are adjacent to the qualifying combustible concealed space.

20.7.1.2

The term *adjacent* shall apply to any sprinkler system protecting a space above, below, or next to the qualifying concealed space except where a barrier with a fire resistance rating at least equivalent to the water supply duration completely separates the concealed space from the sprinklered area.

20.7.2

The following unsprinklered combustible concealed spaces shall not require a minimum design area of sprinkler operation of 3000 ft² (280 m²):

- (1) Noncombustible and limited-combustible concealed spaces with minimal combustible loading having no access. The space shall be considered a concealed space even with small openings such as those used as return air for a plenum.
- (2) Noncombustible and limited-combustible concealed spaces with limited access and not permitting occupancy or storage of combustibles. The space shall be considered a concealed space even with small openings such as those used as return air for a plenum.
- (3) Combustible concealed spaces filled entirely with noncombustible insulation.
- (4) Concealed spaces where rigid materials are used and the exposed surfaces have a flame spread index of 25 or less and the materials have been demonstrated to not propagate fire more than 10.5 ft (3.2 m) when tested in accordance with ASTM E 84, *Standard Test Method for Surface Burning Characteristics of Building Materials*, or ANSI/UL 723, *Standard for Test for Surface Burning Characteristics of Building Materials*, extended for an additional 20 minutes in the form in which they are installed in the space.
- (5) Concealed spaces in which the exposed materials are constructed entirely of fire retardant-treated wood as defined by NFPA 703.
- (6) Concealed spaces over isolated small compartments not exceeding 55 ft² (5.1 m²) in area.
- (7) Vertical pipe chases under 10 ft² (0.9 m²), provided that in multifloor buildings the chases are firestopped at each floor using materials equivalent to the floor construction. Such pipe chases shall contain no sources of ignition, piping shall be noncombustible, and pipe penetrations at each floor shall be properly sealed.
- (8) Exterior columns under 10 ft² (0.9 m²) in area formed by studs or wood joists, supporting exterior canopies that are fully protected with a sprinkler system.

20.8 Room Design Method.

20.8.1*

The water supply requirements for sprinklers only shall be based upon the room that creates the greatest demand.

20.8.2

To utilize the room design method, all rooms shall be enclosed with walls having a fire resistance rating equal to the required water supply duration.

20.8.2.1

Minimum protection of openings shall include automatic- or self-closing doors with the appropriate fire protection rating for the enclosure.

20.8.3

Where the room design method is used, the density shall correspond to that required for the smallest area acceptable under the density/area method.

20.9* High-Expansion Foam Systems.

20.9.1 General: High Expansion Foam Systems.

20.9.1.1

High-expansion foam systems that are installed in addition to automatic sprinklers shall be installed in accordance with NFPA 11.

20.9.1.2

High-expansion foam systems shall be automatic in operation.

20.9.1.3

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

20.9.1.4

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

20.9.1.5

The release system for the high expansion foam deluge system shall be designed to operate prior to the sprinklers installed in the area.

20.9.1.5.1

The maximum submergence time for the high-expansion foam shall be 5 minutes for Class I, Class II, or Class III commodities and 4 minutes for Class IV commodities.

20.9.2 High-Expansion Foam: Reduction in Ceiling Density.

20.9.2.1

Using CMDA sprinkler protection criteria for palletized, solid-piled, bin box, shelf, or back-to-back shelf storage of Class I through Class IV commodities, idle pallets, or plastics, where high-expansion foam systems are used in combination with ceiling sprinklers, a reduction in ceiling density to one-half that required for Class I through Class IV commodities, idle pallets, or plastics shall be permitted without revising the design area, but the density shall be no less than 0.15 gpm/ft² (6.1 mm/min).

20.9.2.2

Using CMDA sprinkler protection criteria for rack storage, where high-expansion foam systems are used in combination with ceiling sprinklers, the minimum ceiling sprinkler design density shall be 0.2 gpm/ft² (8.1 mm/min) for Class I, Class II, or Class III commodities, 0.25 gpm/ft² (10.2 mm/min) for Class IV commodities for the most hydraulically remote 2000 ft² (186 m²) operating area.

20.9.2.3

Where high-expansion foam systems are used in combination with ceiling sprinklers, the maximum submergence time shall be 7 minutes for Class I, Class II, or Class III commodities and 5 minutes for Class IV commodities.

20.9.2.4

Where high-expansion foam systems are used for rack storage of Class I through IV commodities over 25 ft (7.6 m) high up to and including 35 ft (10.7 m), they shall be used in combination with ceiling sprinklers.

20.9.2.5 Reduced-Discharge Density.

Where high-expansion foam systems for rubber tire protection are installed in accordance with NFPA 11, a reduction in sprinkler discharge density to one-half the density specified in Table 21.6.1(a) or 0.24 gpm/ft² (9.8 mm/min), whichever is higher, shall be permitted.

20.9.2.6

In-rack sprinklers for the protection of Class I through IV commodities shall not be required where high-expansion foam systems are used in combination with ceiling sprinklers.

20.9.2.7 Detectors for High-Expansion Foam Systems.

20.9.2.7.1

Detectors shall be listed and shall be installed in one of the following configurations:

- (1) At the ceiling only where installed at one-half the listed linear spacing [e.g., 15 ft × 15 ft (4.6 m × 4.6 m) rather than at 30 ft × 30 ft (9.1 m × 9.1 m)]; at the ceiling at the listed spacing and in racks at alternate levels
- (2) Where listed for rack storage installation and installed in accordance with the listing to provide response within 1 minute after ignition using an ignition source that is equivalent to that used in a rack storage testing program

20.9.2.7.2

Ceiling detectors alone shall not be used where the clearance to ceiling exceeds 10 ft (3.0 m) or the height of the storage exceeds 25 ft (7.6 m).

20.9.2.7.3

Detectors for preaction systems shall be installed in accordance with 20.9.2.7.

20.10* Adjacent Hazards or Design Methods.

20.10.1

For buildings with two or more adjacent hazards or design methods, the following shall apply:

(1) Where areas are not physically separated by a barrier or partition capable of delaying heat from a fire in one area from fusing sprinklers in the adjacent area, the required sprinkler protection for the more demanding design basis shall extend 15 ft (4.6 m) beyond its perimeter.

(2) The requirements of 20.10.1(1) shall not apply where the areas are separated by a draft curtain or barrier located above an aisle, horizontally a minimum of 2 ft (600 mm) from the adjacent hazard on each side, or a partition that is capable of delaying heat from a fire in one area from fusing sprinklers in the adjacent area.

(3) The requirements of 20.10.1(1) shall not apply to the extension of more demanding criteria from an upper ceiling level to beneath a lower ceiling level where the difference in height between the ceiling levels is at least 2 ft (600 mm), located above an aisle, horizontally a minimum 2 ft (600 mm) from the adjacent hazard on each side.

20.10.2*

Protection criteria for Group A plastics shall be permitted for the protection of the same storage height and configuration of Class I, II, III, and IV commodities.

20.10.3

CMSA and ESFR sprinklers shall be permitted to protect storage of Class I through Class IV commodities, Group A plastic commodities, miscellaneous storage, and other storage as specified in Chapter 12 through Chapter 20 or by other NFPA standards.

20.10.4 Systems with Multiple Hazard Classifications.

For systems with multiple hazard classifications, the hose stream allowance and water supply duration shall be in accordance with Section 20.12.2 as well as one of the following:

(1) The water supply requirements for the highest hazard classification within the system shall be used.

(2) The water supply requirements for each individual hazard classification shall be used in the calculations for the design area for that hazard.

(3) *For systems with multiple hazard classifications where the higher classification only lies within single rooms less than or equal to 400 ft² (37.2 m²) in area with no such rooms adjacent, the water supply requirements for the principal occupancy shall be used for the remainder of the system.

20.11* Hose Connections.

20.11.1 Small [1½ in. (40 mm)] Hose Connections.

See Section C.5.

20.11.1.1 Hose Connection.

Small hose connections [1½ in. (38 mm)] shall be provided where required by the authority having jurisdiction in accordance with Section 16.15 for first-aid, fire-fighting, and overhaul operations.

20.11.1.2

Small hose connections shall not be required for the protection of Class I, II, III, and IV commodities stored 12 ft (3.7 m) or less in height.

20.12 Hose Stream Allowance and Water Supply Duration.

20.12.1

Hose stream allowance and water supply duration for Chapters 20 through 25 shall be in accordance with Section 20.12.

20.12.2 Hose Stream Allowance and Water Supply Duration.

20.12.2.1*

Tanks shall be sized to supply the equipment that they serve.

20.12.2.2*

Pumps shall be sized to supply the equipment that they serve.

20.12.2.3

Water allowance for outside hose shall be added to the sprinkler requirement at the connection to the city main or a yard hydrant, whichever is closer to the system riser.

20.12.2.4

Where inside hose connections are planned or are required, the following shall apply:

- (1) A total water allowance of 50 gpm (190 L/min) for a single hose connection installation shall be added to the sprinkler requirements.
- (2) A total water allowance of 100 gpm (380 L/min) for a multiple hose connection installation shall be added to the sprinkler requirements.
- (3) The water allowance shall be added in 50 gpm (190 L/min) increments beginning at the most remote hose connection, with each increment added at the pressure required by the sprinkler system design at that point.

20.12.2.5

When hose valves for fire department use are attached to wet pipe sprinkler system risers in accordance with 16.15.2, the following shall apply:

- (1) The water supply shall not be required to be added to standpipe demand as determined from NFPA 14.
- (2) Where the combined sprinkler system demand and hose stream allowance of Chapter 12 and Chapters 14 through 20 exceeds the requirements of NFPA 14, this higher demand shall be used.
- (3) For partially sprinklered buildings, the sprinkler demand, not including hose stream allowance, as indicated in Chapter 12 and Chapters 14 through 20 shall be added to the requirements given in NFPA 14.

20.12.2.6

Unless indicated otherwise, the minimum water supply requirements for a hydraulically designed sprinkler system shall be determined by adding the hose stream allowance from Table 20.12.2.6 to the water demand for sprinklers.

Table 20.12.2.6 Hose Stream Allowance and Water Supply Duration

Commodity	Sprinkler Type	Sprinkler Spacing Type	Number of Ceiling Sprinklers in Design Area ^a	Size of Design Area at Ceiling	Hose Stream Allowance		Water Supply Duration (minutes)
					gpm	L/min	
Class I-IV Commodities, Group A plastics, idle wood pallets, idle plastic pallets and miscellaneous storage	Control mode density/area (CMDA)	Standard and extended-coverage	NA	Up to 1200 ft ² (110 m ²)	250	950	60
				Over 1200 ft ² (111 m ²) to 1500 ft ² (140 m ²)	500	1900	90
				Over 1500 ft ² (139 m ²) to 2600 ft ² (240 m ²)	500	1900	120
				Over 2600 ft ² (240 m ²)	500	1900	150
		Standard	Up to 12	NA	250	950	60

Commodity	Sprinkler Type	Sprinkler Spacing Type	Number of Ceiling Sprinklers in Design Area ^a	Size of Design Area at Ceiling	Hose Stream Allowance		Water Supply Duration (minutes)
					gpm	L/min	
	Control Mode Specific Application (CMSA)	Extended-coverage	Over 12 to 15	NA	500	1900	90
			Over 15 to 25	NA	500	1900	120
			Over 25	NA	500	1900	150
			Up to 6	NA	250	950	60
			Up to 8 ^b	NA	250	950	60
			Over 6 to 8	NA	500	1900	90
			Over 8 to 12	NA	500	1900	120
			Over 12	NA	500	1900	150
			Up to 12	NA	250	950	60
		Standard	Over 12 to 15	NA	500	1900	90
			Over 15 to 25	NA	500	1900	120
			Over 25	NA	500	1900	150
On-floor rubber tire storage up to 5 ft (1.5 m) in height	CMDA & CMSA	Standard and extended-coverage	Any	Any	250	950	120
Rubber tire storage	CMDA	Standard and extended-coverage	NA	Up to 5000 ft ² (372 m ²)	750	2850	180
	CMSA	Standard	Up to 15	NA	500	1900	180
	ESFR	Standard	Up to 12	NA	250	950	60
			Over 12 to 20	NA	500	1900	120 ^c
Roll paper	CMDA	Standard	NA	Up to 4000 ft ² (372 m ²)	500	1900	120
	CMSA	Standard	Up to 25	NA	500	1900	120
	ESFR	Standard	Up to 12	NA	250	950	120
Alternative Protection per 16.1.2.4 or 17.1.2.9	NA	NA	NA	NA	500	1900	120

NA: Not applicable.

^aFor CSMA and ESFR sprinklers, the additional sprinklers included in the design area for obstructions do not need to be considered in determining the total number of sprinklers in this column.

^bLimited to a maximum of 144 ft² (13.4 m²) per sprinkler.

^cFor storage on-tread, on-side, and laced tires in open portable steel racks or palletized portable racks, with pile height up to 25 ft (7.6 m) and building height up to 30 ft (9.1 m) with K-14.0 (K-200) or K16.8 (K-240) ESFR sprinklers, the water supply duration is 180 minutes.

20.12.2.7

For the protection of baled cotton, the total water supply available shall be sufficient to provide the recommended sprinkler discharge density over the area to be protected, plus a minimum of 500 gpm (1900 L/min) for hose streams.

20.12.2.7.1

Water supplies shall be capable of supplying the total demand for sprinklers and hose streams for not less than 2 hours.

20.12.3

The minimum water supply requirements shall be determined by adding the hose stream allowance from Section 20.12.2 to the water supply for sprinklers as determined by Chapter 12 through Chapter 20.

20.12.4

The minimum water supply requirements determined from 20.12.3 shall be available for the minimum duration specified in Section 20.12.2.

20.12.5

Total system water supply requirements shall be determined in accordance with the hydraulic calculation procedures of Chapter 23.

20.13 Discharge Considerations: General.

20.13.1 Multiple Adjustments.

20.13.1.1

Where multiple adjustments to the area of operation are required to be made, these adjustments shall be compounded based on the area of operation originally selected.

20.13.1.2

If the building has unsprinklered combustibles concealed spaces, the rules of Section 20.7 shall be applied after all other modifications have been made.

20.13.2* Wet Pipe Systems.

20.13.2.1

Sprinkler systems shall be wet pipe systems.

20.13.2.2*

In areas that are subject to freezing or where special conditions exist, dry pipe systems and preaction systems shall be permitted to protect storage occupancies.

20.13.3 Dry Pipe and Preaction Systems.

For dry pipe systems and preaction systems using control mode density/area (CMDA) criteria, the area of sprinkler operation shall be increased by 30 percent without revising the density.

20.14* Protection of Idle Pallets.

20.14.1 Wood Pallets.

20.14.1.1*

Wood pallets shall be permitted to be stored in the following arrangements:

- (1) Stored outside

- (2) Stored in a detached structure
- (3) Stored indoors where arranged and protected in accordance with 20.14.1.2

20.14.1.2

Wood pallets, where stored indoors, shall be protected in accordance with one of the following:

- (1) Control mode density/area sprinkler protection as specified in Table 20.14.1.2(a).
- (2) CMSA sprinkler protection in accordance with Table 20.14.1.2(b).
- (3) ESFR sprinkler protection in accordance with Table 20.14.1.2(c).
- (4) Control mode density/area sprinkler protection in accordance with the OH2 curve of Figure 13.2.1 existing with a hose stream demand of at least 250 gpm (950 L/min) for a duration of at least 60 minutes when pallets are stored no higher than 6 ft (1.8 m) and each pile of no more than four stacks is separated from other pallet piles by at least 8 ft (2.4 m) of clear space or 25 ft (7.6 m) of commodity. The maximum clearance to ceiling of 20 ft (6.1 m) specified in 20.6.4 shall not apply to arrangement 20.14.1.2(4).

Table 20.14.1.2(a) Control Mode Density/Area Sprinkler Protection for Indoor Storage of Idle Wood Pallets

Type of Sprinkler	Location of Storage	Nominal K-Factor	Maximum Storage Height		Maximum Ceiling/Roof Height		Sprinkler Density		Areas of Operation	
			ft	m	ft	m	gpm/ft ²	mm/min	ft ²	m ²
Control mode density/area	On floor	8 (115) or larger	Up to 6	Up to 1.8	20	6.1	0.20	8.1	3000*	280*
	On floor	11.2 (160) or larger	Up to 8	Up to 2.4	30	9.1	0.45	18.3	2500	230
	On floor or rack without solid shelves	11.2 (160) or larger	8 to 12	2.4 to 3.7	30	9.1	0.6	24.4	3500	325
			12 to 20	3.7 to 6.1	30	9.1	0.6	24.4	4500	420
	On floor	16.8 (240) or larger	Up to 20	Up to 6.1	30	9.1	0.6	24.4	2000	185

*The area of sprinkler operation should be permitted to be reduced to 2000 ft² (186 m²) when sprinklers having a nominal K-factor of 11.2 or larger are used or if high temperature-rated sprinklers with a nominal K-factor of 8.0 are used.

Table 20.14.1.2(b) CMSA Sprinkler Protection for Indoor Storage of Idle Wood Pallets

Storage Arrangement	Commodity Class	Maximum Storage Height		Maximum Ceiling/Roof Height		K-Factor/ Orientation	Type of System	Number of Design Sprinklers	Minimum Operating Pressure	
		ft	m	ft	m				psi	bar
On floor	Idle wood pallets	20	6.1	30	9.1	11.2 (160) Upright	Wet	15	25	1.7
							Dry	25	25	1.7
						16.8 (240) Upright	Wet	15	15	1.0
							Dry	25	15	1.0

Storage Arrangement	Commodity Class	Maximum Storage Height		Maximum Ceiling/Roof Height		K-Factor/ Orientation	Type of System	Number of Design Sprinklers	Minimum Operating Pressure	
		ft	m	ft	m				psi	bar
						19.6 (280) Pendent	Wet	15	16	1.1
				35	11	19.6 (280) Pendent	Wet	15	25	1.7
				40	12	19.6 (280) Pendent	Wet	15	30	2.1

Table 20.14.1.2(c) ESFR Sprinkler Protection for Indoor Storage of Idle Wood Pallets

Type of Sprinkler (Orientation)	Location of Storage	Nominal K-Factor	Maximum Storage Height		Maximum Ceiling/ Roof Height		Minimum Operating Pressure	
			ft	m	ft	m	psi	bar
ESFR (pendent)	On floor or rack without solid shelves	14.0 (200)	25	7.6	30	9.1	50	3.4
			25	7.6	32	10	60	4.1
		16.8 (240)	25	7.6	30	9.1	35	2.4
			25	7.6	32	10	42	2.9
			35	11	40	12	52	3.6
		22.4 (320)	25	7.6	30	9.1	25	1.7
			30	9.1	35	11	35	2.4
			35	11	40	12	40	2.7
		25.2 (360)	25	7.6	30	9.1	15	1.0
			30	9.1	35	11	20	1.4
			35	11	40	12	25	1.7
ESFR (upright)	On floor	14.0 (200)	20	6.1	30	9.1	50	3.4
			20	6.1	35	11	75	5.2
		16.8 (240)	20	6.1	30	9.1	35	2.4
			20	6.1	35	11	52	3.6

20.14.1.2.1

The maximum clearance to ceiling of 20 ft (6.1 m) specified in 20.6.4 shall not apply to arrangement 20.14.1.2(4).

20.14.1.3

Idle wood pallets shall not be stored in racks unless they are protected in accordance with the appropriate requirements of Table 20.14.1.2(a) or Table 20.14.1.2(c). (See *Section C.7.*)

20.14.2 Plastic Pallets.

20.14.2.1

Plastic pallets shall be permitted to be stored in the following manner:

- (1) Plastic pallets shall be permitted to be stored outside.
- (2) Plastic pallets shall be permitted to be stored in a detached structure.
- (3) Plastic pallets shall be permitted to be stored indoors where arranged and protected in accordance with the requirements of 20.14.2.2.

20.14.2.2 Protection Criteria for Plastic Pallets Stored Indoors.

20.14.2.2.1

Plastic pallets having a demonstrated fire hazard that is equal to or less than idle wood pallets and is listed for such equivalency shall be permitted to be protected in accordance with 20.14.1.

20.14.2.2.2

When specific test data are available, the data shall take precedence in determining the required protection of idle plastic pallets.

20.14.2.2.3

Protection with ESFR sprinklers shall be in accordance with the requirements of Table 20.14.2.2.3.

Table 20.14.2.2.3 ESFR Sprinkler Protection for Indoor Storage of Idle Plastic Pallets

Type of Sprinkler (Orientation)	Location of Storage	Nominal K-Factor	Maximum Storage Height		Maximum Ceiling/Roof Height		Minimum Operating Pressure	
			ft	m	ft	m	psi	bar
ESFR (pendent)	On floor or rack without solid shelves	14.0	25	7.6	30	9.1	50	3.4
			25	7.6	32	10	60	4.1
		(200)	25	7.6	30	9.1	35	2.4
		16.8	25	7.6	32	10	42	2.9
		(240)	35	11	40	12	52	3.6

20.14.2.2.4

Protection with spray sprinklers shall be in accordance with one of the scenarios in 20.14.2.2.4.1 through 20.14.2.2.4.3.

20.14.2.2.4.1

Where plastic pallets are stored in cutoff rooms, the following shall apply:

- (1) The cutoff rooms shall have at least one exterior wall.
- (2) The plastic pallet storage shall be separated from the remainder of the building by 3 hour-rated fire walls.
- (3) The storage shall be protected by sprinklers designed to deliver 0.6 gpm/ft² (24.4 mm/min) for the entire room or by high-expansion foam and sprinklers designed to deliver 0.3 gpm/ft² (12.2 mm/min) for the entire room.
- (4) The storage shall be piled no higher than 12 ft (3.7 m).
- (5) Any steel columns shall be protected by 1-hour fireproofing or a sidewall sprinkler directed to one side of the column at the top or at the 15 ft (4.6 m) level, whichever is lower. Flow from these sprinklers shall be permitted to be omitted from the sprinkler system demand for hydraulic calculations.

20.14.2.2.4.2

Where plastic pallets are stored without cutoffs from other storage, the following shall apply:

- (1) Maximum storage height of 10 ft (3.0 m)
- (2) Maximum ceiling height of 30 ft (9.1 m)

(3) Sprinkler density 0.6 gpm/ft² over 2000 ft² (24.4 mm/min over 186 m²)

(4) Minimum sprinkler K-factor of 16.8 (240)

20.14.2.2.4.3

Plastic pallets shall have no impact on the required sprinkler protection when stored as follows:

(1) Storage shall be piled no higher than 4 ft (1.2 m).

(2) Sprinkler protection shall employ high temperature-rated sprinklers.

(3) Each pallet pile of no more than two stacks shall be separated from other pallet piles by at least 8 ft (2.4 m) of clear space or 25 ft (7.6 m) of stored commodity.

(4) Minimum ceiling design of OH2 shall be used.

20.14.2.3

Idle plastic pallets shall be stored only in racks where protected in accordance with the requirements of Table 20.14.2.2.3.

20.14.2.3.1

When specific test data and a product listing are available, the data shall take precedence in determining the required protection of idle plastic pallets stored in racks.

20.14.3 Idle Pallets Stored on Racks, on Shelves, and Above Doors.

20.14.3.1

Idle pallets shall not be stored on racks or shelves, except where permitted in 20.14.1.3, 20.14.2.3, and 20.14.3.2.

20.14.3.2

Idle pallets shall be permitted to be stored on the lowest level of storage only where no storage or shelves are located above the stored pallets and the applicable protection criteria referenced for on-floor storage in Section 20.14 are applied.

20.14.3.3

Where idle pallet storage is above a door, the idle pallet storage height and ceiling height shall be calculated from the base of storage above the door using the applicable protection criteria referenced in Section 20.14.

20.15 Column Protection: Rack Storage and Rubber Tire Storage.

20.15.1*

Where fireproofing of building columns is not provided and storage heights are in excess of 15 ft (4.6 m), protection of building columns located wholly or partially within the rack footprint inclusive of flue spaces or within 12 in. (300 mm) of the footprint shall be protected in accordance with one of the following:

(1) In-rack sprinklers

(2) Sidewall sprinklers at the 15 ft (4.6 m) elevation, pointed toward one side of the steel column

(3) Provision of ceiling sprinkler density for a minimum of 2000 ft² (186 m²) with ordinary 165°F (74°C) or high-temperature 286°F (140°C) rated sprinklers as shown in Table 20.15.1 for storage heights above 15 ft (4.6 m), up to and including 20 ft (6.1 m)

(4) Provision of CMSA or ESFR ceiling sprinkler protection

Table 20.15.1 Ceiling Sprinkler Densities for Protection of Steel Building Columns

Commodity Classification	Aisle Width			
	4 ft (1.2 m)		8 ft (2.4 m)	
	gpm/ft ²	(L/min)/m ²	gpm/ft ²	(L/min)/m ²
Class I	0.37	15.1	0.33	13.4
Class II	0.44	17.9	0.37	15.1
Class III	0.49	20.0	0.42	17.1
Class IV	0.68	27.7	0.57	23.2

20.15.1.1

Where storage heights are in excess of 15 ft (4.6 m) and vertical rack members support the building structure, the vertical rack members shall be protected in accordance with one of the options in 20.15.1.

20.15.1.2

The flow from a column sprinkler(s) shall be permitted to be omitted from the sprinkler system hydraulic calculations.

20.15.2 Columns Within Rubber Tire Storage.

20.15.2.1

Where fireproofing is not provided, steel columns shall be protected as follows:

(1) Storage exceeding 15 ft through 20 ft (4.6 m through 6.1 m) in height — one sidewall sprinkler directed to one side of the column at a 15 ft (4.6 m) level

(2) Storage exceeding 20 ft (6.1 m) in height — two sidewall sprinklers, one at the top of the column and the other at a 15 ft (4.6 m) level, both directed to the side of the column

20.15.2.2

The flow from a column sprinkler(s) shall be permitted to be omitted from the sprinkler system hydraulic calculations.

20.15.2.3

The protection specified in 20.15.2.1(1) and 20.15.2.1(2) shall not be required where storage in fixed racks is protected by in-rack sprinklers.

20.15.2.4

The protection specified in 20.15.2.1 shall not be required where ESFR or CMSA sprinkler systems that are approved for rubber tire storage are installed.

20.15.2.5

The rate of water supply shall be sufficient to provide the required sprinkler discharge density over the required area of application plus provision for generation of high-expansion foam and in-rack sprinklers where used.

20.16 Alternative Protection Scheme A.

Class I, II, III, IV commodities requiring a greater level of protection than is available from the overhead sprinkler system shall be permitted to be protected in accordance with 20.16.1.1 through 20.16.1.7.

20.16.1

Class I, II, III, IV, and Group A plastic commodities requiring a greater level of protection than is available from the overhead sprinkler system shall be permitted to be protected in accordance with 20.16.1.1 through 20.16.1.7.

20.16.1.1

Where the storage rack will not be solely dedicated to the storage of commodities requiring a greater level of protection than is available from the overhead sprinkler system, either of the following shall apply:

(1) Extend the protection prescribed by Section 20.16 horizontally one pallet load in all directions beyond the commodity storage area requiring the higher level of protection.

(2) Install a vertical barrier to segregate the commodities requiring the higher level of protection from any adjacent commodities.

20.16.1.2

Commodities that can be protected by the ceiling-level sprinkler system shall be permitted to be stored vertically above and horizontally adjacent to the portions of the storage rack equipped as prescribed by Section 20.16.

20.16.1.3 Horizontal Barriers.

Horizontal barriers shall be installed at every tier level of the dedicated storage rack where the rack is equipped with solid shelves.

20.16.1.3.1

Where the dedicated storage rack is open-frame, horizontal barriers shall be installed at vertical increments not exceeding 12 ft (3.6 m).

20.16.1.3.2

The barriers shall span horizontally so that all flue spaces within the rack bay are covered.

20.16.1.3.3

A maximum 3 in. (75 mm) wide gap shall be permitted at rack uprights.

20.16.1.3.4

The solid barrier shall be installed on a horizontal plane within a rack, beneath which in-rack sprinklers shall be installed, as follows:

(1) The barrier shall be constructed of minimum 22 gauge (0.7 mm) sheet metal or of minimum 3/8 in. (10 mm) plywood.

(2) The barrier shall extend to both aisle faces of the racks, covering up both the longitudinal and the transverse flue spaces of the rack bays in which they are installed.

(3) The barrier shall be fitted to within 3 in. (75 mm) of any vertical rack member or other equipment that would create an opening, such as vertical in-rack sprinkler pipe drops.

20.16.1.4 In-Rack Sprinklers.

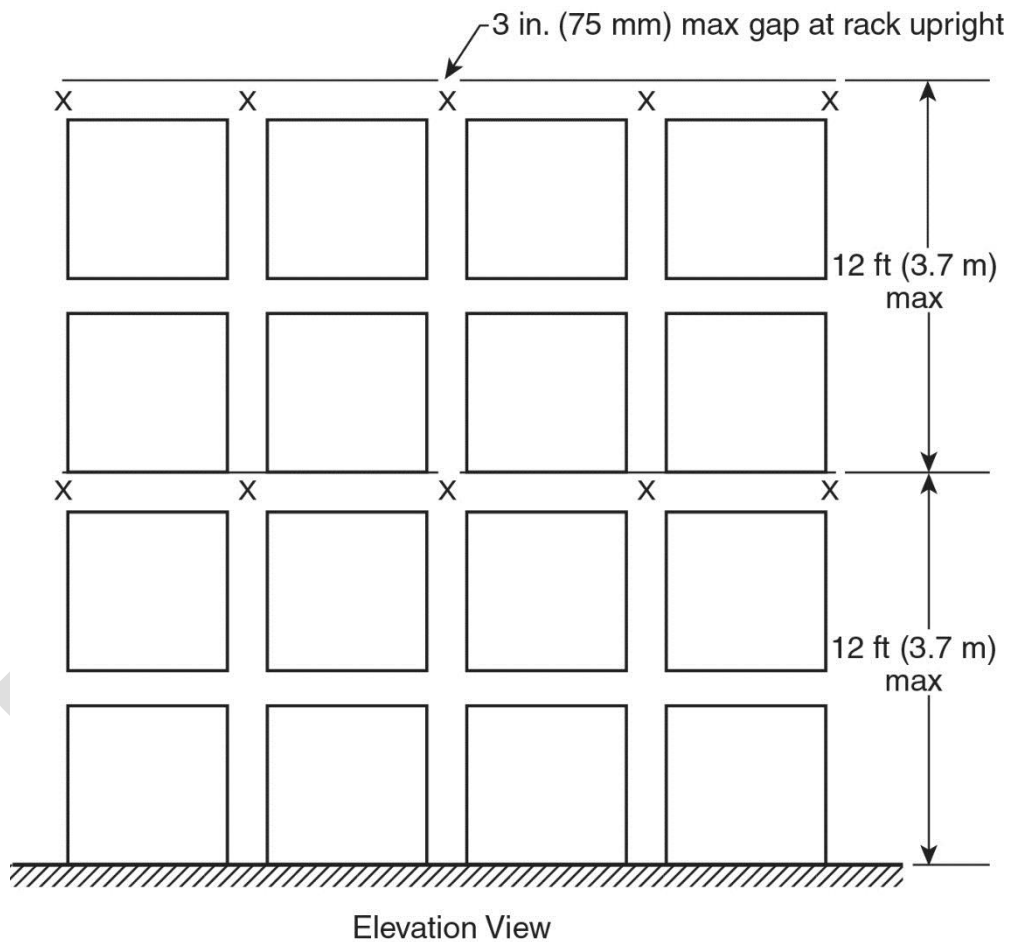
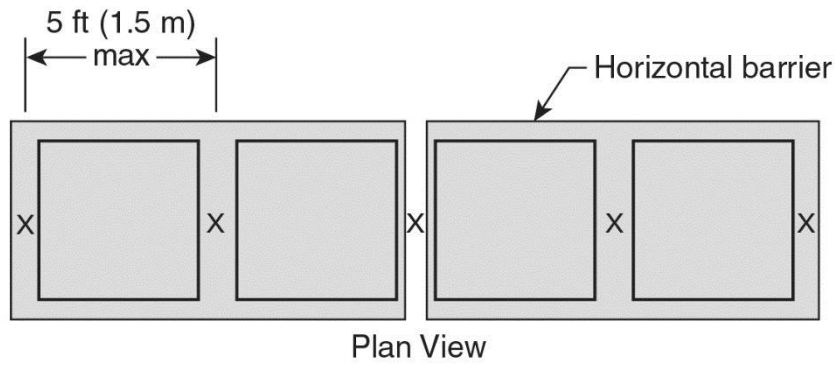
Minimum K-8.0 (K-115) quick-response sprinklers (ceiling-level or in-rack) shall be installed beneath each horizontal barrier. The deflector of the sprinkler shall be located as close to the underside of the horizontal barrier as possible.

20.16.1.4.1 Single-Row Racks.

(A)

For single-row racks, sprinklers shall be installed at each rack upright and at each rack mid-bay as shown in Figure 20.16.1.4.1(A).

Figure 20.16.1.4.1(A) Alternative Protection for Single-Row Racks.



(B)

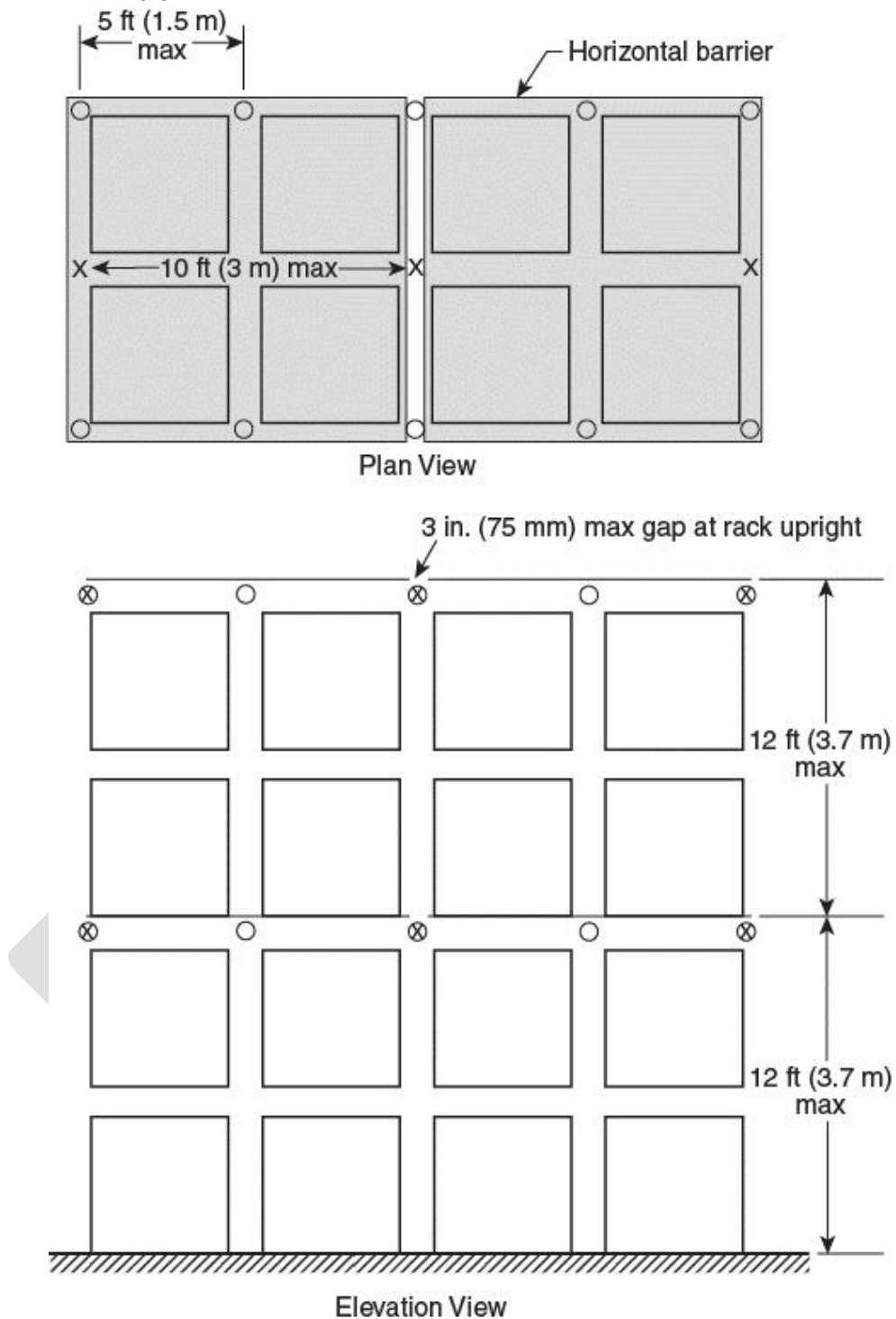
The maximum linear spacing between sprinklers shall not exceed 5 ft (1.5 m).

20.16.1.4.2 Double-Row Racks.

(A)

For double-row racks, sprinklers shall be installed at each rack upright within the longitudinal flue space and at the face of the rack and at the mid-bay face of each rack bay as shown in Figure 20.16.1.4.2(A).

Figure 20.16.1.4.2(A) Alternative Protection for Double-Row Racks.



(B)

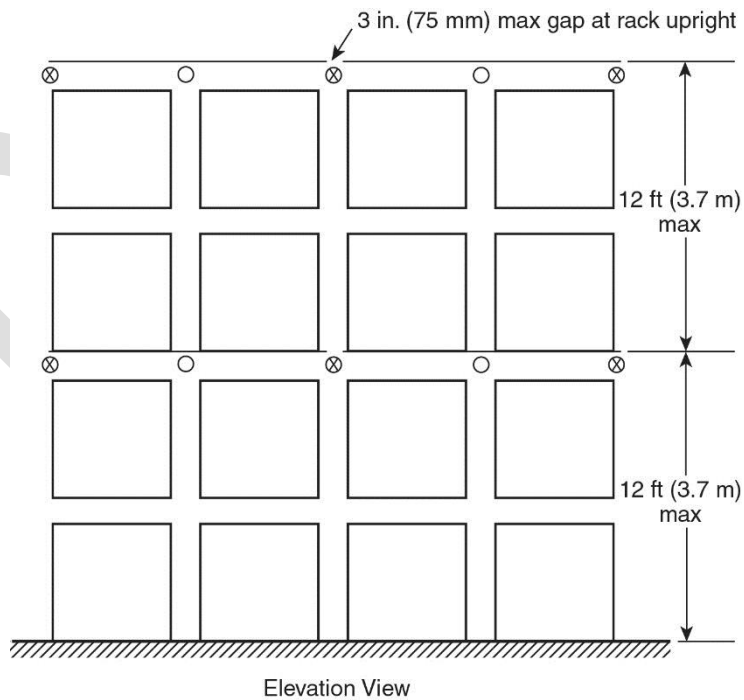
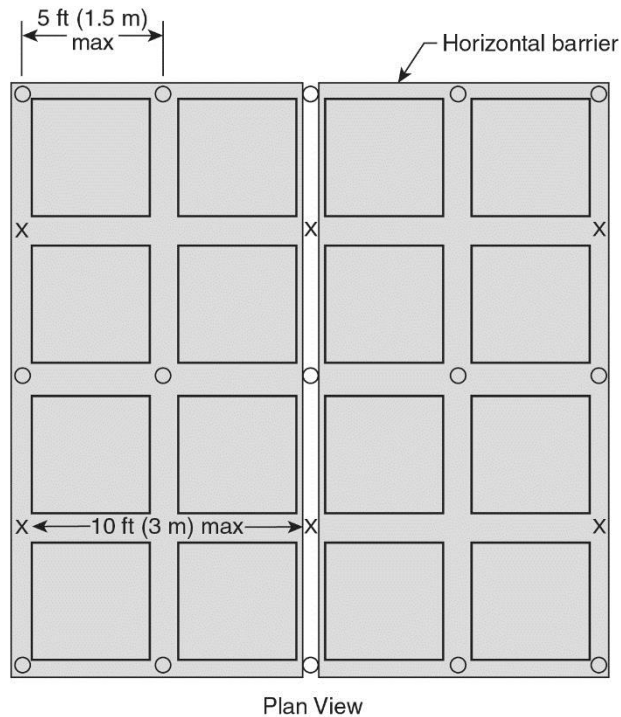
The maximum linear spacing between sprinklers shall not exceed 5 ft (1.5 m) at the rack face and 10 ft (3.0 m) within the longitudinal flue space.

20.16.1.4.3 Multiple-Row Racks.

(A)

For multiple-row racks, an alternating sprinkler arrangement shall be installed within adjacent transverse flue spaces as shown in Figure 20.16.1.4.3(A), with sprinklers at the face of each flue space.

Figure 20.16.1.4.3(A) Alternative Protection for Multiple-Row Racks.



(B)

The maximum linear spacing between sprinklers at the face and at each alternating bay shall not exceed 5 ft (1.5 m) and shall not exceed 10 ft (3.0 m) between sprinklers at every other bay.

20.16.1.5

The design of an in-rack sprinkler system shall be based on a minimum flow of 60 gpm (230 L/min) from the most remote six sprinklers for single-row racks or the most remote eight sprinklers for both double-row and multiple-row racks.

20.16.1.6

The in-rack sprinkler demand shall not be required to be hydraulically balanced with the ceiling-level sprinkler system.

20.16.1.7 Ceiling Sprinkler System.

The ceiling-level sprinkler system shall be designed based on the highest commodity hazard not protected by the criteria prescribed by 20.16.

Chapter 21 Protection of High Piled Storage Using Control Mode Density Area (CMDA) Sprinklers

21.1 General.

21.1.1

The criteria in Chapter 20 shall apply to storage protected with CMDA sprinklers.

21.1.2*

For storage applications with densities of 0.2 gpm/ft² (8.1 mm/min) or less, standard-response sprinklers with a K-factor of K-5.6 (80) or larger shall be permitted.

21.1.3

For general storage applications, rack storage, rubber tire storage, roll paper storage, and baled cotton storage being protected with upright and pendent spray sprinklers with required densities of greater than 0.2 gpm/ft² to 0.34 gpm/ft² (8.1 mm/min to 13.9 mm/min), standard-response sprinklers with a nominal K-factor of K-8.0 (115) or larger shall be used.

21.1.4

For general storage applications, rack storage, rubber tire storage, roll paper storage, and baled cotton storage being protected with upright and pendent spray sprinklers with required densities greater than 0.34 gpm/ft² (13.9 mm/min), standard-response spray sprinklers with a K-factor of K-11.2 (161) or larger that are listed for storage applications shall be used.

21.1.5*

Unless the requirements of 21.1.6 are met, the requirements of 21.1.3 and 21.1.4 shall not apply to modifications to existing storage application systems, using sprinklers with K-factors of K-8.0 (115) or less.

21.1.6

Where applying the requirements of Figure 21.5.1(b) and Figure 21.5.1(c) utilizing the design criteria of 0.6 gpm/ft² per 2000 ft² (24.4 mm/min per 186 m²) to existing storage applications, the requirements of 21.1.4 shall apply.

21.1.7

The use of quick-response spray sprinklers for storage applications shall be permitted when listed for such use.

21.1.8

The design figures indicate water demands for ordinary-temperature-rated and nominal high-temperature-rated sprinklers at the ceiling.

21.1.8.1

The ordinary-temperature design densities correspond to ordinary-temperature-rated sprinklers and shall be used for sprinklers with ordinary- and intermediate-temperature classification.

21.1.8.2

The high-temperature design densities correspond to high-temperature-rated sprinklers and shall be used for sprinklers having a high-temperature rating.

21.1.9

Ordinary- and intermediate-temperature sprinklers with K-factors of K-11.2 (161) or larger, where listed for storage, shall be permitted to use the densities for high-temperature sprinklers.

21.1.10 Discharge Considerations.

21.1.10.1

The water supply for sprinklers only shall be determined either from the density/area requirements of Chapter 12 through Chapter 20 or shall be based upon the room design method in accordance with Section 20.8, at the discretion of the designer.

21.1.10.2

The calculations shall satisfy any single point on appropriate density/area curves.

21.1.10.3

When using the density/area method, the design area shall meet the requirements of 19.6.4.2.1.

21.1.10.4

The minimum design density shall be not less than 0.15 gpm/ft² (6.1 mm/min) after all adjustments are made.

21.2* Control Mode Density/Area Sprinkler Protection Criteria for Palletized, Solid-Piled, Bin Box, Shelf, or Back-to-Back Shelf Storage of Class I Through Class IV Commodities.

21.2.1

Protection for Class I through Class IV commodities in the following configurations shall be provided in accordance with this section:

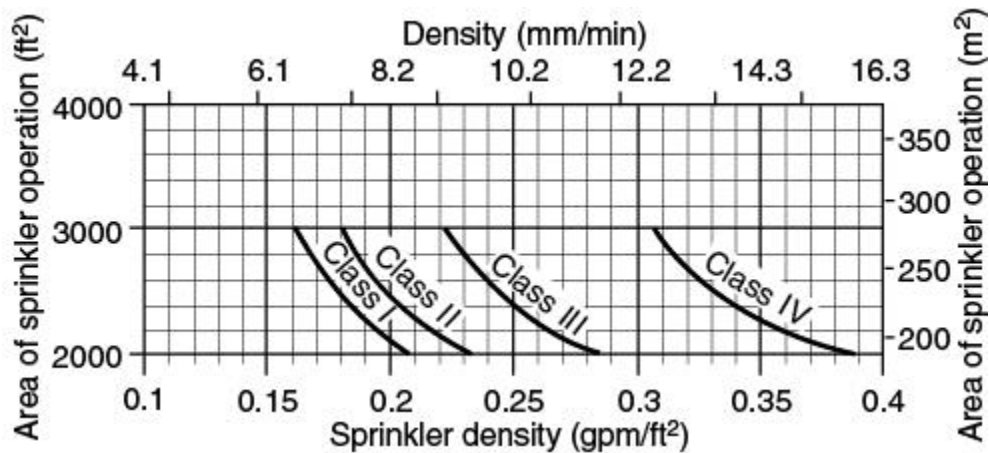
- (1) Nonencapsulated commodities that are solid-piled, palletized, or bin box storage up to 30 ft (9.1 m) in height
- (2) Nonencapsulated commodities on shelf storage up to 15 ft (4.6 m) in height
- (3) *Encapsulated commodities that are solid-piled, palletized, bin box, or shelf storage up to 15 ft (4.6 m) in height
- (4) Back-to-back shelf storage up to 15 ft (4.6 m) in height
- (5) Encapsulated storage of solid-piled and palletized Class I through IV commodities permitted in accordance with 21.2.3 for storage heights over 15 ft (4.6 m) up to and including 20 ft (6.1 m)

21.2.2 Protection Criteria for Palletized, Solid-Piled, Bin Box, Shelf, or Back-to-Back Shelf Storage of Class I Through Class IV Commodities Stored Over 12 ft (3.7 m) in Height.

21.2.2.1

Where using ordinary temperature-rated sprinklers, a single point shall be selected from the appropriate commodity curve on Figure 21.2.2.1.

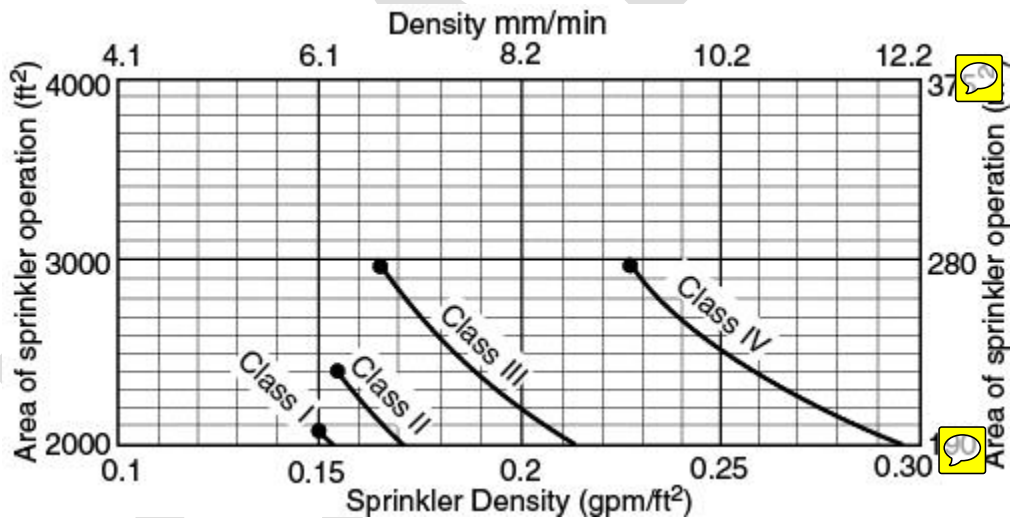
Figure 21.2.2.1 Sprinkler System Design Curves for 20 ft (6.1 m) High Storage — Ordinary Temperature–Rated Sprinklers.



21.2.2.2

Where using high temperature–rated sprinklers, a single point shall be selected from the appropriate commodity curve on Figure 21.2.2.2.

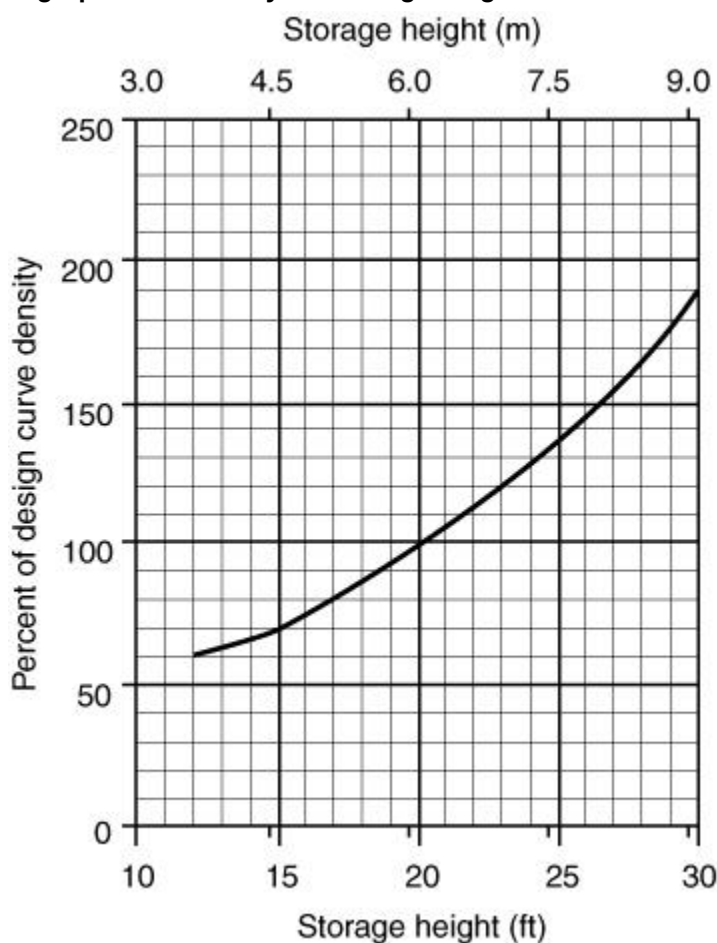
Figure 21.2.2.2 Sprinkler System Design Curves for 20 ft (6.1 m) High Storage — High Temperature–Rated Sprinklers.



21.2.2.3

The densities selected in accordance with 21.2.2.1 or 21.2.2.2 shall be modified in accordance with Figure 21.2.2.3 without revising the design area.

Figure 21.2.2.3 Ceiling Sprinkler Density vs. Storage Height.



21.2.2.4

In the case of metal bin boxes with face areas not exceeding 16 ft² (1.5 m²) and metal closed shelves with face areas not exceeding 16 ft² (1.5 m²), the area of application shall be permitted to be reduced by 33 percent, provided the minimum requirements of 21.2.2.5 and 21.2.2.6 are met.

21.2.2.5

For storage greater than 12 ft (3.7 m), the design density shall not be less than 0.15 gpm/ft² (6.1 mm/min), and the design area shall not be less than 2000 ft² (186 m²) for wet systems or 2600 ft² (242 m²) for dry systems for any commodity, class, or group.

21.2.2.6

For storage greater than 12 ft (3.7 m), the sprinkler design density for any given area of operation for a Class III or Class IV commodity, calculated in accordance with 21.2.2, shall not be less than the density for the corresponding area of operation for ordinary hazard Group 2.

21.2.2.7

For back-to-back shelf storage, the design density shall be taken from Figure 21.2.2.1 for storage greater than 12 ft (3.7 m) and up to 15 ft (4.6 m) with no reduction for design density referenced in Figure 21.2.2.3.

21.2.3 Encapsulated Storage Over 15 ft (4.6 m) in Height Up to and Including 20 ft (6.1 m) in Height.

21.2.3.1

Encapsulated storage over 15 ft (4.6 m) in height up to and including 20 ft (6.1 m) in height shall be limited to solid-piled and palletized storage.

21.2.3.2

Encapsulated storage over 15 ft (4.6 m) in height up to and including 20 ft (6.1 m) in height shall be protected by sprinklers with a K-factor of 11.2 (160) or larger.

21.2.3.3

Encapsulated storage over 15 ft (4.6 m) in height up to and including 20 ft (6.1 m) in height of Class I commodity shall be protected with a density/area of at least 0.46 gpm/ft² over 2000 ft² (18.7 mm/min over 186 m²).

21.2.3.4

Encapsulated storage over 15 ft (4.6 m) in height up to and including 20 ft (6.1 m) in height of Class II commodity shall be protected with a density/area of at least 0.53 gpm/ft² over 2000 ft² (21.6 mm/min over 186 m²).

21.2.3.5

Encapsulated storage over 15 ft (4.6 m) in height up to and including 20 ft (6.1 m) in height of Class III and Class IV commodity shall be protected with a density/area of at least 0.6 gpm/ft² over 2000 ft² (24.4 mm/min over 186 m²).

21.2.4 Special Design for Palletized, Solid-Piled, Bin Box, or Shelf Storage of Class I Through Class IV Commodities.

21.2.4.1 Bin Box and Shelf Storage.

21.2.4.1.1

Bin box and shelf storage that is over 12 ft (3.7 m) but not in excess of the height limits of 21.2.1 and that is provided with walkways at vertical intervals of not over 12 ft (3.7 m) shall be protected with automatic sprinklers under the walkway(s).

21.2.4.1.2

Protection shall be as follows:

- (1) Ceiling design density shall be based on the total height of storage within the building.
- (2) Automatic sprinklers under walkways shall be designed to maintain a minimum discharge pressure of 15 psi (1.0 bar) for the most hydraulically demanding six sprinklers on each level. Walkway sprinkler demand shall not be required to be added to the ceiling sprinkler demand. Sprinklers under walkways shall not be spaced more than 8 ft (2.4 m) apart horizontally.

21.3 Control Mode Density/Area Sprinkler Protection Criteria for Palletized, Solid-Piled, Bin Box, Shelf, or Back-to-Back Shelf Storage of Plastic and Rubber Commodities.

21.3.1

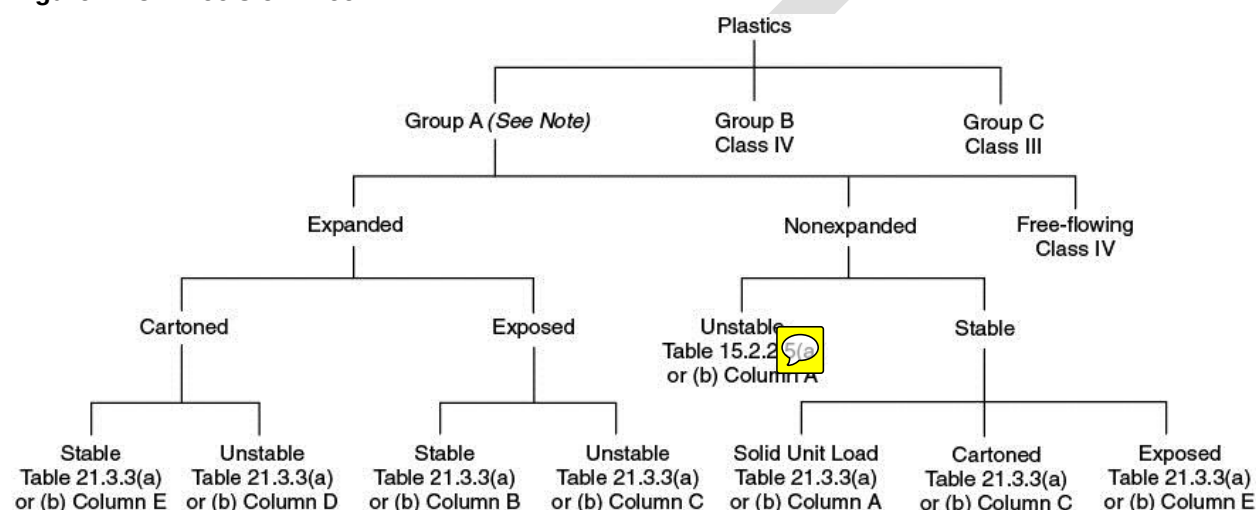
Protection for plastic and rubber commodities shall be in accordance with Section 21.3. The decision tree shown in Figure 21.3.1 shall be used to determine the protection in each specific situation, subject to the following limitations:

- (1) Commodities that are stored palletized, solid piled, or in bin boxes up to 25 ft (7.6 m) in height.
- (2) Commodities that are stored in shelf storage up to 15 ft (4.6 m) in height.
- (3) Commodities that are stored using back-to-back shelf storage up to 15 ft (4.6 m) in height. The minimum aisle width shall be 60 in. (1.5 m). The design criteria shall be in accordance with Table 21.3.1. The back-to-back shelf shall have a full height solid vertical transverse barrier of 3/8 in. (10 mm) plywood or particleboard, 22 gauge sheet metal, or equivalent, from face of aisle to face of aisle, spaced at a maximum 45 ft (14 m) interval. The transverse barrier shall be permitted to terminate at the longitudinal barrier.

Table 21.3.1 Back-to-Back Shelf Storage of Cartoned Nonexpanded Group A Plastics

Storage Height		Ceiling Height		Protection
ft	m	ft	m	
Over 5 up to 8	1.5/2.4	Up to 14	4.3	Ordinary Hazard Group 2
Up to 12	3.7	Up to 15	4.6	0.45 gpm/ft ² over 2500 ft ² 18.3 mm/min/232 m ²
Up to 12	3.7	Up to 30	9.1	0.6 gpm/ft ² over 2500 ft ² 24.4 mm/min/232 m ²
Up to 15	4.6	Up to 30	9.1	0.7 gpm/ft ² over 2500 ft ² 28.5 mm/min/232 m ²

Figure 21.3.1 Decision Tree.



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

- (1) There are multiple layers of corrugation or equivalent outer material that would significantly delay fire involvement of the Group A plastic.
- (2) The amount and arrangement of Group A plastic material within a carton with a single layer of corrugation would not be expected to significantly increase the fire hazard.

21.3.2*

Factors affecting protection requirements such as closed/open array, clearance to ceiling, and stable/unstable piles shall be applicable only to storage of Group A plastics. This decision tree also shall be used to determine protection for commodities that are not wholly Group A plastics but contain such quantities and arrangements of the same that they are deemed more hazardous than Class IV commodities.

21.3.3*

Design areas and densities for the appropriate storage configuration shall be selected from Table 21.3.3(a) or Table 21.3.3(b) as appropriate.

Table 21.3.3(a) Design Densities for Palletized, Solid-Piled, Bin Box, or Shelf Storage of Group A Plastic Commodities (U.S. Customary Units)

Maximum Storage Height (ft)	Roof/Ceiling Height (ft)	Density (gpm/ft ²)				
		A	B	C	D	E
>5 to ≤12	Up to 15	0.2	EH2	0.3	EH1	EH2

Maximum Storage Height (ft)	Roof/Ceiling Height (ft)	Density (gpm/ft ²)				
		A	B	C	D	E
	>15 to 20	0.3	0.6	0.5	EH2	EH2
	>20 to 32	0.4	0.8	0.6	0.45	0.7
15	Up to 20	0.3	0.6	0.5	0.4	0.45
	>20 to 25	0.4	0.8	0.6	0.45	0.7
	>25 to 35	0.45	0.9	0.7	0.55	0.85
20	Up to 25	0.4	0.8	0.6	0.45	0.7
	>25 to 30	0.45	0.9	0.7	0.55	0.85
	>30 to 35	0.6	1.2	0.85	0.7	1.1
25	Up to 30	0.45	0.9	0.7	0.55	0.85
	>30 to 35	0.6	1.2	0.85	0.7	1.1

Notes:

(1) Minimum clearance between sprinkler deflector and top of storage shall be maintained as required.

(2) Column designations correspond to the configuration of plastics storage as follows:

A: (1) Nonexpanded, unstable

(2) Nonexpanded, stable, solid unit load

B: Expanded, exposed, stable

C: (1) Expanded, exposed, unstable

(2) Nonexpanded, stable, cartoned

D: Expanded, cartoned, unstable

E: (1) Expanded, cartoned, stable

(2) Nonexpanded, stable, exposed

(3) EH1 = Density required by Figure 13.2.1 for Curve EH1

EH2 = Density required by Figure 13.2.1 for Curve EH2

(4) Roof/ceiling height >35 ft is not permitted.

Table 21.3.3(b) Design Densities for Palletized, Solid-Piled, Bin Box, or Shelf Storage of Group A Plastic Commodities (S.I. Units)

Maximum Storage Height (m)	Roof/Ceiling Height (m)	Density (mm/min)				
		A	B	C	D	E
>1.5 to ≤3.6	Up to 4.6	8.2	EH2	12.2	EH1	EH2
	>4.6 to 6.1	12.2	24.4	20.4	EH2	EH2
	>6.1 to 9.7	16.3	32.6	24.4	18.3	28.5
4.6	Up to 6.1	12.2	24.4	20.4	16.3	18.3
	>6.1 to 7.6	16.3	32.6	24.4	18.3	28.5
	>7.6 to 11	18.3	36.7	28.5	22.4	34.6

Maximum Storage Height (m)	Roof/Ceiling Height (m)	Density (mm/min)				
		A	B	C	D	E
6.1	Up to 7.6	16.3	32.6	24.4	18.3	28.5
	>7.6 to 9.1	18.3	36.7	28.5	22.4	34.6
	>9.1 to 11	24.4	48.9	34.6	28.5	44.8
7.6	Up to 9.1	18.3	36.7	28.5	22.4	34.6
	>9.1 to 11	24.4	48.9	34.6	28.5	44.8

Notes:

(1) Minimum clearance between sprinkler deflector and top of storage shall be maintained as required.

(2) Column designations correspond to the configuration of plastics storage as follows:

A: (1) Nonexpanded, unstable

(2) Nonexpanded, stable, solid unit load

B: Expanded, exposed, stable

C: (1) Expanded, exposed, unstable

(2) Nonexpanded, stable, cartoned

D: Expanded, cartoned, unstable

E: (1) Expanded, cartoned, stable

(2) Nonexpanded, stable, exposed

(3) EH1 = Density required by Figure 13.2.1 for Curve EH1

EH2 = Density required by Figure 13.2.1 for Curve EH2

(4) Roof/ceiling height >35 ft not permitted.

21.3.4

The ceiling-only protection criteria specified in Chapter 17 for rack storage of Group A plastic commodities shall be permitted to be used for solid-piled and palletized storage of the same commodity at the same height and clearance to ceiling.

21.3.5*

For Table 21.3.3(a) and Table 21.3.3(b), the design area shall be as follows:

(1) The area shall be a minimum of 2500 ft² (232 m²).

(2) Where Table 21.3.3(a) and Table 21.3.3(b) allow densities and areas to be selected in accordance with Curve EH1 and Curve EH2 of Figure 13.2.1, any density/area from the curves in Figure 13.2.1 shall be permitted. When selecting a point from the EH1 or EH2 density/area curves of Figure 13.2.1, the following area reductions shall be permitted:

(a) For K-8.0 (115) sprinklers used with Curve EH1, the design area shall be permitted to be reduced by 25 percent, but not below 2000 ft² (186 m²), where high temperature sprinklers are used.

(b) For K-11.2 (160) or larger sprinklers, the design area shall be permitted to be reduced by 25 percent, but not below 2000 ft² (186 m²), regardless of temperature rating.

(3) For closed arrays, the area shall be permitted to be reduced to 2000 ft² (186 m²).

21.3.6*

Interpolation of densities between storage heights shall be permitted.

21.3.6.1

Densities shall be based on the 2500 ft² (232 m²) design area.

21.3.6.2

Interpolation of ceiling/roof heights shall not be permitted.

21.3.7

For storage of Group A plastics between 5 ft (1.5 m) and 12 ft (3.7 m) in height, the installation requirements for extra hazard systems shall apply.

21.4 Control Mode Density/Area Sprinkler Protection Criteria for Rack Storage of Class I Through Class IV Commodities.

21.4.1 Protection Criteria for Rack Storage of Class I Through Class IV Commodities Stored Over 12 ft (3.7 m) Up to and Including 25 ft (7.6 m) in Height.

21.4.1.1*

Ceiling sprinkler water demand shall be determined in accordance with 21.4.1.2 for single- and double-row racks or 21.4.1.3 for multiple-row racks. (See Section C.14.)

21.4.1.2*

For single- or double-row racks for Class I, Class II, Class III, or Class IV commodities, encapsulated or nonencapsulated in single- or double-row racks, ceiling sprinkler water demand in terms of density [gpm/ft² (mm/min)] and area of sprinkler operation [ft² (m²) of ceiling or roof] shall be selected from the density/area curves of Figure 21.4.1.2(a) through Figure 21.4.1.2(e) that are appropriate for each commodity and configuration as shown in Table 21.4.1.2 and shall be modified as appropriate by 21.4.1.4. These requirements shall apply to portable racks arranged in the same manner as single- or double-row racks.

Figure 21.4.1.2(a) Sprinkler System Design Curves — 20 ft (6.1 m) High Rack Storage — Class I Nonencapsulated Commodities — Conventional Pallets

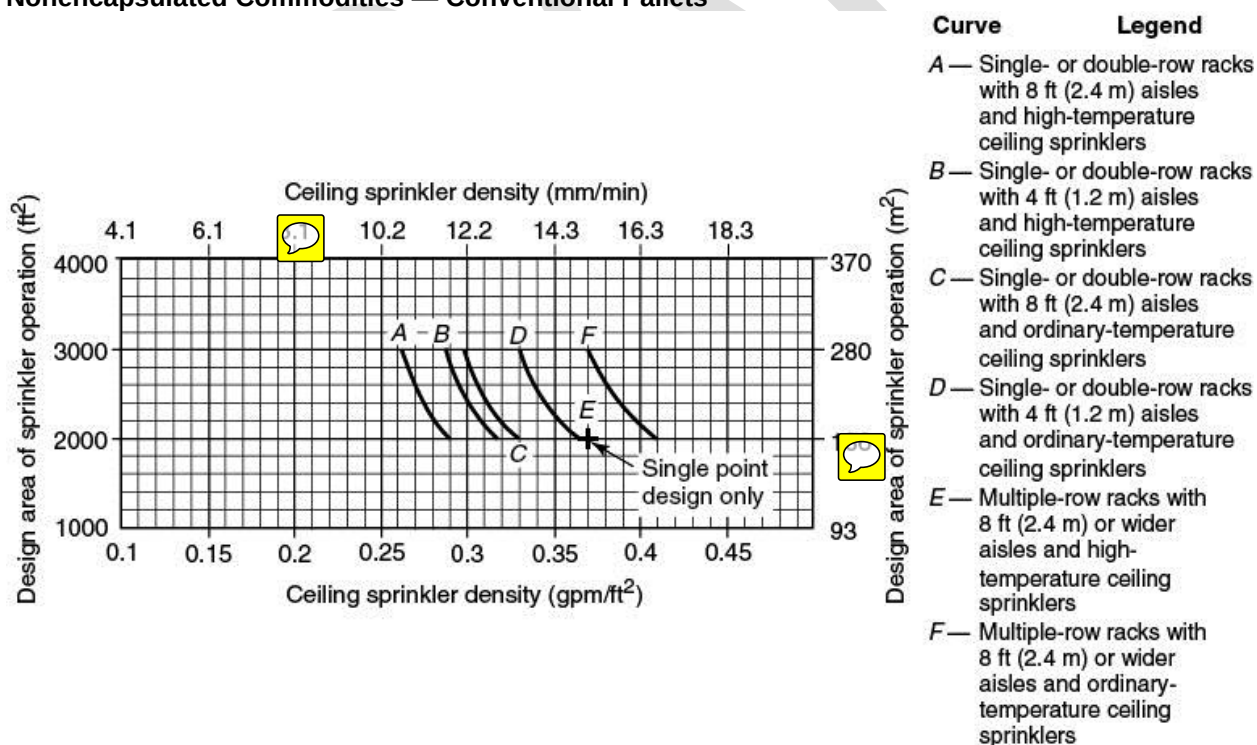


Figure 21.4.1.2(b) Sprinkler System Design Curves — 20 ft (6.1 m) High Rack Storage — Class II Nonencapsulated Commodities — Conventional Pallets.

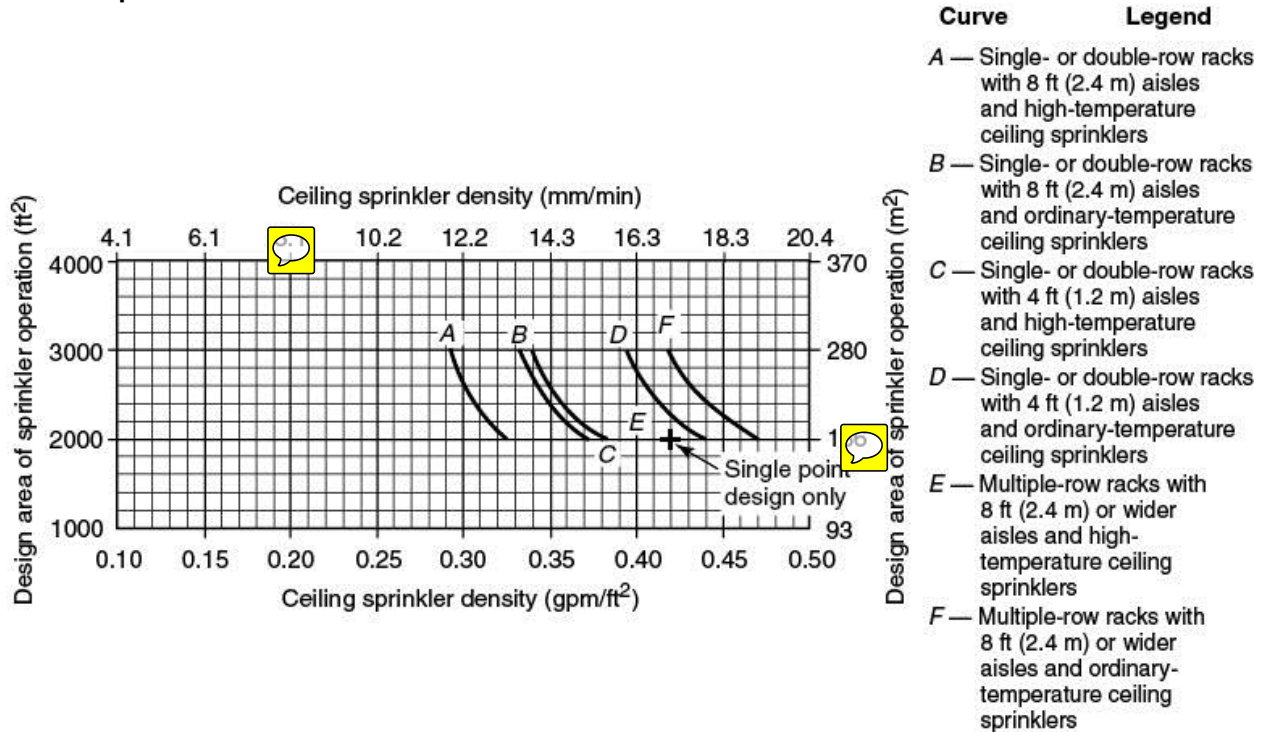


Figure 21.4.1.2(c) Sprinkler System Design Curves — 20 ft (6.1 m) High Rack Storage — Class III Nonencapsulated Commodities — Conventional Pallets.

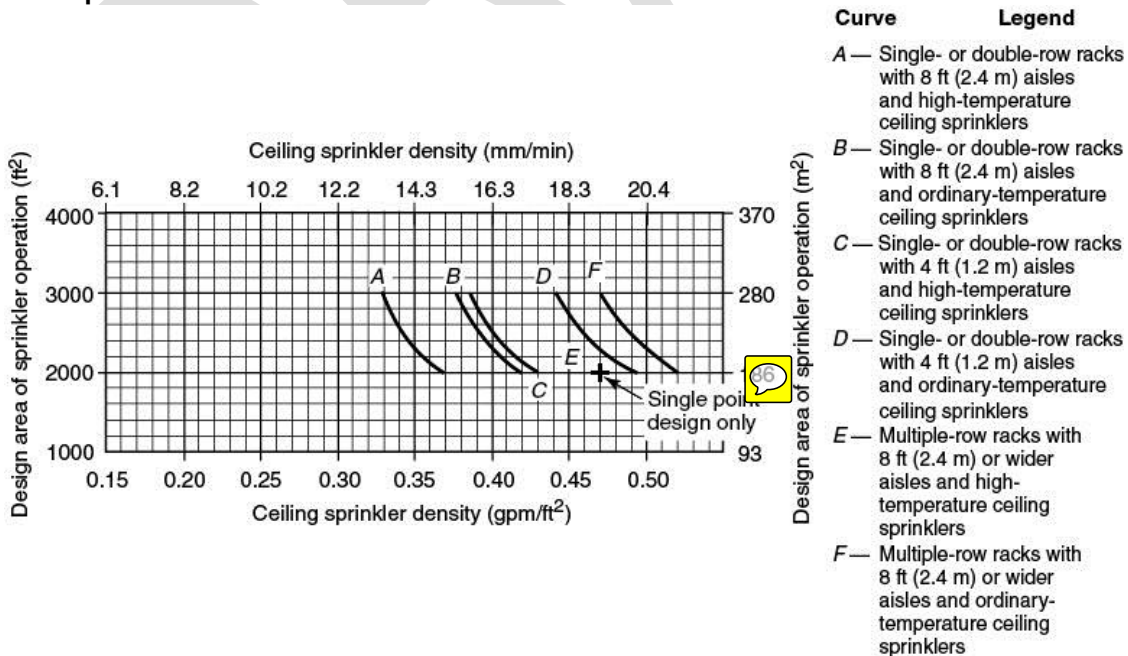


Figure 21.4.1.2(d) Sprinkler System Design Curves — 20 ft (6.1 m) High Rack Storage — Class IV Nonencapsulated Commodities — Conventional Pallets.

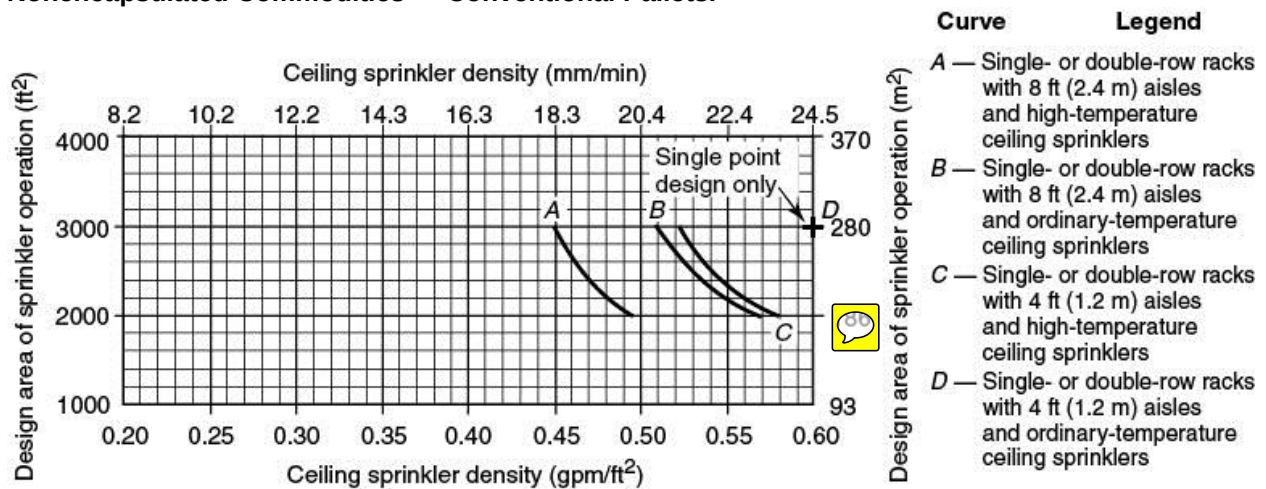


Figure 21.4.1.2(e) Single- or Double-Row Racks — 20 ft (6.1 m) High Rack Storage — Sprinkler System Design Curves — Class I and Class II Encapsulated Commodities — Conventional Pallets.

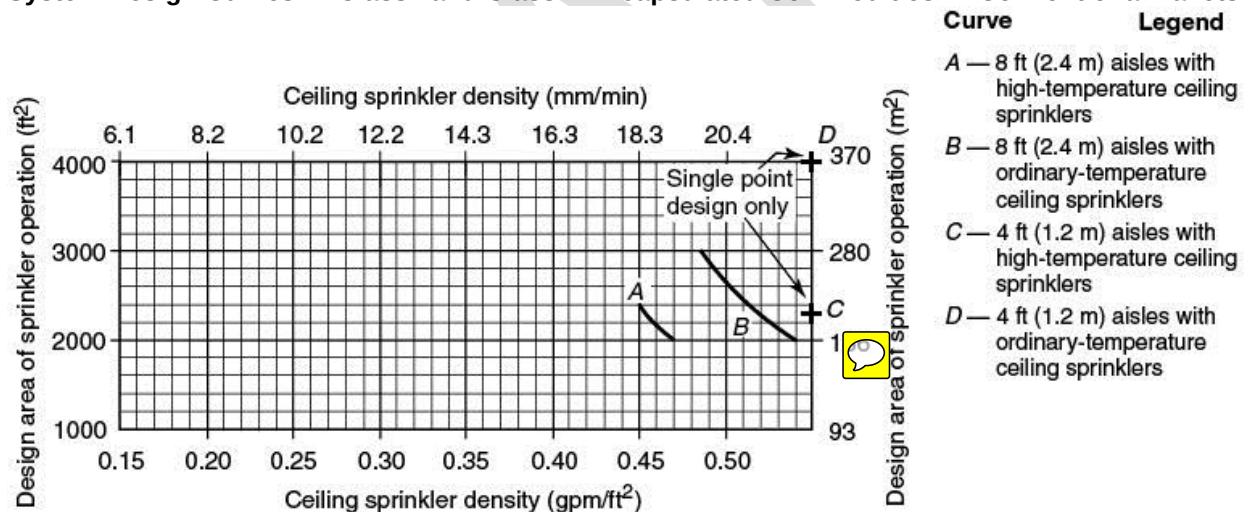


Table 21.4.1.2 Single- or Double-Row Racks — Storage Height Over 12 ft (3.7 m) Up to and Including 25 ft (7.6 m)

Height	Commodity Class	Encapsulated	Aisles*		Sprinklers Mandatory In-Rack	Ceiling Sprinkler Water Demand						
			ft	m		With In-Rack Sprinklers			Without In-Rack Sprinklers			
						Figure	Curves	Apply Figure 16.2.1.3.4.1	Figure	Curves	Apply Figure 16.2.1.3.4.1	
Over 12 ft (3.7 m) up to and including 20 ft (6.1 m)	I	No	4	1.2	No	16.2.1.3.2(a)	C and D	Yes	16.2.1.3.2(a)	F and H	Yes	
			8	2.4			A and B			E and G		
		Yes	4	1.2	No	16.2.1.3.2(e)	C and D		16.2.1.3.2(e)	G and H	Yes	
			8	2.4			A and B			E and F		
	II	No	4	1.2	No	16.2.1.3.2(b)	C and D		Yes	16.2.1.3.2(b)	G and H	Yes
			8	2.4			A and B				E and F	
		Yes	4	1.2	No	16.2.1.3.2(e)	C and D			16.2.1.3.2(e)	G and H	Yes
			8	2.4			A and B				E and F	
	III	No	4	1.2	No	16.2.1.3.2(c)	C and D	16.2.1.3.2(c)	G and H	Yes		
			8	2.4			A and B		E and F			
		Yes	4	1.2	1 level	16.2.1.3.2(f)	C and D	—	—	—		
			8	2.4			A and B					

Height	Commodity Class	Encapsulated	Aisles*		Sprinklers Mandatory In-Rack	Ceiling Sprinkler Water Demand					
			ft	m		With In-Rack Sprinklers			Without In-Rack Sprinklers		
						Figure	Curves	Apply Figure 16.2.1.3. 4.1	Figure	Curves	Apply Figure 16.2.1.3. 4.1
	IV	No	4	1.2	No	16.2.1.3. 2(d)	C and D		16.2.1.3. 2(d)	G and H	Yes
			8	2.4			A and B			E and F	
		Yes	4	1.2	1 level	16.2.1.3. 2(g)	C and D		—	—	—
			8	2.4			A and B				
Over 20 ft (6.1 m) up to and including 22 ft (6.7 m)	I	No	4	1.2	No	16.2.1.3. 2(a)	C and D		16.2.1.3. 2(a)	F and H	Yes
			8	2.4			A and B			E and G	
		Yes	4	1.2	1 level	16.2.1.3. 2(e)	C and D		—	—	—
			8	2.4			A and B				
	II	No	4	1.2	No	16.2.1.3. 2(b)	C and D	No	16.2.1.3. 2(b)	G and H	Yes
			8	2.4			A and B			E and F	
		Yes	4	1.2	1 level	16.2.1.3. 2(e)	C and D		—	—	—
			8	2.4			A and B				
	III	No	4	1.2	No	16.2.1.3. 2(c)	C and D		16.2.1.3. 2(c)	G and H	Yes

Height	Commodity Class	Encapsulated	Aisles*		Sprinklers Mandatory In-Rack	Ceiling Sprinkler Water Demand									
			ft	m		With In-Rack Sprinklers			Without In-Rack Sprinklers						
						Figure	Curves	Apply Figure 16.2.1.3. 4.1	Figure	Curves	Apply Figure 16.2.1.3. 4.1				
		Yes	8	2.4	1 level	16.2.1.3. 2(f)	A and B		—	E and F	—				
			4	1.2			C and D			—					
		8	2.4	A and B			—								
	IV	No	4	1.2	No	16.2.1.3. 2(d)	C and D	16.2.1.3. 2(d)	G and H	Yes					
			8	2.4			A and B		E and F						
		Yes	4	1.2			1 level		16.2.1.3. 2(g)		C and D	—	—	—	
			8	2.4							A and B				
Over 22 ft (6.7 m) up to and including 25 ft (7.6 m)	I	No	4	1.2	No	16.2.1.3. 2(a)		C and D		16.2.1.3. 2(a)	F and H				Yes
			8	2.4				A and B			E and G				
		Yes	4	1.2			1 level	16.2.1.3. 2(e)	C and D		—	—	—		
			8	2.4					A and B						
	II	No	4	1.2	No	16.2.1.3. 2(b)			C and D	16.2.1.3. 2(b)				G and H	Yes
			8	2.4					A and B					E and F	

Height	Commodity Class	Encapsulated	Aisles*		Sprinklers Mandatory In-Rack	Ceiling Sprinkler Water Demand						
			ft	m		With In-Rack Sprinklers			Without In-Rack Sprinklers			
						Figure	Curves	Apply Figure 16.2.1.3. 4.1	Figure	Curves	Apply Figure 16.2.1.3. 4.1	
		Yes	4	1.2	1 level	16.2.1.3. 2(e)	C and D		—	—	—	
			8	2.4			A and B					
	III	No	4	1.2	No	16.2.1.3. 2(c)	C and D	16.2.1.3. 2(c)	G and H	Yes		
			8	2.4			A and B				E and F	
		Yes	4	1.2	1 level	16.2.1.3. 2(f)	C and D		—		—	—
			8	2.4			A and B					
	IV	No	4	1.2	1 level	16.2.1.3. 2(d)	C and D	—	—	—		
			8	2.4			A and B					
		Yes	4	1.2		16.2.1.3. 2(g)	C and D	—	—	—		
			8	2.4			A and B					

*See 16.2.1.3.2.1 for interpolation of aisle widths.

21.4.1.2.1*

Design densities for single- and double-row racks shall be selected to correspond to aisle width. (See Section C.15.)

(A)

For aisle widths between 4 ft (1.2 m) and 8 ft (2.4 m), the rules for 4 ft (1.2 m) aisle width shall be used or direct linear interpolation between the densities shall be permitted.

(B)

The density given for 8 ft (2.4 m) wide aisles shall be applied to aisles wider than 8 ft (2.4 m).

(C)

The density given for 4 ft (1.2 m) wide aisles shall be applied to aisles more narrow than 4 ft (1.2 m) down to 3½ ft (1.1 m).

(D)

Where aisles are more narrow than 3½ ft (1.1 m), racks shall be considered to be multiple-row racks.

21.4.1.3 Multiple-Row Racks — Storage Height Over 12 ft (3.7 m) Up to and Including 25 ft (7.6 m).

21.4.1.3.1 Multiple-Row Racks — Rack Depth Up to and Including 16 ft (4.9 m) with Aisles 8 ft (2.4 m) or Wider.

For Class I, Class II, Class III, or Class IV commodities, encapsulated or nonencapsulated, ceiling sprinkler water demand in terms of density [gpm/ft² (mm/min)] and area of sprinkler operation [ft² (m²) of ceiling or roof] shall be selected from the density/area curves of Figure 21.4.1.2(a) through Figure 21.4.1.2(e) that are appropriate for each commodity and configuration as shown in Table 21.4.1.3.1 and shall be modified as appropriate by 21.4.1.4. The protection criteria shall apply to portable racks arranged in the same manner as multiple-row racks.

Table 21.4.1.3.1 Multiple-Row Racks — Rack Depth Up to and Including 16 ft (4.9 m), Aisles 8 ft (2.4 m) or Wider and Storage Height Over 12 ft (3.7 m) Up to 25 ft (7.6 m)

Height	Commodity Class	Encapsulated	Sprinklers Mandatory In-Rack	Ceiling Sprinkler Water Demand							
				With In-Rack Sprinklers				Without In-Rack Sprinklers			
				Figure	Curves	Apply Figure 16.2.1.3.4.1	1.25 × Density	Figure	Curves	Apply Figure 16.2.1.3.4.1	1.25 × Density
Over 12 ft (3.7 m) up to and including 15 ft (4.6 m)	I	No	No	16.2.1.3.2(a)	C and D	Yes	No	16.2.1.3.2(a)	I and J	Yes	No
		Yes		16.2.1.3.2(a)			Yes	16.2.1.3.2(a)	I and J		Yes
	II	No		16.2.1.3.2(b)			No	16.2.1.3.2(b)	I and J	Yes	No
		Yes		16.2.1.3.2(b)			Yes	16.2.1.3.2(b)	I and J		Yes
	III	No	No	16.2.1.3.2(c)			No	16.2.1.3.2(c)	I and J	Yes	No
		Yes	1 level	16.2.1.3.2(c)			Yes		NA	NA	NA
	IV	No	No	16.2.1.3.2(d)			No	16.2.1.3.2(d)	C and D	No	No
		Yes	1 level	16.2.1.3.2(d)	A and B		1.50 × density		NA	NA	NA
Over 15 ft (4.6 m) up to	I	No	No	16.2.1.3.2(a)	C and D	Yes	No	16.2.1.3.2(a)	I and J	Yes	No
		Yes		16.2.1.3.2(a)			Yes	16.2.1.3.2(a)	I and J		Yes

Height	Commodity Class	Encapsulated	Sprinklers Mandatory In-Rack	Ceiling Sprinkler Water Demand							
				With In-Rack Sprinklers				Without In-Rack Sprinklers			
				Figure	Curves	Apply Figure 16.2.1.3.4.1	1.25 × Density	Figure	Curves	Apply Figure 16.2.1.3.4.1	1.25 × Density
and including 20 ft (6.1 m)	II	No		16.2.1.3.2(b)			No	16.2.1.3.2(b)	I and J	Yes	No
		Yes		16.2.1.3.2(b)			Yes	16.2.1.3.2(b)	I and J		Yes
	III	No	No	16.2.1.3.2(c)			No	16.2.1.3.2(c)	I and J	Yes	No
		Yes	1 level	16.2.1.3.2(c)			Yes				
	IV	No	1 level	16.2.1.3.2(d)	A and B		No	NA	NA	NA	NA
		Yes		16.2.1.3.2(d)			1.50 × density				
Over 20 ft (6.1 m) up to and including 25 ft (7.6 m)	I	No	No	16.2.1.3.2(a)	C and D	No	No	16.2.1.3.2(a)	I and J	Yes	No
		Yes	1 level	16.2.1.3.2(a)			Yes				
	II	No	1 level	16.2.1.3.2(b)			No	NA	NA	NA	NA
		Yes		16.2.1.3.2(b)			Yes				
	III	No		16.2.1.3.2(c)			No				
		Yes		16.2.1.3.2(c)			Yes				
	IV	No	2 levels	16.2.1.3.2(d)			No				
		Yes		16.2.1.3.2(d)			1.50 × density				

NA: Not applicable.

21.4.1.3.2 Multiple-Row Racks — Rack Depth Over 16 ft (4.9 m) or Aisles More Narrow Than 8 ft (2.4 m).

For Class I, Class II, Class III, or Class IV commodities, encapsulated or nonencapsulated, ceiling sprinkler water demand in terms of density [gpm/ft² (mm/min)] and area of sprinkler operation [ft² (m²) of ceiling or roof] shall be selected from the density/area curves of Figure 21.4.1.2(a) through Figure 21.4.1.2(e) that are appropriate for each commodity and configuration as shown in Table 21.4.1.3.2 and

shall be modified as appropriate by 21.4.1.4. The protection criteria shall apply to portable racks arranged in the same manner as multiple-row racks.

Table 21.4.1.3.2 Multiple-Row Racks — Rack Depth Over 16 ft (4.9 m) or Aisles Narrower Than 8 ft (2.4 m), Storage Height Over 12 ft (3.7 m) Up to and Including 25 ft (7.6 m)

Height	Commodity Class	Encapsulated	Sprinklers Mandatory In-Rack	Ceiling Sprinkler Water Demand							
				With In-Rack Sprinklers				Without In-Rack Sprinklers			
				Figure	Curves	Apply Figure 16.2.1.3.4.1	1.25 × Density	Figure	Curves	Apply Figure 16.2.1.3.4.1	1.25 × Density
Over 12 ft (3.7 m) up to and including 15 ft (4.6 m)	I	No	No	16.2.1.3.2(a)	C and D	Yes	No	16.2.1.3.2(a)	I and J	Yes	No
		Yes		16.2.1.3.2(a)			Yes	16.2.1.3.2(a)	I and J		Yes
	II	No		16.2.1.3.2(b)			No	16.2.1.3.2(b)	I and J	Yes	No
		Yes		16.2.1.3.2(b)			Yes	16.2.1.3.2(b)	I and J		Yes
	III	No	1 level	16.2.1.3.2(c)			No	16.2.1.3.2(c)	I and J	Yes	No
		Yes		16.2.1.3.2(c)			Yes				
	IV	No	No	16.2.1.3.2(d)			No	16.2.1.3.2(d)	C and D	No	No
		Yes	1 level	16.2.1.3.2(d)			1.50 × density				
Over 15 ft (4.6 m) up to and including 20 ft (6.1 m)	I	No	1 level	16.2.1.3.2(a)	C and D	Yes	No	NA	NA	NA	NA
		Yes		16.2.1.3.2(a)			Yes				
	II	No		16.2.1.3.2(b)			No				
		Yes		16.2.1.3.2(b)			Yes				
	III	No		16.2.1.3.2(c)			No				
		Yes		16.2.1.3.2(c)			Yes				
	IV	No		16.2.1.3.2(d)			No				
		Yes		16.2.1.3.2(d)			1.50 ×				

Height	Commodity Class	Encapsulated	Sprinklers Mandatory In-Rack	Ceiling Sprinkler Water Demand							
				With In-Rack Sprinklers				Without In-Rack Sprinklers			
				Figure	Curves	Apply Figure 16.2.1.3.4.1	1.25 × Density	Figure	Curves	Apply Figure 16.2.1.3.4.1	1.25 × Density
Over 20 ft (6.1 m) up to and including 25 ft (7.6 m)	I	No	1 level	16.2.1.3.2(a)	C and D	No	No	NA	NA	NA	NA
		Yes		16.2.1.3.2(a)			Yes				
	II	No		16.2.1.3.2(b)			No				
		Yes		16.2.1.3.2(b)			Yes				
	III	No		16.2.1.3.2(c)			No				
		Yes		16.2.1.3.2(c)			Yes				
	IV	No	2 levels	16.2.1.3.2(d)			No				
		Yes		16.2.1.3.2(d)			1.50 × density				

NA: Not applicable.

21.4.1.3.3

Where Class I, Class II, and Class III commodities are encapsulated, ceiling sprinkler density shall be 25 percent greater than for nonencapsulated.

21.4.1.3.4

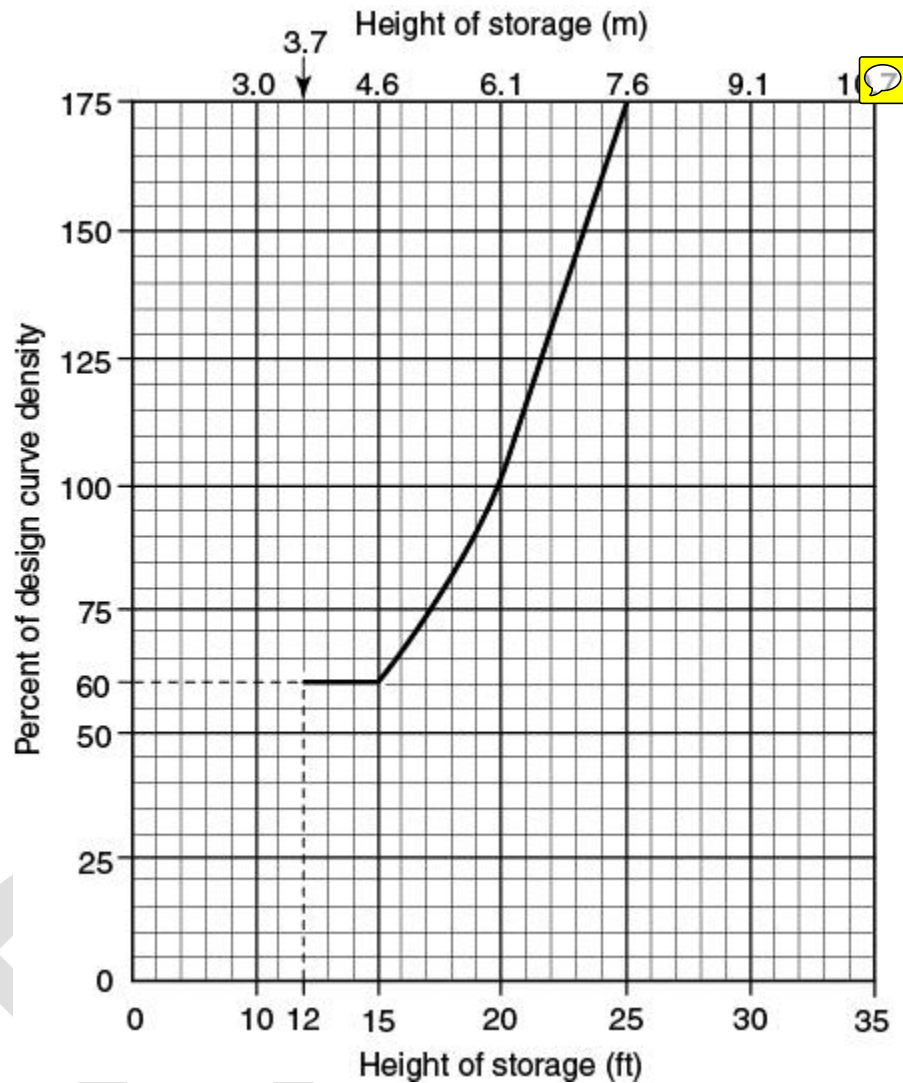
Where Class IV commodities are encapsulated, ceiling sprinkler density shall be 50 percent greater than for nonencapsulated.

21.4.1.4 Ceiling Sprinkler Density Adjustments.

21.4.1.4.1

For storage height over 12 ft (3.7 m) up to and including 25 ft (7.6 m) protected with ceiling sprinklers only and for storage height over 12 ft (3.7 m) up to and including 20 ft (6.1 m) protected with ceiling sprinklers and minimum required in-rack sprinklers, densities obtained from design curves shall be adjusted in accordance with Figure 21.4.1.4.1.

Figure 21.4.1.4.1 Ceiling Sprinkler Density vs. Storage Height.



21.4.1.4.2

For storage height over 20 ft (6.1 m) up to and including 25 ft (7.6 m) protected with ceiling sprinklers and minimum required in-rack sprinklers, densities obtained from design curves shall be used. Densities shall not be adjusted in accordance with Figure 21.4.1.4.1.

21.4.1.4.3

For storage height over 12 ft (3.7 m) up to and including 20 ft (6.1 m) protected with ceiling sprinklers and with more than one level of in-rack sprinklers, but not in every tier, densities obtained from design curves and adjusted in accordance with Figure 21.4.1.4.1 shall be permitted to be reduced an additional 20 percent, as indicated in Table 21.4.1.4.3.

Table 21.4.1.4.3 Adjustment to Ceiling Sprinkler Density for Storage Height and In-Rack Sprinklers

Storage Height	In-Rack Sprinklers	Apply Figure 16.2.1.3.4.1 for Storage Height Adjustment	Permitted Ceiling Sprinkler Density Adjustments Where In-Rack Sprinklers Are Installed
Over 12 ft (3.7 m) through 25 ft (7.6 m)	None	Yes	None
Over 12 ft (3.7 m) through 20 ft (6.1 m)	Minimum required	Yes	None
	More than minimum, but not in every tier	Yes	Reduce density 20% from that of minimum in-rack sprinklers
	In every tier except above the top tier	Yes	Reduce density 40% from that of minimum in-rack sprinklers
Over 20 ft (6.1 m) through 25 ft (7.6 m)	Minimum required	No	None
	More than minimum, but not in every tier	No	Reduce density 20% from that of minimum in-rack sprinklers
	In every tier except above the top tier	No	Reduce density 40% from that of minimum in-rack sprinklers

21.4.1.4.4

For storage height over 20 ft (6.1 m) up to and including 25 ft (7.6 m) protected with ceiling sprinklers and with more than the minimum required level of in-rack sprinklers, but not in every tier, densities obtained from design curves shall be permitted to be reduced 20 percent, as indicated in Table 21.4.1.4.3. Densities shall not be adjusted in accordance with Figure 21.4.1.4.1 for storage height.

21.4.1.4.5*

For storage height over 12 ft (3.7 m) up to and including 20 ft (6.1 m) protected with ceiling sprinklers and in-rack sprinklers at each tier, densities obtained from design curves and adjusted in accordance with Figure 21.4.1.4.1 shall be permitted to be reduced an additional 40 percent, as indicated in Table 21.4.1.4.3.

21.4.1.4.6

For storage height over 20 ft (6.1 m) up to and including 25 ft (7.6 m) protected with ceiling sprinklers and in-rack sprinklers at each tier except above the top tier, densities obtained from design curves shall be permitted to be reduced 40 percent, as indicated in Table 21.4.1.4.3. Densities shall not be adjusted in accordance with Figure 21.4.1.4.1 for storage height.

21.4.1.4.7

Where solid, flat-bottom, combustible pallets (slave pallets) are used with storage height up to and including 25 ft (7.6 m), the densities that are indicated in the design curves shown in Figure 21.4.1.2(a) through Figure 21.4.1.2(e), based on conventional pallets, shall be increased 20 percent for the given area.

(A)

The percentage shall be applied to the density determined in accordance with 21.4.1.4.

(B)

The increase in density shall not apply where in-rack sprinklers are utilized in the design.

21.4.2 Control Mode Density/Area Sprinkler Protection Criteria for Rack Storage of Class I Through Class IV Commodities Stored Over 25 ft (7.6 m) in Height.
21.4.2.1*

For single- and double-row racks, the water demand for nonencapsulated storage separated by aisles at least 4 ft (1.2 m) wide and with a clearance to ceiling up to and including 10 ft (3.0 m) shall be in accordance with Table 21.4.2.1.

Table 21.4.2.1 Single- or Double-Row Racks of Class I Through Class IV Commodities Stored Over 25 ft (7.6 m) in Height with Aisles 4 ft (1.2 m) or More in Width

Commodity Class	In-Rack Sprinklers Approximate Vertical Spacing at Tier Nearest the Vertical Distance and Maximum Horizontal Spacing ^{a,b,c}		Figure	Maximum Storage Height	Stagger	Ceiling Sprinkler Operating Area		Ceiling Sprinkler Density Clearance to Ceiling Up to 10 ft (3 m) ^g			
	Longitudi- nal Flue ^d	Face ^{e,f}				ft ²	m ²	Ordinary Temperature		High Temperature	
								gpm/ ft ²	mm/m in	gpm/ ft ²	mm/m in
I	Vertical 20 ft (6.1 m) Horizontal 10 ft (3.0 m) under horizontal barriers	None	16.3.1.3.1.1(A)(a)	30 ft (9.1 m)	No	200 0	16 6	0.25	10.2	0.35	14.2
	Vertical 20 ft (6.1 m) Horizontal 10 ft (3.0 m)	Vertical 20 ft (6.1 m) Horizontal 10 ft (3.0 m)	16.3.1.3.1.1(A)(b)	Higher than 25 ft (7.6 m)	Yes			0.25	10.2	0.35	14.2
I, II, III	Vertical 10 ft (3.0 m) or at 15 ft (4.6 m) and 25 ft (7.6 m)	None	16.3.1.3.1.1(A)(c)	30 ft (9.1 m)	Yes	200 0	16 6	0.3	12.2	0.4	16.3
	Vertical 10 ft (3.0 m m) Horizontal 10 ft (3.0 m m)	Vertical 30 ft (9.1 m) Horizontal 10 ft (3.0 m)	16.3.1.3.1.1(A)(d)	Higher than 25 ft (7.6 m)	Yes			0.3	12.2	0.4	16.3
	Vertical 20 ft (6.1 m) Horizontal 10 ft (3.0 m)	Vertical 20 ft (6.1 m) Horizontal 5 ft (1.5 m)	16.3.1.3.1.1(A)(e)		Yes			0.3	12.2	0.4	16.3

Commodity Class	In-Rack Sprinklers Approximate Vertical Spacing at Tier Nearest the Vertical Distance and Maximum Horizontal Spacing ^{a,b,c}		Figure	Maximum Storage Height	Stagger	Ceiling Sprinkler Operating Area		Ceiling Sprinkler Density Clearance to Ceiling Up to 10 ft (3 m) ⁹			
	Longitudi nal Flue ^d	Face ^{e,f}				ft ²	m ²	Ordinary Temperature		High Temperature	
								gpm/ ft ²	mm/m in	gpm/ ft ²	mm/m in
I, II, III, IV	Vertical 25 ft (7.6 m) Horizontal 5 ft (1.5 m)	Vertical 25 ft (7.6 m) Horizontal 5 ft (1.5 m)	16.3.1.3.1.1(A)(f)	Higher than 25 ft (7.6 m)	No	200 0	16 6	0.3	12.2	0.4	16.3
	Horizontal barriers at 20 ft (6.1 m) Vertical intervals — two lines of sprinklers under barriers — maximum horizontal spacing 10 ft (3.0 m), staggered		16.3.1.3.1.1(A)(g)		Yes			0.3	12.2	0.4	16.3
	Vertical 15 ft (4.6 m) Horizontal 10 ft (3.1 m)	Vertical 20 ft (6.1 m) Horizontal 10 ft (3.0 m)	16.3.1.3.1.1(A)(h)	Yes	0.35			14.3	0.45	18.3	
	Vertical 20 ft (6.1 m) Horizontal 5 ft (1.5 m)	Vertical 20 ft (6.1 m) Horizontal 5 ft (1.5 m)	16.3.1.3.1.1(A)(i)	No	0.35			14.2	0.45	18.3	
	Horizontal barriers at 15 ft (4.6 m) Vertical intervals		16.3.1.3.1.1(A)(j)		Yes			0.35	14.2	0.45	18.3

Commodity Class	In-Rack Sprinklers Approximate Vertical Spacing at Tier Nearest the Vertical Distance and Maximum Horizontal Spacing ^{a,b,c}		Figure	Maximum Storage Height	Stagger	Ceiling Sprinkler Operating Area		Ceiling Sprinkler Density Clearance to Ceiling Up to 10 ft (3 m) ^g			
	Longitudi nal Flue ^d	Face ^{e,f}				Ordinary Temperature		High Temperature			
						gpm/ ft ²	mm/m in	gpm/ ft ²	mm/m in		
	— two lines of sprinklers under barriers — maximum horizontal spacing 10 ft (3.0 m), staggered										

^aMinimum in-rack sprinkler discharge, 30 gpm (114 L/min).

^bWater shields required.

^cAll in-rack sprinkler spacing dimensions start from the floor.

^dInstall sprinklers at least 3 in. (75 mm) from uprights.

^eFace sprinklers shall not be required for a Class I commodity consisting of noncombustible products on wood pallets (without combustible containers), except for arrays shown in Figure 16.3.1.3.1.1(A)(g) and Figure 16.3.1.3.1.1(A)(j).

^fIn Figure 16.3.1.3.1.1(A)(a) through Figure 16.3.1.3.1.1(A)(j), each square represents a storage cube that measures 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. to 10 ft (450 mm to 3.0 m). Therefore, there can be one load to six or seven loads between in-rack sprinklers that are spaced 10 ft (3.0 m) apart vertically.

^gFor encapsulated commodity, increase density 25 percent.

21.4.2.1.1

Where storage as described in 21.4.2.1 is encapsulated, ceiling sprinkler density shall be 25 percent greater than for nonencapsulated storage.

21.4.2.2

For multiple-row racks, the water demand for nonencapsulated storage separated by aisles at least 4 ft (1.2 m) wide and with a clearance to ceiling up to and including 10 ft (3.0 m) shall be in accordance with Table 21.4.2.2.

Table 21.4.2.2 Multiple-Row Racks of Class I Through Class IV Commodities Stored Over 25 ft (7.6 m) in Height

Commodity Class	Encapsulated	In-Rack Sprinklers ^{a,b,c}						Height Limit (ft)	Stagger	Figure	Maximum Spacing from Top of Storage to Highest In-Rack Sprinklers		Ceiling Sprinkler Operating Area		Ceiling Sprinklers Density Clearance to Ceiling Up to 10 ft			
		Maximum Vertical Spacing		Maximum Horizontal Spacing in A Flue		Maximum Horizontal Spacing across Flue					ft ²	m ²	165°F (74°C) Rating		286°F (141°C) Rating			
		ft	m	ft	m	ft	m						gpm/ft ²	mm/min	gpm/ft ²	mm/min		
I	No	20	6.1	12	3.7	10	3.0	Between adjacent flues		16.3.1.3.1.3(A)(a)	10	3.0	2000	86	0.25	10.2	0.35	14.3
	Yes									0.31	12.6	0.44			17.9			
I, II, and III	No	15	4.6	10	3.0	10	3.0			16.3.1.3.1.3(A)(b)	10	3.0			0.30	12.2	0.40	16.3
	Yes									0.37	15.1	0.50			20.4			
I, II, III, and IV	No	10	3.1	10	3.0	10	3.0			16.3.1.3.1.3(A)(c)	5	1.5			0.35	14.2	0.45	18.3
	Yes														0.44	17.9	0.56	22.8

For SI units, °C = $\frac{5}{9}$ (°F-32); 1 gpm/ft² = 40.746 mm/min.

^aAll four rack faces shall be protected by sprinklers located within the racks and no more than 18 in. (450 mm) from the faces, as indicated in Figure 16.3.1.3.1.3(A)(a) through Figure 16.3.1.3.1.3(A)(c). It shall not be required for each sprinkler level to protect all faces.

^bAll in-rack sprinkler spacing dimensions start from the floor.

^cIn Figure 16.3.1.3.1.3(A)(a) through Figure 16.3.1.3.1.3(A)(c), each square represents a storage cube measuring 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. to 10 ft (450 mm to 3.0 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.1 m) apart vertically.

21.4.2.2.1

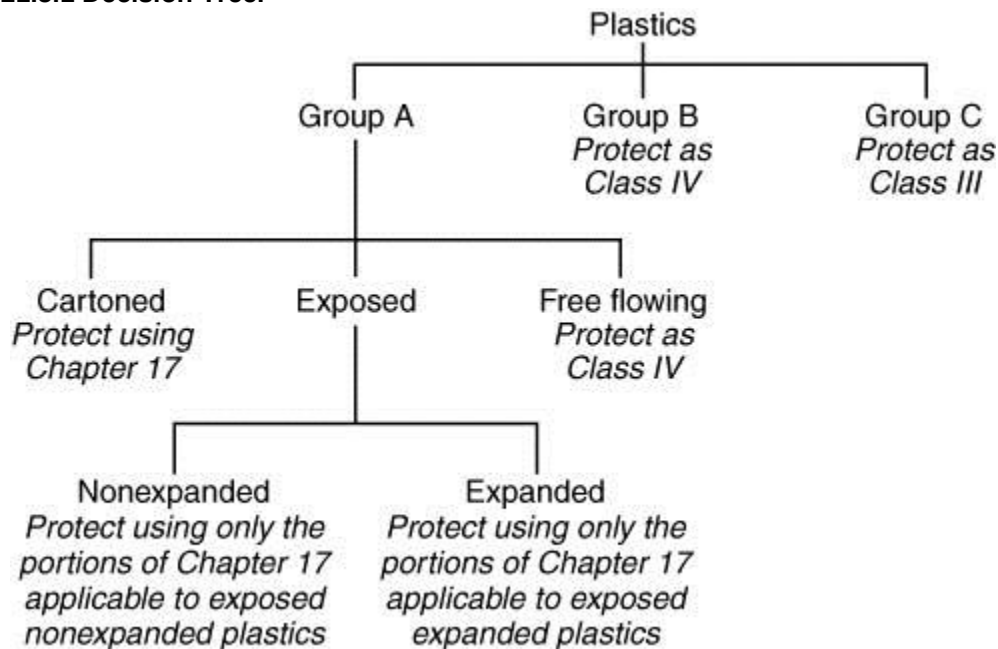
Where such storage is encapsulated, ceiling sprinkler density shall be 25 percent greater than for nonencapsulated storage.

21.5 Control Mode Density/Area Sprinkler Protection Criteria for Single-, Double-, and Multiple-Row Racks for Group A Plastic Commodities Stored Up to and Including 25 ft (7.6 m) in Height.

21.5.1

Plastic commodities shall be protected in accordance with Figure 21.5.1. (See Section C.21.).

Figure 21.5.1 Decision Tree.



21.5.1.1

For Group A plastic commodities in cartons, encapsulated or nonencapsulated in single-, double-, and multiple-row racks and with a clearance to ceiling up to and including 10 ft (3.1 m), ceiling sprinkler water demand in terms of density [gpm/ft² (mm/min)] and area of operation [ft² (m²)] shall be selected from Table 21.5.1.1.

Table 21.5.1.1 Control Mode Density/Area Sprinkler Protection Criteria for Single-, Double-, and Multiple-Row Racks for Group A Plastic Commodities Stored Up to and Including 25 ft (7.6 m) in Height

Commodity	Storage height	Maximum Clearance from Top of Storage to Ceiling	Maximum Ceiling Height	In-Racks Requirements	Ceiling Sprinklers Density Clearance to Ceiling Up to 10 ft	Ceiling Sprinkler Operating Area
	ft (m)	ft (m)	ft (m)		gpm/ft ² (mm/min)	ft ² (m ²)
Group A plastic commodities in cartons, encapsulated	5 ft to 10 ft (1.5 m to 3.1 m)	<5 ft (1.5 m)	<15 ft (3.1 m)	Not Required	0.30 gpm/ft ² (12.2 mm/min)	2000 ft ² (186 m ²)
		5 ft to 10 ft (1.5 m to 3.1 m)	20 ft (6.1 m)	Not Required	0.45 gpm/ft ² (18.3 mm/min)	
	15 ft (4.6 m),	5 ft (1.5 m) and up	22 ft (6.7 m)	Not Required	0.45 gpm/ft ² (18.3 mm/min)	
		Up to 10 ft (3.1 m)	25 ft (7.6 m)	Not Required	0.60 gpm/ft ² (24.5 mm/min)	
				Figure 25.9.3.2(a)	0.30 gpm/ft ² (12.2 mm/min)	

Commodity	Storage height	Maximum Clearance from Top of Storage to Ceiling	Maximum Ceiling Height	In-Racks Requirements	Ceiling Sprinklers Density Clearance to Ceiling Up to 10 ft	Ceiling Sprinkler Operating Area
	ft (m)	ft (m)	ft (m)		gpm/ft ² (mm/min)	ft ² (m ²)
	20 ft (6.1 m)	<5 ft (1.5 m)	<25 ft (7.6 m)	Not Required 1,2	0.60 gpm/ft ² (24.5 mm/min)	
				Figure 25.9.3.2(b)	0.45 gpm/ft ² (18.3 mm/min)	
				Figure 25.9.3.2(c)	0.30 gpm/ft ² (12.2 mm/min)	
		5 ft to 10 ft (1.5 m to 3.1 m)	27 ft (8.2 m).	Not Required 1	0.60 gpm/ft ² (24.5 mm/min)	
			30 ft (9.1 m)	Figure 25.9.3.2(d)	0.45 gpm/ft ² (18.3 mm/min)	
				Figure 25.9.3.2(e)	0.30 gpm/ft ² (12.2 mm/min)	
				Figure 25.9.3.2(f)	0.30 gpm/ft ² (12.2 mm/min)	
			Figure 25.9.3.2(g)	0.30 gpm/ft ² (12.2 mm/min)		
	25 ft (7.6 m)	<5 ft (1.5 m)	30 ft (9.1 m)	Not Required 2	0.8 gpm/ft ² (32.6 mm/min)	
				Figure 25.9.3.2(h)	0.45 gpm/ft ² (18.3 mm/min)	
				Figure 25.9.3.2(i)	0.30 gpm/ft ² (12.2 mm/min)	
		5 ft to 10 ft (1.5 m to 3.1 m)	35 ft (10.7 m)	Figure 25.9.3.2(j)	0.30 gpm/ft ² (12.2 mm/min)	

Notes

(1) Ceiling-only protection is not permitted for this storage configuration except where K-11.2 or larger spray sprinklers listed for storage use are installed.

(2) For the protection of Single and Double Row rack only

(3) Ceiling-only protection shall not be permitted for this storage configuration except where K-16.8 spray sprinklers listed for storage use are installed

21.5.1.2

Linear interpolation of design densities and areas of application shall be permitted between storage heights with the same clearance to ceiling.

21.5.1.3

No interpolation between clearance to ceiling shall be permitted.

21.5.1.4*

An option shall be selected from Table 25.1.1 given the storage height and clearance being protected.

21.5.1.4.1

The density/area criteria shall be applied to the ceiling sprinklers and the in-rack sprinklers shown in the option (if any) shall be provided.

21.5.1.4.2

Options that do not show multiple-row racks in the figures shall not be permitted to protect multiple-row rack storage.

21.5.1.4.3

Notes in each figure shall be permitted to clarify options or to present additional options not shown in the figures.

21.5.2

For storage of Group A plastics between 5 ft and 12 ft (1.5 m and 3.7 m) in height, the installation requirements for extra hazard systems shall apply.

21.5.3*

Exposed nonexpanded Group A plastics protected with control mode density/area sprinklers shall be protected in accordance with Table 21.5.3.

Table 21.5.3 Control Mode Density/Area Sprinkler Protection Criteria for Exposed Unexpanded Group A Plastics

Commodity	Storage height	Maximum Ceiling Height	In-Racks Requirements	Ceiling Sprinklers Density Clearance to Ceiling Up to 10 ft	Ceiling Sprinkler Operating Area
	ft (m)	ft (m)		gpm/ft² (mm/min)	ft² (m²)
Exposed Unexpanded Group A plastic	10 ft (3.1 m)	20 ft (6.1 m)	Not Required	0.80 gpm/ft² (32.6 mm/min)	2500 ft² (232 m²)
			Figure 25.9.3.2(a)	0.45 gpm/ft² (18.3 mm/min)	2000 ft² (186 m²)
			Figure 25.9.3.2(b)	0.30 gpm/ft² (12.2 mm/min)	
	15 ft (4.6 m)	25 ft (7.6 m)	Figure 25.9.3.2(c)	0.45 gpm/ft² (18.3 mm/min)	
			Figure 25.9.3.2(d)	0.30 gpm/ft² (12.2 mm/min)	
	20 ft (6.1 m)	25 ft (7.6 m)	Figure 25.9.3.2(e)	0.60 gpm/ft² (24.5 mm/min)	1500 ft² (139 m²)
			Figure 25.9.3.2(f)	0.45 gpm/ft² (18.3 mm/min)	
		30 ft (9.1 m)	Figure 25.9.3.2(g)	0.80 gpm/ft² (32.6 mm/min)	
	Figure 25.9.3.2(h)		0.60 gpm/ft² (24.5 mm/min)		
	Figure 25.9.3.2(i)		0.30 gpm/ft² (12.2 mm/min)		
	25 ft (7.6 m)	35 ft (10.7 m)	Figure 25.9.3.2(j)	0.80 gpm/ft² (32.6 mm/min)	1500 ft² (139 m²)
			Figure 25.9.3.2(k)	0.30 gpm/ft² (12.2 mm/min)	2000 ft² (186 m²)

21.5.4 Control Mode Density/Area Sprinkler Protection Criteria for Rack Storage of Group A Plastic Commodities Stored Over 25 ft (7.6 m) in Height for Single-, Double-, and Multiple-Row Racks.

21.5.4.1

Protection of Group A plastics in cartons, expanded or nonexpanded, whether encapsulated or nonencapsulated and with a clearance to ceiling up to and including 10 ft (3.1 m), shall be permitted using control mode density/area sprinklers in accordance with 21.5.4.

21.5.4.2

Protection of Group A plastics that are exposed and nonexpanded, whether encapsulated or nonencapsulated racks and with a clearance to ceiling up to and including 10 ft (3.1 m), shall be permitted only using in-rack sprinkler arrangements that are specifically permitted to be used with exposed unexpanded plastics.

21.5.4.3* Ceiling Sprinkler Water Demand.

For Group A plastic commodities, encapsulated or nonencapsulated, ceiling sprinkler water demand in terms of density [gpm/ft² (mm/min)] and area of operation [ft² (m²)] shall be selected from Table 21.5.4.3 where in-rack sprinklers are installed per Chapter 25.

Table 21.5.4.3 Control Mode Density/Area Sprinkler Discharge Criteria for Single-, Double-, and Multiple-Row Racks of Group A Plastic Commodities with Storage Over 25 ft (7.6 m) in Height

Commodity	Rack Type	Storage height above top level of in-rack sprinklers	In-Racks Requirements	Ceiling Sprinklers Density Clearance to Ceiling Up to 10 ft	Ceiling Sprinkler Operating Area
				gpm/ft ² (mm/min)	ft ² (m ²)
Cartoned Unexpanded and Expanded Group A plastic	Single Row and Double Row Racks	up to 5 ft (1.5 m)	Figure 21.5.5.5(a) to (c) or Figure 21.5.5.7	0.30 gpm/ft ² (12.2 mm/min)	2000 ft ² (186 m ²)
	Single Row and Double Row Racks	>5 ft up to 10 ft (>1.5 m up to 3.1 m)	21.5.5.5(a) to (c) or Figure 21.5.5.7	0.45 gpm/ft ² (18.3 mm/min)	2000 ft ² (186 m ²)
	Multiple Row Racks	up to 5 ft (1.5 m)	Figure 21.5.5.8(a) to (f)	0.30 gpm/ft ² (12.2 mm/min)	2000 ft ² (186 m ²)
		up to and including 10 ft (3.1 m)		0.45 gpm/ft ² (18.3 mm/min)	2000 ft ² (186 m ²)
Exposed Unexpanded Group A Plastic	Single Row and Double Row Racks	up to and including 10 ft (3.1 m)	Figure 21.5.5.7	0.45 gpm/ft ² (18.3 mm/min)	2000 ft ² (186 m ²)
		up to 5 ft (1.5m)	Figure 21.5.5.8(a) to (f)	0.30 gpm/ft ² (12.2 mm/min)	2000 ft ² (186 m ²)

Commodity	Rack Type	Storage height above top level of in-rack sprinklers	In-Racks Requirements	Ceiling Sprinklers Density Clearance to Ceiling Up to 10 ft	Ceiling Sprinkler Operating Area
	ft (m)	ft (m)		gpm/ft ² (mm/min)	ft ² (m ²)
	Multiple Row Racks	up to and including 10 ft (3.1 m)		0.45 gpm/ft ² (18.3 mm/min)	2000 ft ² (186 m ²)

21.5.4.4

The minimum water supply requirements for a hydraulically designed occupancy hazard fire control sprinkler system shall be determined by adding the hose stream allowance from Table 21.5.4.4 to the water supply for sprinklers determined in Section 17.3.

Table 21.5.4.4 Hose Stream Allowance and Water Supply Duration Requirements for Rack Storage of Group A Plastic Commodities Stored Over 25 ft (7.6 m) in Height

Commodity Classification	Storage Height		Inside Hose		Total Combined Inside and Outside Hose		Duration (minutes)
	ft	m	gpm	L/min	gpm	L/min	
Plastic	>25	>7.6	0, 50, or 100	0, 190, or 380	500	1900	120

21.6* Control Mode Density/Area Sprinkler Protection Criteria for Rack Storage Rubber Tires.

21.6.1 Ceiling Systems.

Protection of rubber tire storage shall be selected from Table 21.6.1(a) or Table 21.6.1(b).

Table 21.6.1(a) Protection Criteria for Rubber Tire Storage Using Control Mode Density/Area Sprinklers

Piling Method	Pile Height [ft (m)]	Sprinkler Discharge Density [gpm/ft ² over mm/min over m ²] (see Note 1)	Areas of Application [ft ² (m ²)] (see Note 1)	
			Ordinary Temperature	High Temperature (see Note 1)
(1) On-floor storage	Up to 5 (1.5)	0.19 (0.72)	2000 (186)	2000 (186)
(a) Pyramid piles, on-side	Over 5 (1.5) to 12 (3.7)	0.30 (1.1)	2500 (232)	2500 (232)
(b) Other arrangements such that no horizontal channels are formed (see Note 2)	Over 12 (3.7) to 18 (5.5)	0.60 (2.3)	Not allowed	2500 (232)
(2) On-floor storage	Up to 5 (1.5)	0.19 (0.72)	2000 (186)	2000 (186)

Piling Method	Pile Height [ft (m)]	Sprinkler Discharge Density [gpm/ft ² over ft ² mm/min over m ²] (see Note 1)	Areas of Application [ft ² (m ²)] (see Note 1)	
			Ordinary Temperature	High Temperature (see Note 1)
Tires, on-tread	Over 5 (1.5) to 12 (3.7)	0.30 (1.1)	2500 (232)	2500 (232)
(3) Palletized portable rack storage	Up to 5 (1.5)	0.19 (0.72)	2000 (186)	2000 (186)
On-side or on-tread	Over 5 (1.5) to 20 (6.1)	See Table 18.4(b)	—	—
	Over 20 (6.1) to 30 (9.1)	0.30 (1.1) plus high-expansion foam	3000 (280)	3000 (280)
(4) Palletized portable rack storage, on-side	Up to 5 (1.5)	0.19 (0.72)	2000 (186)	2000 (186)
	Over 5 (1.5) to 20 (6.1)	See Table 18.4(b)	—	—
	Over 20 (6.1) to 25 (7.6)	0.60 (2.2) and	Not allowed	5000 (465)
		0.90 (3.4) (see Note 3)	Not allowed	3000 (280)
		or 0.75 (2.8) with 1-hour fire-resistive rating of roof and ceiling assembly	Not allowed	4000 (370)
(5) Open portable rack storage, on-side or on-tread	Up to 5 (1.5)	0.19 (0.72)	2000 (186)	2000 (186)
	Over 5 (1.5) to 12 (3.7)	0.60 (2.2)	5000 (465)	3000 (280)
	Over 12 (3.7) to 20 (6.1)	0.60 (2.2) and	Not allowed	5000 (465)
		0.90 (3.4) (see Note 3)	Not allowed	3000 (280)
		or 0.30 (1.1) plus high-expansion foam	3000 (280)	3000 (280)
(6) Open portable rack storage, laced	Over 12 (3.7) to 20 (6.1)	0.60 (2.2)	Not allowed	5000 (465)
		0.90 (3.4) (see Notes 3 and 5)	Not allowed	3000 (280)
(7) Single-, double-, and multiple-row fixed rack storage on pallets,	Up to 5 (1.5)	0.19 (0.72)	2000 (186)	2000 (186)

Piling Method	Pile Height [ft (m)]	Sprinkler Discharge Density [gpm/ft ² over ft ² mm/min over m ²] (see Note 1)	Areas of Application [ft ² (m ²)] (see Note 1)	
			Ordinary Temperature	High Temperature (see Note 1)
on-side, or on-tread without shelves		See Table 18.4(b) or 0.40 (1.5) plus one level in-rack sprinklers or 0.30 (1.1) plus high-expansion foam	3000 (280)	3000 (280)
	Over 5 (1.5) to 20 (6.1)		3000 (280)	3000 (280)
	Over 20 (6.1) to 30 (9.1)	0.30 (1.1) plus high-expansion foam	Not allowed	3000 (280)
(8) Single-, double-, and multiple-row fixed rack storage without pallets or shelves, on-side or on-tread	Up to 5 (1.5)	0.19 (0.72)	2000 (186)	2000 (186)
	Over 5 (1.5) to 12 (3.7)	0.60 (2.2)	5000 (465)	3000 (280)
		0.40 (1.5) plus one level in-rack sprinklers	3000 (280)	3000 (280)
		0.60 (2.2) plus high-expansion foam	Not allowed	5000 (465)
		0.90 (3.4) plus one level in-rack sprinklers or 0.40 (1.5) plus one level in-rack sprinklers or 0.30 (1.1) plus high-expansion foam	Not allowed	3000 (280)
	Over 12 (3.7) to 20 (6.1)		3000 (280)	3000 (280)
		0.30 (1.1) plus high-expansion foam	3000 (280)	3000 (280)
	Over 20 (6.1) to 30 (9.1)	0.30 (1.1) plus high-expansion foam	Not allowed	3000 (280)

Notes:

(1) Sprinkler discharge densities and areas of application are based on a maximum clearance to ceiling of 10 ft (3.0 m) with the maximum height of storage anticipated.

(2) Laced tires on-floor, vertical stacking on-side (typical truck tires), and off-road tires. Laced tires are not stored to a significant height by this method due to the damage inflicted on the tire (i.e., bead).

(3) Water supply shall fulfill both requirements.

(4) Shelf storage of rubber tires shall be protected as solid rack shelving.

(5) This protection scheme is for use with K-16.8 (240) or larger control mode sprinklers only. Maximum clearance to ceiling can be increased to 14 ft (4.3 m) with this scheme.

Table 21.6.1(b) Control Mode Density/Area Sprinklers System Density (gpm/ft² over ft²) Palletized Portable Rack Storage and Fixed Rack Storage of Rubber Tires with Pallets Over 5 ft (1.5 m) to 20 ft (3.7 m) in Height

Storage Height [ft (m)]	Sprinkler Temperature	
	High Temperature	Ordinary Temperature
>5 to 10 (1.5 to 3.0)	0.32/2000 (1.2/186)	0.32/2000 (1.2/186)
>10 to 12 (3.0 to 3.7)	0.39/2000 (1.5/186)	0.39/2600 (1.5/241)
>12 to 14 (3.7 to 4.3)	0.45/2000 (1.7/186)	0.45/3200 (1.7/300)
>14 to 16 (4.3 to 4.9)	0.5/2300 (1.9/214)	0.5/3700 (1.9/345)
>16 to 18 (4.9 to 5.5)	0.55/2600 (2.1/241)	0.55/4400 (2.1/410)
>18 to 20 (5.5 to 6.1)	0.6/3000 (2.3/280)	0.6/5000 (2.3/465)

21.7 Control Mode Density/Area Sprinkler Protection Criteria for Roll Paper Storage.

21.7.1

Storage of heavyweight or mediumweight classes of rolled paper up to 10 ft (3.0 m) in height shall be protected by sprinklers designed for ordinary hazard Group 2 densities.

21.7.2

Storage of tissue and lightweight classes of paper up to 10 ft (3.0 m) in height shall be protected by sprinklers in accordance with extra hazard Group 1 densities.

21.7.3

Sprinkler design criteria for storage of roll paper 10 ft (3.0 m) high and higher in buildings or structures with roof or ceilings up to 30 ft (9.1 m) shall be in accordance with Table 21.7.3(a) and Table 21.7.3(b).

Table 21.7.3(a) Control Mode Density/Area Sprinkler Protection Criteria for Roll Paper Storage for Buildings or Structures with Roof or Ceilings Up to 30 ft (Discharge Densities are gpm/ft² over ft²)

Storage Height (ft)	Ceiling (ft)	Heavyweight					Mediumweight				Tissue All Storage Arrays
		Closed Array Banded or Unbanded	Standard Array		Open Array		Closed Array Banded or Unbanded	Standard Array		Open Array Banded or Unbanded	
			Banded	Unbanded	Banded	Unbanded		Banded	Unbanded		
10	≤5	0.3/2000	0.3/2000	0.3/2000	0.3/2000	0.3/2000	0.3/2000	0.3/2000	0.3/2000	0.3/2000	0.45/2000
10	>5	0.3/2000	0.3/2000	0.3/2000	0.3/2000	0.3/2000	0.3/2000	0.3/2000	0.3/2000	0.3/2000	0.45/2500
15	≤5	0.3/2000	0.3/2000	0.3/2000	0.3/2500	0.3/3000	0.3/2000	0.3/2000	0.45/2500	0.45/2500	0.60/2000
15	>5	0.3/2000	0.3/2000	0.3/2000	0.3/3000	0.3/3500	0.3/2000	0.3/2500	0.45/3000	0.45/3000	0.60/3000
20	≤5	0.3/2000	0.3/2000	0.3/2500	0.45/3000	0.45/3500	0.3/2000	0.45/2500	0.6/2500	0.6/2500	0.75/2500
20	>5	0.3/2000	0.3/2500	0.3/3000	0.45/3500	0.45/4000	0.3/2500	0.45/3000	0.6/3000	0.6/3000	0.75/3000

Storage Height (ft)	Ceiling (ft)	Heavyweight					Mediumweight				Tissue All Storage Arrays
		Closed Array Banded or Unbanded	Standard Array		Open Array		Closed Array Banded or Unbanded	Standard Array		Open Array Banded or Unbanded	
			Banded	Unbanded	Banded	Unbanded		Banded	Unbanded		
25	≤5	0.45/2500	0.45/3000	0.45/3500	0.6/2500	0.6/3000	0.45/3000	0.6/3000	0.75/2500	0.75/2500	see Note 1

Notes:

(1) Sprinkler protection requirements for tissue stored above 20 ft have not been determined.

(2) Densities or areas, or both, shall be permitted to be interpolated between any 5 ft storage height increment.

Table 21.7.3(b) Control Mode Density/Area Sprinkler Protection Criteria for the Protection of Roll Paper Storage for Buildings or Structures with Roof or Ceilings Up to 9.1 m (Discharge Densities are mm/min over m²)

Storage Height (m)	Ceiling (m)	Heavyweight					Mediumweight				Tissue All Storage Arrays
		Closed Array Banded or Unbanded	Standard Array		Open Array		Closed Array Banded or Unbanded	Standard Array		Open Array Banded or Unbanded	
			Banded	Unbanded	Banded	Unbanded		Banded	Unbanded		
3.0	≤1.5	12.2/186 	12.2/186	12.2/186	12.2/186	12.2/186	12.2/186	12.2/186	12.2/186	12.2/186	18.3/186
3.0	>1.5	12.2/186	12.2/186	12.2/186	12.2/186	12.2/186	12.2/186	12.2/186	12.2/186	12.2/186	18.3/232
4.6	≤1.5	12.2/186	12.2/186	12.2/186	12.2/232	12.2/280	12.2/186	12.2/186	18.3/232	18.3/232	24.5/186
4.6	>1.5	12.2/186	12.2/186	12.2/186	12.2/280	12.2/335	12.2/186	12.2/232	18.3/280	18.3/280	24.5/280
6.1	≤1.5	12.2/186	12.2/186	12.2/280 	18.3/280	18.3/325	12.2/186	18.3/232	24.5/232	24.5/232	30.6/232
6.1	>1.5	12.2/186	12.2/186	12.2/280	18.3/25	18.3/372	12.2/232	18.3/280	24.5/280	24.5/280	30.6/280 
7.6	≤1.5	18.3/232 	18.3/280	18.3/325	24.5/232 	24.5/280	18.3/280	24.5/280	30.6/232 	30.6/232	see Note 1

Notes:

(1) Sprinkler protection requirements for tissue stored above 6.1 m have not been determined.

(2) Densities or areas, or both, shall be permitted to be interpolated between any 1.5 m storage height increment.

21.7.4*

High-temperature sprinklers shall be used for installations protecting roll paper stored 15 ft (4.6 m) or higher.

21.7.5

The protection area per sprinkler shall not exceed 100 ft² (9.3 m²) or be less than 70 ft² (6.5 m²).

21.7.6

Where high-expansion foam systems are installed in heavyweight class and mediumweight class storage areas, sprinkler discharge design densities shall be permitted to be reduced to not less than 0.24 gpm/ft² (9.8 mm/min) with a minimum operating area of 2000 ft² (186 m²).

21.7.7

Where high-expansion foam systems are installed in tissue storage areas, sprinkler discharge densities and areas of application shall not be reduced below those provided in Table 21.7.3(a) and Table 21.7.3(b).

21.8 Special Design for Rack Storage of Class I Through Class IV Commodities and Group A Plastics Stored Up to and Including 25 ft (7.6 m) in Height.

21.8.1 Slatted Shelves.

21.8.1.1*

Slatted rack shelves shall be considered equivalent to solid rack shelves where the shelving is not considered open rack shelving or where the requirements of 21.8.1.2 are not met. (See Section C.20.)

21.8.1.2

A wet pipe system that is designed to provide a minimum of 0.6 gpm/ft² (24.4 mm/min) density over a minimum area of 2000 ft² (186 m²) shall be permitted to protect single-row and double-row racks with slatted rack shelving where all of the following conditions are met:

- (1) Sprinklers shall be K-11.2 (160), K-14.0 (200), or K-16.8 (240) orifice spray sprinklers with a temperature rating of ordinary, intermediate, or high and shall be listed for storage occupancies.
- (2) The protected commodities shall be limited to Class I through Class IV, Group B plastics, Group C plastics, cartoned (expanded and nonexpanded) Group A plastics, and exposed (nonexpanded) Group A plastics.
- (3) Slats in slatted rack shelving shall be a minimum nominal 2 in. (50 mm) thick by maximum nominal 6 in. (150 mm) wide, with the slats held in place by spacers that maintain a minimum 2 in. (50 mm) opening between each slat.
- (4) Where K-11.2 (160), K-14.0 (200), or K-16.8 (240) orifice sprinklers are used, there shall be no slatted shelf levels in the rack above 12 ft (3.7 m). Open rack shelving using wire mesh shall be permitted for shelf levels above 12 ft (3.7 m).
- (5) Transverse flue spaces at least 3 in. (75 mm) wide shall be provided at least every 10 ft (3.0 m) horizontally.
- (6) The aisle widths shall be at least 7½ ft (2.3 m).
- (7) The maximum roof height shall be 27 ft (8.2 m).
- (8) The maximum storage height shall be 20 ft (6.1 m).
- (9) Solid plywood or similar materials shall not be placed on the slatted shelves so that they block the 2 in. (50 mm) spaces between slats, nor shall they be placed on wire mesh shelves.

21.8.1.3 Reduced-Discharge Density.

Where high-expansion foam systems are installed in accordance with NFPA 11, a reduction in sprinkler discharge density to one-half the density specified in Table 21.6.1(a) or 0.24 gpm/ft² (9.8 mm/min), whichever is higher, shall be permitted.

21.9 Sprinkler Design Criteria for Storage and Display of Class I Through Class IV Commodities, Cartoned Nonexpanded Group A Plastics and Nonexpanded Exposed Group A Plastics in Retail Stores.

21.9.1

A wet pipe system designed to meet two separate design points — 0.6 gpm/ft² (24.4 mm/min) density over 2000 ft² (186 m²) and 0.7 gpm/ft² (28.5 mm/min) density for the four hydraulically most demanding sprinklers with 500 gpm (1900 L/min) hose stream allowance for a 2-hour duration — shall be permitted to protect single- and double-row slatted shelf racks when the following conditions are met:

- (1) An extended coverage sprinkler with a nominal K-factor of K-25.2 (360) listed for storage occupancies shall be provided.
- (2) Shelves shall be either open shelving or slatted using a 2 in. (50 mm) thick by maximum 6 in. (150 mm) wide slat held in place by spacers that maintain a minimum 2 in. (50 mm) opening between each slat.
- (3) There shall be no slatted shelf levels in the rack above nominal 12 ft (3.7 m) level. Wire mesh (greater than 50 percent opening) shall be permitted for shelf levels above 12 ft (3.7 m).
- (4) A single level of solid shelving (3½ ft × 8 ft 3 in.) (1.1 m × 2.5 m) shall be permissible at an elevation of not more than 5 ft (1.5 m).
- (5) Perforated metal (open area of 40 percent or more) shall be permitted over either the open shelving or the slatted shelves up to the 60 in. (1.5 m) height.
- (6) Other than what is allowed in this section, solid plywood or similar materials shall not be placed on the slatted shelves.
- (7) Solid displays shall be permissible, provided that all flues are maintained and only one display is installed per bay.
- (8) Maximum roof height shall be 30 ft (9.1 m) in the protected area.
- (9) Maximum storage height shall be 22 ft (6.7 m).
- (10) Aisle widths shall be a minimum of 8 ft (2.4 m).
- (11) Minimum transverse flue spaces of 3 in. every 10 ft (75 mm every 3.0 m) horizontally shall be provided.
- (12) Minimum longitudinal flue spaces of 6 in. (150 mm) shall be provided for double-row racks.
- (13) Storage in the aisle shall be permissible, provided the aisle storage is no more than 4 ft (1.2 m) high and a minimum clear aisle of 4 ft (1.2 m) is maintained.

21.9.2

A wet pipe system designed to meet two separate design points — 0.425 gpm/ft² (17.3 mm/min) density over 2000 ft² (186 m²) and 0.50 gpm/ft² (20.4 mm/min) density for the four hydraulically most demanding sprinklers with 500 gpm (1900 L/min) hose stream allowance for a 2-hour duration — shall be permitted in solid steel cantilever-style retail shelving racks (gondola racks) when the following conditions are met:

- (1) An extended coverage sprinkler with a nominal K-factor of K-25.2 (360) listed for storage occupancies shall be provided.
- (2) The storage height shall not exceed 12 ft (3.7 m).
- (3) The ceiling height shall not exceed 22 ft (6.7 m) in the protected area.
- (4) Gondola rack structure shall not exceed 48 in. (1.2 m) in aggregate depth or 78 in. (2 m) height.
- (5) A minimum aisle of 5 ft (1.5 m) between storage shall be maintained.
- (6) Rack lengths shall be no more than 70 ft (21 m).

21.9.3

A wet system designed to meet two separate design points — 0.425 gpm/ft² (17.3 mm/min) density over 2000 ft² (186 m²) and 0.50 gpm/ft² (20.4 mm/min) density for the four hydraulically most demanding sprinklers with 500 gpm (1900 L/min) hose stream allowance for a 2-hour duration — shall be permitted in solid steel cantilever-style retail shelving racks (gondola racks) when the following conditions are met:

- (1) An extended coverage sprinkler with a nominal K-factor of K-25.2 (360) listed for storage occupancies shall be provided.

- (2) Storage height shall not exceed 15 ft (4.6 m).
- (3) Ceiling height shall not exceed 25 ft (7.6 m) in the protected area.
- (4) Gondola rack structure shall not exceed 60 in. (1.5 m) aggregate depth or 8 ft (2.4 m) in height.
- (5) A perforated metal deck at the 8 ft (2.4 m) level shall be permissible with storage placed on top with or without flue spaces to a maximum height from floor of 15 ft (4.6 m).
- (6) Rack lengths shall not exceed 70 ft (21 m).
- (7) A minimum aisle space of 6 ft (1.8 m) shall be provided.

21.9.4

A wet pipe system designed to meet two separate design points — 0.45 gpm/ft² (18.3 mm/min) density over 2000 ft² (186 m²) and 0.55 gpm/ft² (22.4 mm/min) density for the four hydraulically most demanding sprinklers with 500 gpm (1900 L/min) hose stream allowance for a 2-hour duration — shall be permitted without the use of in-rack sprinklers when the following conditions are met:

- (1) An extended coverage sprinkler with a nominal K-factor of K-25.2 (360) listed for storage occupancies shall be provided.
- (2) Storage height shall not exceed 15 ft (4.6 m).
- (3) Ceiling height shall not exceed 25 ft (7.6 m).
- (4) Shelving structure shall not exceed 48 in. (1.2 m) aggregate depth or 12 ft (3.7 m) in height.
- (5) Shelving shall be permitted to be made of solid particleboard.
- (6) A minimum aisle space of 3 ft (900 mm) shall be maintained.
- (7) Shelving length shall be a maximum of 70 ft (21 m).

21.9.5

A wet pipe system designed to meet two separate design points — 0.38 gpm/ft² (15.5 mm/min) density over 2000 ft² (186 m²) and 0.45 gpm/ft² (18.3 mm/min) density for the four hydraulically most demanding sprinklers with 500 gpm (1900 L/min) hose stream allowance for a 2-hour duration — shall be permitted without the use of in-rack sprinklers in steel retail sales floor shelving racks where the following conditions are met:

- (1) An extended coverage sprinkler with a nominal K-factor of K-25.2 (360) listed for storage occupancies shall be provided.
- (2) Storage height shall not exceed 14 ft (4.3 m).
- (3) Ceiling height shall not exceed 20 ft (6.1 m).
- (4) Solid metal shelving shall be permissible up to the 72 in. (1.8 m) level and wire shelving shall be permissible up to the 10 ft (3.0 m) level.
- (5) The solid metal shelving shall not exceed 66 in. (1.7 m) aggregate depth with a 6 in. (150 mm) longitudinal flue between two 30 in. (750 mm) deep shelves.
- (6) A minimum aisle space of 5 ft (1.5 m) shall be maintained.
- (7) A minimum longitudinal flue of 6 in. (150 mm) shall be maintained.
- (8) Rack length shall be a maximum of 70 ft (21 m).

21.9.6

A wet pipe system designed to meet two separate design points — 0.49 gpm/ft² (20 mm/min) density over 2000 ft² (186 m²) and 0.55 gpm/ft² (22.4 mm/min) density for the four hydraulically most demanding sprinklers with 500 gpm (1900 L/min) hose stream allowance for a 2-hour duration — shall be permitted without the use of in-rack sprinklers in retail solid shelved steel rack structure when the following conditions are met:

- (1) An extended coverage sprinkler with a nominal K-factor of K-25.2 (360) listed for storage occupancies shall be provided.

- (2) Storage height shall not exceed 16.5 ft (5 m).
- (3) Ceiling height shall not exceed 22 ft (6.7 m).
- (4) Shelving structure shall not exceed 51 in. (1.3 m) aggregate depth or 148 in. (3.7 m) height.
- (5) The intersection of perpendicular steel racks shall be permissible as long as no storage is placed within the void space at the junction of the racks.
- (6) The top shelf shall be wire mesh.
- (7) A minimum aisle width of 4 ft (1.2 m) shall be maintained between shelf units and other displays.

21.10 Control Mode Density/Area Sprinkler Protection Criteria for Baled Cotton Storage.

21.10.1

For tiered or rack storage up to a nominal 15 ft (4.6 m) in height, sprinkler discharge densities and areas of application shall be in accordance with Table 21.10.1.

Table 21.10.1 Baled Cotton Storage Up to and Including 15 ft (4.6 m)

System Type	Discharge Density per Area [gpm/ft ² over (ft ² (mm/min over m ²)]		
	Tiered Storage	Rack Storage	Untiered Storage
Wet	0.25/3000 (0.95/100)	0.33/3000 (1.2/250)	0.15/3000 (0.57/100)
Dry	0.25/3900 (0.95/360)	0.33/3900 (1.2/360)	0.15/3900 (0.57/360)

21.10.2

Where roof or ceiling heights would prohibit storage above a nominal 10 ft (3 m), the sprinkler discharge density shall be permitted to be reduced by 20 percent of that indicated in Table 21.10.1 but shall not be reduced to less than 0.15 gpm/ft² (6.1 mm/min).

21.11 Control Mode Density/Area Sprinkler Protection Criteria for Carton Records Storage with Catwalk Access.

21.11.1

Carton records storage shall be permitted to be protected in accordance with the succeeding subsections of Section 21.11.

21.11.2

Carton records storage shall be permitted to be supported on shelving that is a minimum of 50 percent open from approved flue space to approved flue space.

21.11.2.1

Transverse flue spaces of a nominal 6 in. (150 mm) width shall be located at each rack upright.

21.11.2.2

Rack uprights shall be installed on a maximum of 10 ft 6 in. (3.2 m) centers.

21.11.2.3

Longitudinal flues shall not be required.

21.11.3

The storage rack structure for carton records storage shall consist of either of the following:

- (1) A single-row rack not greater than 72 in. (1.8 m) deep
- (2) Double-row racks having a total depth of not greater than 102 in. (2.6 m) to aisle

21.11.3.1

Each storage rack shall be separated from other storage racks by aisles that are not less than 30 in. (750 mm) and not more than 36 in. (900 mm) in width.

21.11.3.2

Aisles used for ingress and egress shall be permitted to be up to 44 in. (1.1 m) wide when solid decking is used.

21.11.4

Catwalk aisles between racks shall be constructed of open metal grating that is at least 50 percent open.

21.11.4.1

Catwalk aisles at the ends of racks shall be permitted to be constructed of solid materials.

21.11.5

Catwalks shall be installed at a maximum of 12 ft (3.7 m) apart vertically.

21.11.6 Sprinkler Criteria.

21.11.6.1

Cartoned record storage in racks with access utilizing catwalks shall be protected in accordance with this subsection.

21.11.6.2

The design criteria for the ceiling sprinkler system shall be in accordance with Table 21.11.6.2.

Table 21.11.6.2 Ceiling Sprinkler Design Criteria for Carton Record Storage

	Up to 25 ft (7.6 m) High Storage		Over 25 ft (7.6 m) High Storage	
	Ordinary Temperature	High Temperature	Ordinary Temperature	High Temperature
Density				
gpm/ft ²	0.33	0.29	0.3	0.4
mm/min	13.4	11.8	12.2	16.3
Area ft ²	2000	2000	2000	2000
m ²	186	186	186	186
Hose Allowance				
(gpm)	500	500	500	500
L/m	1900	1900	1900	1900
Duration				
(hours)	2	2	2	2

21.11.6.2.1

Ceiling sprinklers spaced to cover a maximum of 100 ft² (9.3 m²) shall be standard-response spray sprinklers with K-factors per Section 12.6.

21.11.6.3

Intermediate-level sprinklers shall be installed at each catwalk level in accordance with 21.11.6.3.1 through 21.11.6.3.4 and shall be quick-response, ordinary temperature, nominal K-5.6 (80), K-8.0 (115), or K-11.2 (160).

21.11.6.3.1

Intermediate-level sprinklers shall be installed in the center ± 4 in. (100 mm) of each aisle below each catwalk level.

21.11.6.3.2

Intermediate-level sprinklers shall be installed a minimum 6 in. (150 mm) above the top of storage.

21.11.6.3.3

Sprinklers shall be supplied from the in-rack sprinkler system.

21.11.6.3.4

Spacing of sprinklers within the aisles shall be located so as to align with the transverse flues and the center of the storage unit when staggered and shall not exceed 10 ft 6 in. (3.2 m) on center.

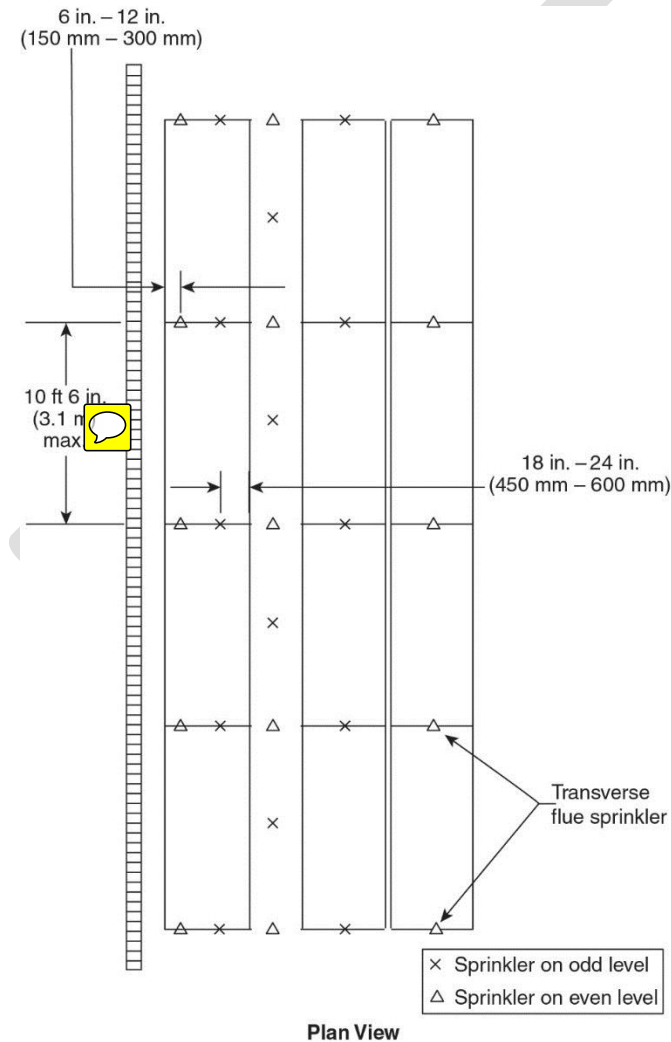
21.11.6.3.5*

Sprinklers installed below each catwalk level shall be staggered vertically and horizontally. [See Figure A.21.11.6.3.5(a) and Figure A.21.11.6.3.5(b).]

21.11.6.4

Sprinklers shall be provided in transverse flue spaces in accordance with 21.11.6.4.1 through 21.11.6.4.3.1 and Figure 21.11.6.4.

Figure 21.11.6.4 Sprinkler Location and Spacing in Transverse Flues.



21.11.6.4.1

For double- and multiple-row racks, in-rack sprinklers shall be installed in the transverse flues at each catwalk level and shall be staggered vertically. For single-row racks, in-rack sprinklers shall be installed in the transverse flue at each catwalk level.

21.11.6.4.2

For double- and multiple-row racks sprinklers installed in the transverse flues shall be located not less than 18 in. (450 mm) but not greater than 24 in. (600 mm) from the face of the rack on the catwalk side.

21.11.6.4.3

For single-row racks, sprinklers installed in the transverse flues shall be staggered horizontally such that the sprinkler at first level is not less than 18 in. (450 mm) but not greater than 24 in. (600 mm) from the face of the rack on the catwalk side.

21.11.6.4.3.1

At the next level the sprinkler in the transverse flue shall be located not less than 6 in. (150 mm) but not greater than 12 in. (300 mm) from the back face of the rack. This staggering shall be repeated throughout all catwalk levels.

21.11.6.4.4

In-rack sprinklers shall be installed a minimum 6 in. (150 mm) above the top of storage.

21.11.6.4.5

Transverse flue sprinklers shall be quick-response, ordinary temperature, nominal K-5.6 (80), K-8.0 (115), or K-11.2 (160) and installed in accordance with Figure A.21.11.6.3.5(a) and Figure A.21.11.6.3.5(b).

21.11.6.5

For multiple-level catwalk systems, a minimum of 10 sprinklers, five on each of the top two levels, shall be calculated with a minimum flow rate of 30 gpm (115 L/min) per sprinkler. Calculated sprinklers shall be the hydraulically most demanding on each level.

21.11.6.5.1

For single-level catwalks, a minimum of six sprinklers shall be calculated with a minimum flow rate at 30 gpm (115 L/min) per sprinkler. Calculated sprinklers shall be the hydraulically most demanding.

21.11.6.5.2

The in-rack sprinkler system shall be balanced in with the ceiling system.

21.12 Control Mode Density/Area Sprinkler Protection Criteria for Compact Storage of Commodities Consisting of Paper Files, Magazines, Books, and Similar Documents in Folders and Miscellaneous Supplies with No More Than 5 Percent Plastics Up to 8 ft (2.4 m) High.

21.12.1*

Compact storage modules up to 8 ft (2.4 m) high storing commodities consisting of paper files, magazines, books, and similar documents in folders and miscellaneous supplies with no more than 5 percent plastics shall be permitted to be classified as light hazard.

21.12.2

The top of the compact storage module shall be at least 18 in. (450 mm) below the sprinkler deflector.

21.12.3

Sprinklers shall be ordinary temperature, quick-response, standard spray upright or pendent.

21.12.4

The compact storage module shall be provided with minimum solid steel 24 gauge (0.63 mm) metal longitudinal barriers installed every third carriage.

21.12.5*

Solid 24 (0.63 mm) gauge metal transverse barriers shall be spaced not more than 4 ft (1.2 m) apart.

21.12.6

Compact storage module sizes shall not exceed 250 ft² (23.2 m²).

21.12.6.1

The size of a module shall be defined as the area of compact storage bound by the length of the carriages times the distance between longitudinal barriers or to the outward edge of a fixed storage unit in the module, including the width of the aisle in the module.

21.12.6.2

The lengths of the carriages shall be measured to the end of the carriages enclosed by solid metal transverse panels and separated by a minimum 28 in. (700 mm) aisle to a storage unit perpendicular to the carriage.

Chapter 22 CMSA Requirements for Storage Applications

22.1 General.

The criteria in Chapter 20 shall apply to storage protected with CMSA sprinklers.

22.1.1

Quick-response CMSA sprinklers designed to meet any criteria in Chapter 20 through Chapter 25 shall be permitted to protect any of the following:

- (1) Light hazard occupancies
- (2) Ordinary hazard occupancies

22.1.2

Standard-response CMSA sprinklers designed to meet any criteria in Chapter 20 through Chapter 25 shall be permitted to protect ordinary hazard occupancies.

22.1.3

When using CMSA, the design area shall meet the requirements of 23.4.4.3.1.

22.1.4

Protection shall be provided as specified in Table 22.4 or appropriate NFPA standards in terms of minimum operating pressure and the number of sprinklers to be included in the design area.

22.1.5 Open Wood Joist Construction.

22.1.5.1

Where CMSA sprinklers are installed under open wood joist construction, one of the following shall be provided:

- (1) A minimum pressure of 50 psi (3.4 bar) for K-11.2 (160) sprinklers
- (2) A minimum pressure of 22 psi (1.5 bar) for K-16.8 (240) sprinklers
- (3) The pressure from Table 22.4 for K-19.6 (280) or larger sprinkler.
- (4) The pressure from Table 22.4 for K-11.2 (160) or K-16.8 (240) where each joist channel is fully separated with material equal to the joist material to its full depth at intervals not exceeding 20 ft (6.1 m).

22.1.5.2 Preaction Systems.

22.1.5.2.1

For the purpose of using Table 22.2, preaction systems shall be classified as dry pipe systems.

22.1.5.3

Building steel shall not require special protection where Table 22.2 are applied as appropriate for the storage configuration.

22.1.5.4* Storage Conditions.

The design of the sprinkler system shall be based on those conditions that routinely or periodically exist in a building and create the greatest water demand, which include the following:

- (1) Pile height
- (2) Clearance to ceiling
- (3) Pile stability
- (4) Array

22.1.6*

The ceiling design criteria for single-, double-, and multiple-row racks in Chapter 16 shall be based on open rack configurations as defined in 3.3.141.

22.1.7

CMSA sprinklers shall not be permitted to protect storage on solid shelf racks unless the solid shelf racks are protected with in-rack sprinklers in accordance with 16.1.6.

22.1.7.1

Where solid shelves are used, in-rack sprinklers shall be installed in every level below the highest solid shelf.

22.1.8*

Protection criteria for Group A plastics shall be permitted for the protection of the same storage height and configuration of Class I, II, III, and IV commodities.

22.2

Protection of palletized and solid-piled storage of Class I through Class IV commodities shall be in accordance with Table 22.2.

Table 22.2 CMSA Sprinkler Design Criteria for Palletized and Solid-Piled Storage of Class I Through Class IV Commodities (Encapsulated and Nonencapsulated)

Configuration	Commodity Class	Maximum Storage Height		Maximum Ceiling/Roof Height		K-Factor/ Orientation	Type of System	Number of Design Sprinklers	Minimum Operating Pressure	
		ft	m	ft	m				psi	bar
Palletized	Class I or II	20	6.1	30	9.1	25.2 (360) Pendent	Wet	15	10	0.7
				40	12.1	25.2 (360) Pendent	Wet	15	23	1.6
		25	7.6	30	9.1	11.2 (160) Upright	Wet	15	25	1.7
							Dry	25	25	1.7
						16.8 (240) Upright	Wet	15	10	0.7
							Dry	25	15	1.0
						19.6 (280) Pendent	Wet	15	16	1.1
						25.2 (360) Pendent	Wet	15	10	0.7
				35	11	11.2 (160) Upright	Wet	15	25	1.7
							Dry	25	25	1.7
						16.8 (240) Upright	Wet	15	15	1.0
							Dry	25	15	1.0
				40	12.1	25.2 (360) Pendent	Wet	15	23	1.6
		30	9.1	35	11	19.6 (280) Pendent	Wet	15	25	1.7
				40	12.1	25.2 (360) Pendent	Wet	15	23	1.6

Configuration	Commodity Class	Maximum Storage Height		Maximum Ceiling/Roof Height		K-Factor/ Orientation	Type of System	Number of Design Sprinklers	Minimum Operating Pressure	
		ft	m	ft	m				psi	bar
		35	11	40	12	19.6 (280) Pendent	Wet	15	30	2.1
						25.2 (360) Pendent	Wet	15	23	1.6
	Class III	20	6.1	30	9.1	25.2 (360) Pendent	Wet	15	10	0.7
				40	12	25.2 (360) Pendent	Wet	15	23	1.6
		25	7.6	30	9.1	11.2 (160) Upright	Wet	15	25	1.7
							Dry	25	25	1.7
						16.8 (240) Upright	Wet	15	15	1.0
							Dry	25	15	1.0
						19.6 (280) Pendent	Wet	15	16	1.1
						25.2 (360) Pendent	Wet	15	16	1.1
				35	11	11.2 (160) Upright	Wet	15	25	1.7
							Dry	25	25	1.7
						16.8 (240) Upright	Wet	15	15	1.0
							Dry	25	15	1.0
				40	12	25.2 (360) Pendent	Wet	15	23	1.6
		30	9.1	35	11	19.6 (280) Pendent	Wet	15	25	1.7
				40	12	25.2 (360) Pendent	Wet	15	23	1.6
		35	11	40	12	19.6 (280) Pendent	Wet	15	30	2.1
				40	12	25.2 (360) Pendent	Wet	15	23	1.6
	Class IV	20	6.1	30	9.1	11.2 (160) Upright	Wet	20	25	1.7
								15	50	3.4
						16.8 (240) Upright	Wet	20	15	1.0
								15	22	1.5
						19.6 (280) Pendent	Wet	15	16	1.1

Configuration	Commodity Class	Maximum Storage Height		Maximum Ceiling/Roof Height		K-Factor/ Orientation	Type of System	Number of Design Sprinklers	Minimum Operating Pressure	
		ft	m	ft	m				psi	bar
						25.2 (360) Pendent	Wet	15	10	0.7
				40	12	25.2 (360) Pendent	Wet	15	23	1.6
		25	7.6	30	9.1	16.8 (240) Upright	Wet	15	22	1.5
						19.6 (280) Pendent	Wet	15	16	1.1
						25.2 (360) Pendent	Wet	15	10	0.7
				40	12	25.2 (360) Pendent	Wet	15	23	1.6
		30	9.1	35	11	19.6 (280) Pendent	Wet	15	25	1.7
				40	12	25.2 (360) Pendent	Wet	15	23	1.6
		35	11	40	12	19.6 (280) Pendent	Wet	15	30	2.1
						25.2 (360) Pendent	Wet	15	23	1.6
Solid piled	Class I or II	20	6.1	30	9.1	11.2 (160) Upright	Wet	15	25	1.7
						11.2 (160) Upright	Dry	25	25	1.7
						16.8 (240) Upright	Wet	15	10	0.7
						16.8 (240) Upright	Dry	25	15	1.0
						19.6 (280) Pendent	Wet	15	16	1.1
						25.2 (360) Pendent	Wet	15	10	0.7
				40	12	25.2 (360) Pendent	Wet	15	23	1.6
		25	7.6	30	9.1	16.8 (240) Upright	Wet	15	10	0.7
						19.6 (280) Pendent	Wet	15	16	1.1
						25.2 (360) Pendent	Wet	15	10	0.7
				40	12	25.2 (360) Pendent	Wet	15	23	1.6

Configuration	Commodity Class	Maximum Storage Height		Maximum Ceiling/Roof Height		K-Factor/ Orientation	Type of System	Number of Design Sprinklers	Minimum Operating Pressure	
		ft	m	ft	m				psi	bar
		30	9.1	35	11	19.6 (280) Pendent	Wet	15	25	1.7
				40	12	25.2 (360) Pendent	Wet	15	23	1.6
		35	11	40	12	19.6 (280) Pendent	Wet	15	30	2.1
						25.2 (360) Pendent	Wet	15	23	1.6
	Class III	20	6.1	30	9.1	11.2 (160) Upright	Wet	15	25	1.7
							Dry	25	25	1.7
						16.8 (240) Upright	Wet	15	15	1.0
							Dry	25	15	1.0
						19.6 (280) Pendent	Wet	15	16	1.1
						25.2 (360) Pendent	Wet	15	10	0.7
		25	7.6	30	9.1	25.2 (360) Pendent	Wet	15	23	1.6
						16.8 (240) Upright	Wet	15	22	1.5
						19.6 (280) Pendent	Wet	15	16	1.1
						25.2 (360) Pendent	Wet	15	10	0.7
						25.2 (360) Pendent	Wet	15	23	1.6
		30	9.1	35	11	19.6 (280) Pendent	Wet	15	25	1.7
				40	12	25.2 (360) Pendent	Wet	15	23	1.6
		35	11	40	12	19.6 (280) Pendent	Wet	15	30	2.1
						25.2 (360) Pendent	Wet	15	23	1.6
	Class IV	20	6.1	30	9.1	11.2 (160) Upright	Wet	15	50	3.4
						16.8 (240) Upright	Wet	15	22	1.5

Configuration	Commodity Class	Maximum Storage Height		Maximum Ceiling/Roof Height		K-Factor/ Orientation	Type of System	Number of Design Sprinklers	Minimum Operating Pressure	
		ft	m	ft	m				psi	bar
						19.6 (280) Pendent	Wet	15	16	1.1
						25.2 (360) Pendent	Wet	15	10	0.7
				40	12	25.2 (360) Pendent	Wet	15	23	1.6
		25	7.6	30	9.1	16.8 (240) Upright	Wet	15	22	1.5
						19.6 (280) Pendent	Wet	15	16	1.1
						25.2 (360) Pendent	Wet	15	10	0.7
				40	12	25.2 (360) Pendent	Wet	15	23	1.6
		30	9.1	35	11	19.6 (280) Pendent	Wet	15	25	1.7
				40	12	25.2 (360) Pendent	Wet	15	23	1.6
		35	11	40	12	19.6 (280) Pendent	Wet	15	30	2.1
						25.2 (360) Pendent	Wet	15	23	1.6

22.3

Protection of palletized and solid-piled storage of nonexpanded and expanded Group A plastic commodities shall be in accordance with Table 22.3.

Table 22.3 CMSA Sprinkler Design Criteria for Palletized and Solid-Piled Storage of Group A Plastic Commodities

Storage Arrangement	Commodity Class	Maximum Storage Height		Maximum Ceiling/Roof Height		K-Factor/Orientation	Type of System	Number of Design Sprinklers	Minimum Operating Pressure	
		ft	m	ft	m				psi	bar
Palletized	Cartoned nonexpanded plastics	20	6.1	30	9.1	11.2 (160) Upright	Wet	25	25	1.7
						16.8 (240) Upright	Wet	15	22	1.5
						19.6 (280) Pendent	Wet	15	16	1.1
						25.2 (360) Pendent	Wet	15	10	0.7

Storage Arrangement	Commodity Class	Maximum Storage Height		Maximum Ceiling/Roof Height		K-Factor/Orientation	Type of System	Number of Design Sprinklers	Minimum Operating Pressure	
		ft	m	ft	m				psi	bar
				40	12	25.2 (360) Pendent	Wet	15	23	1.6
		25	7.6	30	9.1	16.8 (240) Upright	Wet	15	22	1.5
						19.6 (280) Pendent	Wet	15	16	1.1
						25.2 (360) Pendent	Wet	15	10	0.7
				40	12	25.2 (360) Pendent	Wet	15	23	1.6
		30	9.1	35	11	19.6 (280) Pendent	Wet	15	25	1.7
				40	12.1	25.2 (360) Pendent	Wet	15	23	1.6
		35	11	40	12	19.6 (280) Pendent	Wet	15	30	2.1
						25.2 (360) Pendent	Wet	15	23	1.6
Solid piled	Cartoned nonexpanded plastics	20	6.1	30	9.1	11.2 (160) Upright	Wet	15	50	3.4
						16.8 (240) Upright	Wet	15	22	1.5
						19.6 (280) Pendent	Wet	15	16	1.1
						25.2 (360) Pendent	Wet	15	10	0.7
				40	12	25.2 (360) Pendent	Wet	15	23	1.6
		25	7.6	30	9.1	16.8 (240) Upright	Wet	15	22	1.5
						19.6 (280) Pendent	Wet	15	16	1.1
						25.2 (360) Pendent	Wet	15	10	0.7
				40	12	25.2 (360) Pendent	Wet	15	23	1.6
		30	9.1	35	11	19.6 (280) Pendent	Wet	15	25	1.7
				40	12	25.2 (360) Pendent	Wet	15	23	1.6
		35	11	40	12	19.6 (280) Pendent	Wet	15	30	2.1

Storage Arrangement	Commodity Class	Maximum Storage Height		Maximum Ceiling/Roof Height		K-Factor/Orientation	Type of System	Number of Design Sprinklers	Minimum Operating Pressure	
		ft	m	ft	m				psi	bar
						25.2 (360) Pendent	Wet	15	23	1.6
Palletized	Exposed nonexpanded plastics	20	6.1	30	9.1	11.2 (160) Upright	Wet	25	25	1.7
						16.8 (240) Upright	Wet	15	22	1.5
		25	7.6	30	9.1	16.8 (240) Upright	Wet	15	22	1.5
	Cartoned or exposed expanded plastics	18	5.5	26	7.9	11.2 (160) Upright	Wet	15	50	3.4
						16.8 (240) Upright	Wet	15	22	1.5
Solid piled	Cartoned or exposed nonexpanded plastics	20	6.1	30	9.1	11.2 (160) Upright	Wet	15	50	3.4
		25	7.6	30	9.1	16.8 (240) Upright	Wet	15	22	1.5

22.4

Protection of single-, double-, and multiple-row rack storage for Class I through Class IV commodities shall be in accordance with Table 22.4.

Table 22.4 CMSA Sprinkler Design Criteria for Rack Storage of Class I Through Class IV Commodities (Encapsulated and Nonencapsulated)

Storage Arrangement	Commodity Class	Maximum Storage Height		Maximum Ceiling/Roof Height		K-Factor/Orientation	Type of System	Number of Design Sprinklers	Minimum Operating Pressure	
		ft	m	ft	m				psi	bar
Single-, double-, and multiple-row racks (no open-top containers)	Class I or II	20	6.1	30	9.1	11.2 (160) Upright	Wet	15	25	1.7
							Dry	25	25	1.7
						16.8 (240) Upright	Wet	15	10	0.7
							Dry	25	15	1.0
						19.6 (280) Pendent	Wet	15	16	1.1
						25.2 (360) Pendent	Wet	15	10	0.7
		25	7.6	40	12.2	25.2 (360) Pendent	Wet	15	23	1.6
				30	9.1	11.2 (160) Upright	Wet	20	25	1.7
							Dry	30	25	1.7
						16.8 (240) Upright	Wet	15	10	0.7
							Dry	30	15	1.0

Storage Arrangement	Commodity Class	Maximum Storage Height		Maximum Ceiling/Roof Height		K-Factor/ Orientation	Type of System	Number of Design Sprinklers	Minimum Operating Pressure	
		ft	m	ft	m				psi	bar
						19.6 (280) Pendent	Wet	15	16	1.1
						25.2 (360) Pendent	Wet	15	10	0.7
						25.2 (360) Pendent	Wet	15	23	1.6
						11.2 (160) Upright	Wet	15	25	1.7
						11.2 (160) Upright	Dry	25	25	1.7
						16.8 (240) Upright	Wet	15	15	1.0
						16.8 (240) Upright	Dry	25	15	1.0
						19.6 (280) Pendent	Wet	15	16	1.1
						25.2 (360) Pendent	Wet	15	10	0.7
						25.2 (360) Pendent	Wet	15	23	1.6
	Class III	20	6.1	30	9.1	11.2 (160) Upright	Wet	15 + 1 level of in-rack	25	1.7
						11.2 (160) Upright	Dry	25 + 1 level of in-rack	25	1.7
						16.8 (240) Upright	Wet	15	22	1.5
						16.8 (240) Upright	Dry	25 + 1 level of in-rack	15	1.0
						19.6 (280) Pendent	Wet	15	16	1.1
						25.2 (360) Pendent	Wet	15	10	0.7
				35	10.7	11.2 (160) Upright	Wet	15 + 1 level of in-rack	25	1.7
						11.2 (160) Upright	Dry	25 + 1 level of in-rack	25	1.7
						16.8 (240) Upright	Wet	15 + 1 level of in-rack	15	1.0
						16.8 (240) Upright	Wet	15 + 1 level of in-rack	15	1.0

Storage Arrangement	Commodity Class	Maximum Storage Height		Maximum Ceiling/Roof Height		K-Factor/ Orientation	Type of System	Number of Design Sprinklers	Minimum Operating Pressure	
		ft	m	ft	m				psi	bar
							Dry	25 + 1 level of in-rack	15	1.0
						19.6 (280) Pendent	Wet	15	25	1.7
				40	11.6	19.6 (280) Pendent	Wet	15	30	2.1
						25.2 (360) Pendent	Wet	15	23	1.6
	Class IV	20	6.1	25	7.6	11.2 (160) Upright	Wet	15	50	3.4
						16.8 (240) Upright	Wet	15	22	1.5
						19.6 (280) Pendent	Wet	15	16	1.1
				30	9.1	11.2 (160) Upright	Wet	20	50	3.4
								15	75	5.2
						16.8 (240) Upright	Wet	15	22	1.5
						19.6 (280) Pendent	Wet	15	16	1.1
						25.2 (360) Pendent	Wet	15	10	0.7
				40	12.1	25.2 (360) Pendent	Wet	15	23	1.6
		25	7.6	30	9.1	11.2 (160) Upright	Wet	15 + 1 level of in-rack	50	3.4
						16.8 (240) Upright	Wet	15	22	1.5
						19.6 (280) Pendent	Wet	15	16	1.1
						25.2 (360) Pendent	Wet	15	10	0.7
				35	10.4	11.2 (160) Upright	Wet	20 + 1 level of in-rack	50	3.4
								15 + 1 level of in-rack	75	5.2

Storage Arrangement	Commodity Class	Maximum Storage Height		Maximum Ceiling/Roof Height		K-Factor/ Orientation	Type of System	Number of Design Sprinklers	Minimum Operating Pressure	
		ft	m	ft	m				psi	bar
						16.8 (240) Upright	Wet	20 + 1 level of in-rack	22	1.5
								15 + 1 level of in-rack	35	2.4
						19.6 (280) Pendent	Wet	15	25	1.7
				40		19.6 (280) Pendent	Wet	15	30	2.1
						25.2 (360) Pendent	Wet	15	23	1.6

22.5

Protection of single-, double-, and multiple-row rack storage for nonexpanded Group A plastic commodities shall be in accordance with Table 22.5.

Table 22.5 CMSA Sprinkler Design Criteria for Single-, Double-, and Multiple-Row Racks of Group A Plastic Commodities Stored Up and Including 25 ft (7.6 m) in Height

Storage Arrangement	Commodity Class	Maximum Storage Height		Maximum Ceiling/Roof Height		K-Factor/ Orientation	Type of System	Number of Design Sprinklers	Minimum Operating Pressure	
		ft	m	ft	m				psi	bar
Single-, double-, and multiple-row racks (no open-top containers)	Cartoned nonexpanded plastics	20	6.1	25	7.6	11.2 (160) Upright	Wet	15	50	3.4
						16.8 (240) Upright	Wet	15	22	1.5
						19.6 (280) Pendent	Wet	15	16	1.1
				30	9.1	11.2 (160) Upright	Wet	30	50	3.4
						20	Wet	75	5.2	
						16.8 (240) Upright	Wet	15*	22	1.5
						19.6 (280) Pendent	Wet	15	16	1.1
		25	7.6	30	9.1	11.2 (160) Upright	Wet	15 + 1 level of in-rack	50	3.4
						16.8 (240) Upright	Wet	15*	22	1.5
						19.6 (280) Pendent	Wet	15	16	1.1

Storage Arrangement	Commodity Class	Maximum Storage Height		Maximum Ceiling/Roof Height		K-Factor/ Orientation	Type of System	Number of Design Sprinklers	Minimum Operating Pressure	
		ft	m	ft	m				psi	bar
		25	7.6	35	11	11.2 (160) Upright	Wet	30 + 1 level of in-rack	50	3.4
						16.8 (240) Upright	Wet	20 + 1 level of in-rack	75	5.2
							Wet	30 + 1 level of in-rack	22	1.5
						19.6 (280) Pendent	Wet	20 + 1 level of in-rack	35	2.4
							Wet	15	25	1.7
	Exposed nonexpanded plastics	20	6.1	25	7.6	11.2 (160) Upright	Wet	15	50	3.4
						16.8 (240) Upright	Wet	15	22	1.5
		20	6.1	30	9.1	11.2 (160) Upright	Wet	30	50	3.4
						16.8 (240) Upright	Wet	20	75	5.2
							Wet	15*	22	1.5
		25	7.6	30	9.1	11.2 (160) Upright	Wet	15 + 1 level of in-rack	50	3.4
						16.8 (240) Upright	Wet	15*	22	1.5
		25	7.6	35	11	11.2 (160) Upright	Wet	30 + 1 level of in-rack	50	3.4
							Wet	20 + 1 level of in-rack	75	5.2
						16.8 (240) Upright	Wet	30 + 1 level of in-rack	22	1.5
							Wet	20 + 1 level of in-rack	35	2.4

*Minimum 8 ft (2.4 m) aisle.

22.6 Rubber Tires.

Protection of rubber tires with CMSA sprinklers shall be in accordance with Table 22.6.

22.7 Roll Paper Storage.

Protection of roll paper storage with CMSA sprinklers shall be in accordance with Table 22.7.

Table 22.7 Protection of Roll Paper Storage [Number of Sprinklers at Operating Pressure, psi (bar)]

Storage Height		Maximum Building Height		Nominal K-Factor	Type of System	Heavyweight					Mediumweight					Tissue All Storage Arrays
						Closed Array	Standard Array		Open Array		Closed Array	Standard Array		Open Array		
ft	m	ft	m			Banded or Unbanded	Banded	Unbanded	Banded	Unbanded	Banded or Unbanded	Banded	Unbanded	Banded	Unbanded	
20	6.1	30	9.1	11.2 (160)	Wet	15 at 50(3.4)	15 at 50(3.4)	15 at 50(3.4)	15 at 50(3.4)	NA	15 at 50(3.4)	15 at 50(3.4)	15 at 50(3.4)	NA	NA	See Note
20	6.1	30	9.1	11.2 (160)	Dry	25 at 50(3.4)	25 at 50(3.4)	25 at 50(3.4)	NA	NA	25 at 50(3.4)	25 at 50(3.4)	25 at 50(3.4)	NA	NA	NA
26	7.9	60	18	11.2 (160)	Wet	15 at 50(3.4)	15 at 50(3.4)	15 at 50(3.4)	15 at 50(3.4)	NA	NA	NA	NA	NA	NA	NA
20	6.1	30	9.1	16.8 (240)	Wet	15 at 22(1.5)	15 at 22(1.5)	15 at 22(1.5)	15 at 22(1.5)	NA	15 at 22(1.5)	15 at 22(1.5)	15 at 22(1.5)	NA	NA	See Note
20	6.1	30	9.1	16.8 (240)	Dry	25 at 22(1.5)	25 at 22(1.5)	25 at 22(1.5)	NA	NA	25 at 22(1.5)	25 at 22(1.5)	25 at 22(1.5)	NA	NA	NA
26	7.9	60	18	16.8 (240)	Wet	15 at 22(1.5)	15 at 22(1.5)	15 at 22(1.5)	15 at 22(1.5)	NA	NA	NA	NA	NA	NA	NA

Note: Base design on 25 AS at 75 psi (5.2 bar) for K-11.2 (160) sprinklers or 25 AS at 35 psi (240) for K-16.8 (240) sprinklers when storage is in closed or standard array; other arrays NA.

NA: Not applicable.

Chapter 23 ESFR Requirements for Storage Applications

23.1 General.

The criteria in Chapter 20 shall apply to storage protected with ESFR sprinklers.

23.1.1

ESFR sprinklers designed to meet any criteria in this chapter shall be permitted to protect any of the following:

- (1) Light hazard occupancies
- (2) Ordinary hazard occupancies
- (3) Any storage arrangement OH1, OH2, EH1, and EH2 design criteria

23.1.2 Draft Curtains.

23.1.2.1

Where ESFR sprinkler systems are installed adjacent to sprinkler systems with standard-response sprinklers, a draft curtain of noncombustible construction and at least 2 ft (600 mm) in depth shall be required to separate the two areas.

23.1.2.2

A clear aisle of at least 4 ft (1.2 m) centered below the draft curtain shall be maintained for separation.

23.1.2.3 Temperature Ratings.

Sprinkler temperature ratings for ESFR sprinklers shall be ordinary unless 8.3.2 requires intermediate- or high-temperature ratings.

23.1.3

ESFR sprinkler systems shall be designed such that the minimum operating pressure is not less than that indicated in Table 23.3.1 for commodity, storage height, and building height involved.

23.1.4

The ceiling design criteria for single-, double-, and multiple-row racks in Chapter 23 shall be based on open rack configurations as defined in 3.9.3.7.4.

23.1.4.1

ESFR sprinklers shall not be permitted to protect storage on solid shelf racks unless the solid shelf racks are protected with in-rack sprinklers in accordance with Chapter 25.

23.1.4.2

ESFR sprinklers shall not be permitted to protect storage on solid shelf racks unless the solid shelf racks are protected with in-rack sprinklers in accordance with 16.1.6.

23.1.4.2.1

Where solid shelves are used, in-rack sprinklers shall be installed in every level below the highest solid shelf.

23.1.4.3

ESFR sprinklers shall not be permitted to protect storage with open top containers.

23.1.4.4

ESFR sprinkler systems shall be designed such that the minimum operating pressure is not less than that indicated in Table 23.5.1 for type of storage, commodity, storage height, and building height involved.

23.2 ESFR Design Criteria.

ESFR design criteria shall be selected from Section 23.3 through Section 23.13.

23.3 Early Suppression Fast-Response (ESFR) Sprinklers for Palletized or Solid-Piled Storage of Class I Through Class IV Commodities.

23.3.1

Protection of palletized and solid-piled storage of Class I through Class IV commodities shall be in accordance with Table 23.3.1.

Table 23.3.1 ESFR Protection of Palletized and Solid-Piled Storage of Class I Through Class IV Commodities

Commodity	Maximum Storage Height		Maximum Ceiling/Roof Height		Nominal K-Factor	Orientation	Minimum Operating Pressure	
	ft	m	ft	m			psi	bar
Class I, II, III, or IV, encapsulated and nonencapsulated (no open-top containers)	20	6.1	25	7.6	14.0 (200)	Upright/pendent	50	3.4
					16.8 (240)	Upright/pendent	35	2.4
					22.4 (320)	Pendent	25	1.7
					25.2 (360)	Pendent	15	1.0
	25	7.6	30	9.1	14.0 (200)	Upright/pendent	50	3.4
					16.8 (240)	Upright/pendent	35	2.4
					22.4 (320)	Pendent	25	1.7
					25.2 (360)	Pendent	15	1.0
			32	10	14.0 (200)	Upright/pendent	60	4.1
					16.8 (240)	Upright/pendent	42	2.9
	30	9.1	35	11	14.0 (200)	Upright/pendent	75	5.2
					16.8 (240)	Upright/pendent	52	3.6
					22.4 (320)	Pendent	35	2.4
					25.2 (360)	Pendent	20	1.4
	35	11	40	12	16.8 (240)	Pendent	52	3.6
					22.4 (320)	Pendent	40	2.7
					25.2 (360)	Pendent	25	1.7
	35	11	45	14	22.4 (320)	Pendent	40	2.7
					25.2 (360)	Pendent	40	2.7
	40	12	45	14	22.4 (320)	Pendent	40	2.7
					25.2 (360)	Pendent	40	2.7

23.4 Early Suppression Fast-Response (ESFR) Sprinklers for Palletized or Solid-Piled Storage of Group A Plastic Commodities.

23.4.1* Storage Conditions.

The design of the sprinkler system shall be based on those conditions that routinely or periodically exist in a building and create the greatest water demand, which include the following:

- (1) Pile height
- (2) Clearance to ceiling
- (3) Pile stability

(4) Array

23.4.2

Protection of palletized and solid-piled storage of cartoned or exposed nonexpanded plastic and cartoned expanded or exposed expanded plastic shall be in accordance with Table 23.4.2.

Table 23.4.2 ESFR Protection of Palletized and Solid-Piled Storage of Group A Plastic Commodities

Storage Arrangement	Commodity	Maximum Storage Height		Maximum Ceiling/Roof Height		Nominal K-Factor	Orientation	Minimum Operating Pressure	
		ft	m	ft	m			psi	bar
Palletized and solid-piled storage (no open-top containers)	Cartoned nonexpanded plastic	20	6.1	25	7.6	14.0 (200)	Upright/pendent	50	3.4
						16.8 (240)	Upright/pendent	35	2.4
						22.4 (320)	Pendent	25	1.7
						25.2 (360)	Pendent	15	1.0
				30	9.1	14.0 (200)	Upright/pendent	50	3.4
						16.8 (240)	Upright/pendent	35	2.4
						22.4 (320)	Pendent	25	1.7
						25.2 (360)	Pendent	15	1.0
				35	11	14.0 (200)	Upright/pendent	75	5.2
						16.8 (240)	Upright/pendent	52	3.6
						22.4 (320)	Pendent	35	2.4
						25.2 (360)	Pendent	20	1.4
				40	12	16.8 (240)	Pendent	52	3.6
						22.4 (320)	Pendent	40	2.7
						25.2 (360)	Pendent	25	1.7
				45	14	22.4 (320)	Pendent	40	2.7

Storage Arrangement	Commodity	Maximum Storage Height		Maximum Ceiling/Roof Height		Nominal K-Factor	Orientation	Minimum Operating Pressure	
		ft	m	ft	m			psi	bar
		25	7.6	30	9.1	25.2 (360)	Pendent	40	2.7
						14.0 (200)	Upright/pendent	50	3.4
						16.8 (240)	Upright/pendent	35	2.4
						22.4 (320)	Pendent	25	1.7
						25.2 (360)	Pendent	15	1.0
				32	10	14.0 (200)	Upright/pendent	60	4.1
						16.8 (240)	Upright/pendent	42	2.9
				35	11	14.0 (200)	Upright or pendent	75	5.2
						16.8 (240)	Upright/pendent	52	3.6
						22.4 (320)	Pendent	35	2.4
						25.2 (360)	Pendent	20	1.4
				40	12	16.8 (240)	Pendent	52	3.6
						22.4 (320)	Pendent	40	2.7
						25.2 (360)	Pendent	25	1.7
				45	14	22.4 (320)	Pendent	40	2.7
						25.2 (360)	Pendent	40	2.7
		30	9.1	35	11	14.0 (200)	Upright/pendent	75	5.2
						16.8 (240)	Upright/pendent	52	3.6
						22.4 (320)	Pendent	35	2.4

Storage Arrangement	Commodity	Maximum Storage Height		Maximum Ceiling/Roof Height		Nominal K-Factor	Orientation	Minimum Operating Pressure	
		ft	m	ft	m			psi	bar
						25.2 (360)	Pendent	20	1.4
				40	12	16.8 (240)	Pendent	52	3.6
						22.4 (320)	Pendent	40	2.7
						25.2 (360)	Pendent	25	1.7
				45	14	22.4 (320)	Pendent	40	2.7
						25.2 (360)	Pendent	40	2.7
				40	12	16.8 (240)	Pendent	52	3.6
						22.4 (320)	Pendent	40	2.7
						25.2 (360)	Pendent	25	1.7
					45	22.4 (320)	Pendent	40	2.7
						25.2 (360)	Pendent	40	2.7
						25.2 (360)	Pendent	40	2.7
		40	12.2	45	14	22.4 (320)	Pendent	40	2.7
						25.2 (360)	Pendent	40	2.7
	Exposed nonexpanded plastic	20	6.1	25	7.6	14.0 (200)	Pendent	50	3.4
						16.8 (240)	Pendent	35	2.4
				30	9.1	14.0 (200)	Pendent	50	3.4
						16.8 (240)	Pendent	35	2.4
				35	11	14.0 (200)	Pendent	75	5.2
						16.8 (240)	Pendent	52	3.6

Storage Arrangement	Commodity	Maximum Storage Height		Maximum Ceiling/Roof Height		Nominal K-Factor	Orientation	Minimum Operating Pressure	
		ft	m	ft	m			psi	bar
				40	12	16.8 (240)	Pendent	52	3.6
		25	7.6	30	9.1	14.0 (200)	Pendent	50	3.4
						16.8 (240)	Pendent	35	2.4
				32	9.7	14.0 (200)	Pendent	60	4.1
						16.8 (240)	Pendent	42	2.9
				35	11	14.0 (200)	Pendent	75	5.2
						16.8 (240)	Pendent	52	3.6
				40	12	16.8 (240)	Pendent	52	3.6
						22.4 (320)	Pendent	50	3.4
						25.2 (360)	Pendent	50	3.4
				35	11	14.0 (200)	Pendent	75	5.2
						16.8 (240)	Pendent	52	3.6
		30	9.1	40	12	16.8 (240)	Pendent	52	3.6
						22.4 (320)	Pendent	50	3.4
						25.2 (360)	Pendent	50	3.4
		35	11	40	12	16.8 (240)	Pendent	52	3.6
						22.4 (320)	Pendent	50	3.4
						25.2 (360)	Pendent	50	3.4
		20	6.1	25	7.6	14.0 (200)	Upright/ pendent	50	3.4

Storage Arrangement	Commodity	Maximum Storage Height		Maximum Ceiling/Roof Height		Nominal K-Factor	Orientation	Minimum Operating Pressure	
		ft	m	ft	m			psi	bar
	Cartoned expanded plastic	25	7.6	30	9.1	16.8 (240)	Upright/pendent	35	2.4
						14.0 (200)	Upright/pendent	50	3.4
						16.8 (240)	Upright/pendent	35	2.4
				30	9.1	14.0 (200)	Upright/pendent	50	3.4
						16.8 (240)	Upright/pendent	35	2.4
						14.0 (200)	Pendent	60	4.1
				32	10	16.8 (240)	Upright/pendent	42	2.9
						25.2 (360)	Pendent	60	4.1
	Exposed* expanded plastic	25	7.6	40	12	25.2 (360)	Pendent	60	4.1

*Applies to closed array storage only.

23.5 Early Suppression Fast-Response (ESFR) Sprinklers for Rack Storage of Class I Through Class IV Commodities.

23.5.1

Protection of single-, double-, and multiple-row rack storage of Class I through Class IV commodities shall be in accordance with Table 23.5.1.

Table 23.5.1 ESFR Sprinkler Protection of Rack Storage of Class I Through Class IV Commodities

Storage Arrangement	Commodity	Maximum Storage Height		Maximum Ceiling/Roof Height		Nominal K-Factor	Orientation	Minimum Operating Pressure		In-Rack Sprinkler Requirements
		ft	m	ft	m			psi	bar	
Single-row, double-row, and multiple-row racks (no open-top containers)	Class I, II, III, or IV, encapsulated or nonencapsulated	20	6.1	25	7.6	14 (200)	Upright/pendent	50	3.4	No
						16.8 (240)	Upright/pendent	35	2.4	No
						22.4 (320)	Pendent	25	1.7	No
						25.2 (360)	Pendent	15	1	No

Storage Arrangement	Commodity	Maximum Storage Height		Maximum Ceiling/Roof Height		Nominal K-Factor	Orientation	Minimum Operating Pressure		In-Rack Sprinkler Requirements
		ft	m	ft	m			psi	bar	
				30	9.1	14 (200)	Upright/pendent	50	3.4	No
						16.8 (240)	Upright/pendent	35	2.4	No
						22.4 (320)	Pendent	25	1.7	No
						25.2 (360)	Pendent	15	1	No
				35	10.7	14 (200)	Upright/pendent	75	5.2	No
						16.8 (240)	Upright/pendent	52	3.6	No
						22.4 (320)	Pendent	35	2.4	No
						25.2 (360)	Pendent	20	1.4	No
				40	12.8	16.8 (240)	Pendent	52	3.6	No
						22.4 (320)	Pendent	40	2.8	No
						25.2 (360)	Pendent	25	1.7	No
				45	13.7	14 (200)	Pendent	90	6.2	Yes
						16.8 (240)	Pendent	63	4.4	Yes
						22.4 (320)	Pendent	40	2.8	No
						25.2 (360)	Pendent	40	2.8	No
		25	7.6	30	9.1	14 (200)	Upright/pendent	50	3.4	No
						16.8 (240)	Upright/pendent	35	2.4	No
						22.4 (320)	Pendent	25	1.7	No
						25.2 (360)	Pendent	15	1.0	No

Storage Arrangement	Commodity	Maximum Storage Height		Maximum Ceiling/Roof Height		Nominal K-Factor	Orientation	Minimum Operating Pressure		In-Rack Sprinkler Requirements
		ft	m	ft	m			psi	bar	
				32	9.8	14 (200)	Upright/pendent	60	4.1	No
						16.8 (240)	Upright/pendent	42	2.9	No
				35	10.7	14 (200)	Upright/pendent	75	5.2	No
						16.8 (240)	Upright/pendent	52	3.6	No
						22.4 (320)	Pendent	35	2.4	No
						25.2 (360)	Pendent	20	1.4	No
				40	12.2	16.8 (240)	Pendent	52	3.6	No
						22.4 (320)	Pendent	40	2.8	No
						25.2 (360)	Pendent	25	1.7	No
				45	13.7	14 (200)	Pendent	90	6.2	Yes
						16.8 (240)	Pendent	63	4.3	Yes
						22.4 (320)	Pendent	40	2.8	No
						25.2 (360)	Pendent	40	2.8	No
Single-, double-, and multiple-row rack (no open-top containers)	Class I, II, III, or IV, encapsulated or nonencapsulated	30	9.1	35	10.7	14 (200)	Upright/pendent	75	5.2	No
						16.8 (240)	Upright/pendent	52	3.6	No
						22.4 (320)	Pendent	35	2.4	No
						25.2 (360)	Pendent	20	1.4	No
				40	12.2		Pendent	52	3.6	No

Storage Arrangement	Commodity	Maximum Storage Height		Maximum Ceiling/Roof Height		Nominal K-Factor	Orientation	Minimum Operating Pressure		In-Rack Sprinkler Requirements
		ft	m	ft	m			psi	bar	
						16.8 (240)				
						22.4 (320)	Pendent	40	2.8	No
						25.2 (360)	Pendent	25	1.7	No
						14 (200)	Pendent	90	6.2	Yes
				45		16.8 (240)	Pendent	63	4.3	Yes
						22.4 (320)	Pendent	40	2.8	No
						25.2 (360)	Pendent	40	2.8	No
						16.8 (240)	Pendent	52	3.6	No
				40		22.4 (320)	Pendent	40	2.8	No
						25.2 (360)	Pendent	25	1.7	No
		35				14 (200)	Pendent	90	6.2	Yes
				45		16.8 (240)	Pendent	63	4.3	Yes
						22.4 (320)	Pendent	40	2.8	No
						25.2 (360)	Pendent	40	2.8	No
		40	12	45		16.8 (240)	Pendent	63	4.3	Yes
							Pendent	40	2.8	No

Storage Arrangement	Commodity	Maximum Storage Height		Maximum Ceiling/Roof Height		Nominal K-Factor	Orientation	Minimum Operating Pressure		In-Rack Sprinkler Requirements
		ft	m	ft	m			psi	bar	
						22.4 (320)				
						25.2 (360)	Pendent	40	2.8	No

23.6 Early Suppression Fast-Response (ESFR) Sprinklers for Rack Storage of Group A Plastic Commodities.

23.6.1

Protection of single-, double-, and multiple-row rack storage of cartoned or exposed nonexpanded Group A plastic and cartoned expanded Group A plastic shall be in accordance with Table 23.6.1.

Table 23.6.1 ESFR Protection of Rack Storage of Group A Plastic Commodities

Storage Arrangement	Commodity	Maximum Storage Height		Maximum Ceiling/Roof Height		Nominal K-Factor	Orientation	Minimum Operating Pressure		In-Rack Sprinkler Requirements
		ft	m	ft	m			psi	bar	
Single-, double-, and multiple-row racks (no open-top containers)	Cartoned unexpanded	20	6.1	25	7.6	14 (200)	Upright/pendent	50	3.4	No
						16.8 (240)	Upright/pendent	35	2.4	No
						22.4 (320)	Pendent	25	1.7	No
						25.2 (360)	Pendent	15	1	No
				30	9.1	14 (200)	Upright/pendent	50	3.4	No
							Upright/pendent	35	2.4	No
							Upright/pendent	35	2.4	No

Storage Arrangement	Commodity	Maximum Storage Height		Maximum Ceiling/Roof Height		Nominal K-Factor	Orientation	Minimum Operating Pressure		In-Rack Sprinkler Requirements
		ft	m	ft	m			psi	bar	
						16.8 (240)	Pendent			
						22.4 (320)	Pendent	25	1.7	No
						25.2 (360)	Pendent	15	1	No
				35	11	14 (200)	Upright/Pendent	75	5.2	No
						16.8 (240)	Upright/Pendent	52	3.6	No
						22.4 (320)	Pendent	35	2.4	No
						25.2 (360)	Pendent	20	1.4	No
				40	12	16.8 (240)	Pendent	52	3.6	No
						22.4 (320)	Pendent	40	2.7	No
						25.2 (360)	Pendent	25	1.7	No
				45	14	14 (200)	Pendent	90	6.2	Yes
						16.8 (240)	Pendent	63	4.3	Yes
						22.4 (320)	Pendent	40	2.7	No
						25.2 (360)	Pendent	40	2.7	No
		25	7.6	30	9.1	14 (200)	Upright/pendent	50	3.4	No
						16.8 (240)	Upright/Pendent	35	2.4	No

Storage Arrangement	Commodity	Maximum Storage Height		Maximum Ceiling/Roof Height		Nominal K-Factor	Orientation	Minimum Operating Pressure		In-Rack Sprinkler Requirements
		ft	m	ft	m			psi	bar	
						22.4 (320)	Pendent	25	1.7	No
						25.2 (360)	Pendent	15	1	No
				32	10	14 (200)	Upright/pendent	60	4.1	No
						16.8 (240)	Upright/pendent	42	2.9	No
				35	11	14 (200)	Upright/pendent	75	5.2	No
						16.8 (240)	Upright/pendent	52	3.6	No
						22.4 (320)	Pendent	35	2.4	No
						25.2 (360)	Pendent	20	1.4	No
				40	12	16.8 (240)	Pendent	52	3.6	No
						22.4 (320)	Pendent	40	2.7	No
						25.2 (360)	Pendent	25	1.7	No
				45	14	14 (200)	Pendent	90	6.2	Yes
						16.8 (240)	Pendent	63	4.3	Yes
						22.4 (320)	Pendent	40	2.7	No
						25.2 (360)	Pendent	40	2.7	No
				30	9.1	14 (200)	Upright/pendent	75	5.2	No

Storage Arrangement	Commodity	Maximum Storage Height		Maximum Ceiling/Roof Height		Nominal K-Factor	Orientation	Minimum Operating Pressure		In-Rack Sprinkler Requirements
		ft	m	ft	m			psi	bar	
						16.8 (240)	Upright/Pendent	52	3.6	No
						22.4 (320)	Pendent	35	2.4	No
						25.2 (360)	Pendent	20	1.4	No
						16.8 (240)	Pendent	52	3.6	No
						22.4 (320)	Pendent	40	2.7	No
						25.2 (360)	Pendent	25	1.7	No
				40	12	14 (200)	Pendent	90	6.2	Yes
						16.8 (240)	Pendent	63	4.3	Yes
						22.4 (320)	Pendent	40	2.7	No
						25.2 (360)	Pendent	40	2.7	No
				45	14	16.8 (240)	Pendent	52	3.6	No
						25.2 (360)	Pendent	25	1.7	No
						14 (200)	Pendent	90	6.2	Yes
						16.8 (240)	Pendent	63	4.3	Yes
				45	14	22.4 (320)	Pendent	40	2.7	No
						25.2 (360)	Pendent	40	2.7	No
				35	11	14 (200)	Pendent	90	6.2	Yes
						16.8 (240)	Pendent	63	4.3	Yes
						22.4 (320)	Pendent	40	2.7	No
						25.2 (360)	Pendent	40	2.7	No

Storage Arrangement	Commodity	Maximum Storage Height		Maximum Ceiling/Roof Height		Nominal K-Factor	Orientation	Minimum Operating Pressure		In-Rack Sprinkler Requirements
		ft	m	ft	m			psi	bar	
		40	12	45	14	14 (200)	Pendent	90	6.2	Yes
						16.8 (240)	Pendent	63	4.3	Yes
						22.4 (320)	Pendent	40	2.7	No
						25.2 (360)	Pendent	40	2.7	No
	Cartoned Expanded	20	6.1	25	7.6	14 (200)	Upright/pendent	50	3.4	No
						16.8 (240)	Upright/pendent	35	2.4	No
				30	9.1	14 (200)	Upright/pendent	50	3.4	No
						16.8 (240)	Upright/pendent	35	2.4	No
		25	7.6	30	9.1	14 (200)	Upright/pendent	50	3.4	No
						16.8 (240)	Upright/pendent	35	2.4	No
				32	10	14 (200)	Pendent	60	4.1	No
						16.8 (240)	Upright/pendent	42	2.9	No
	Exposed unexpanded	20	6.1	25	7.6	14 (200)	Pendent	50	3.4	No
						16.8 (240)	Pendent	35	2.4	No
				30	9.1	14 (200)	Pendent	50	3.4	No
						16.8 (240)	Pendent	35	2.4	No
				35	11		Pendent	75	5.2	No

Storage Arrangement	Commodity	Maximum Storage Height		Maximum Ceiling/Roof Height		Nominal K-Factor	Orientation	Minimum Operating Pressure		In-Rack Sprinkler Requirements
		ft	m	ft	m			psi	bar	
						14 (200)				
						16.8 (240)	Pendent	52	3.6	No
				40	12	16.8 (240)	Pendent	52	3.6	No
				45	14	14 (200)	Pendent	90	6.2	Yes
						16.8 (240)	Pendent	63	4.3	Yes
				30	9.1	14 (200)	Pendent	50	3.4	No
						16.8 (240)	Pendent	35	2.4	No
				32	10	14 (200)	Pendent	60	4.1	No
						16.8 (240)	Pendent	42	2.9	No
				35	11	14 (200)	Pendent	75	5.2	No
		25	7.6			16.8 (240)	Pendent	52	3.6	No
				40	12	16.8 (240)	Pendent	52	3.6	No
						22.4 (320)	Pendent	50	3.4	No
						25.2 (360)	Pendent	50	3.4	No
				45	14	14 (200)	Pendent	90	6.2	Yes
						16.8 (240)	Pendent	63	4.3	Yes

Storage Arrangement	Commodity	Maximum Storage Height		Maximum Ceiling/Roof Height		Nominal K-Factor	Orientation	Minimum Operating Pressure		In-Rack Sprinkler Requirements		
		ft	m	ft	m			psi	bar			
		30	9.1	35	10.7	14 (200)	Pendent	75	5.2	No		
						16.8 (240)	Pendent	52	3.6	No		
				40	11	16.8 (240)	Pendent	52	3.6	No		
						22.4 (320)	Pendent	50	3.4	No		
						25.2 (360)	Pendent	50	3.4	No		
						14 (200)	Pendent	90	6.2	Yes		
				45	12	16.8 (240)	Pendent	63	4.3	Yes		
				35	11	40	12	16.8 (240)	Pendent	52	3.6	No
								22.4 (320)	Pendent	50	3.4	No
								25.2 (360)	Pendent	50	3.4	No
						45	14	14 (200)	Pendent	90	6.2	Yes
		16.8 (240)	Pendent					63	4.3	Yes		
40	12	45	14	14 (200)	Pendent	90	6.2	Yes				
				16.8 (240)	Pendent	63	4.3	Yes				

23.6.1.1

ESFR protection as defined shall not apply to the following:

- (1) Rack storage involving solid shelves, except as permitted by 23.6.1.2
- (2) Rack storage involving open-top cartons or containers

23.6.1.2

ESFR sprinklers shall not be permitted to protect storage on solid shelf racks unless the solid shelf racks are protected with in-rack sprinklers in accordance with 17.1.5.

23.6.1.2.1

Where solid shelves are used, in-rack sprinklers shall be installed in every level below the highest solid shelf.

23.6.2

ESFR sprinkler systems shall be designed such that the minimum operating pressure is not less than that indicated in Table 23.6.1 for type of storage, commodity, storage height, and building height involved.

23.6.3

The design area shall consist of the most hydraulically demanding area of 12 sprinklers, consisting of four sprinklers on each of three branch lines.

23.6.4 In-Rack Sprinkler Requirements Where ESFR Sprinklers Are Used at Ceiling.

23.6.4.1

Where required by Table 23.6.1, in-rack sprinklers shall be installed at the first tier level at or above one-half of the storage height.

23.6.4.2

In-rack sprinklers shall be K-8.0 (115) or K-11.2 (160) quick-response, ordinary-temperature sprinklers.

23.6.4.3

The minimum of 6 in. (150 mm) vertical clear space shall be maintained between the sprinkler deflectors and the top of a tier of storage.

(A)

Sprinkler discharge shall not be obstructed by horizontal rack members.

23.6.4.4

The maximum horizontal distance between in-rack sprinklers shall be 5 ft (1.5 m).

23.6.4.5

In-rack sprinklers shall be located at an intersection of transverse and longitudinal flues while not exceeding the maximum spacing rules.

23.6.4.6

Where distances between transverse flues exceed the maximum allowable distances, sprinklers shall be installed at the intersection of the transverse and longitudinal flues, and additional sprinklers shall be installed between transverse flues to meet the maximum distance rules.

23.6.4.7

Where no transverse flues exist, in-rack sprinklers shall not exceed the maximum spacing rules.

23.6.4.8

The water demand for sprinklers installed in racks shall be based on simultaneous operation of the most hydraulically remote eight sprinklers.

23.6.4.9

Each of the in-rack sprinklers described in 23.6.4.8 shall discharge at a minimum of 60 gpm (227  min).

23.7* Protection of Exposed Expanded Group A Plastics.

23.7.1

Protection of single-, double-, and multiple-row rack storage of exposed expanded Group A plastics shall be permitted to be in accordance with 23.7.2 through 23.7.8.

23.7.2

The maximum storage height shall be 35 ft (10.7 m). 

23.7.3

The maximum ceiling height shall be 40 ft (12.2 m)

23.7.4

Sprinklers shall be intermediate temperature-rated ESFR pendent sprinklers with a nominal K-factor of K-25.2 (360).

23.7.4.1

The maximum sprinkler deflector distance below the ceiling shall be 14 in. (350 mm).

23.7.5

The design area shall consist of the most hydraulically demanding area of 12 sprinklers.

23.7.6

The minimum operating pressure shall be either 30 psi (2.0 bar) or 60 psi (4.1 bar) based upon the applicable storage and ceiling height for the installation as follows:

(1) 30 psi (2.0 bar) for storage heights up to 25 ft (7.6 m) with a maximum ceiling height of 30 ft (9.1 m)

(2) 60 psi (4.1 bar) for storage heights up to 25 ft (7.6 m) with a maximum ceiling height of 40 ft (12.2 m)

23.7.7

The minimum aisle width shall be 8 ft (2.4 m).

23.7.8

The rack shall have a solid vertical barrier of 3/4 in. (9.5 mm) plywood or particleboard, 22 gauge sheet metal, or equivalent, from face of rack to face of rack, spaced at a maximum of 16.5 ft (5.0 m) intervals.

23.7.8.1

The vertical barrier shall extend from a maximum of 4 in. (102 mm) above the floor to the maximum storage height.

23.7.8.2

The plan area of storage between vertical barriers and aisles shall not exceed 124 ft² (11.5 m²).

23.7.8.3

The vertical barrier shall extend across the longitudinal flue.

23.7.8.4

Commodity shall be permitted to extend a nominal 4 in. (102 mm) beyond the vertical barrier at the aisle.

23.8 ESFR Protection of Rack Storage of Rubber Tires.

Sprinkler discharge and area of application shall be in accordance with Table 23.8.

Table 23.8 Early Suppression Fast-Response (ESFR) Sprinklers for Protection of Rubber Tires (see Note 1)

Piling Method	Pile Height	Maximum Building Height		Nominal K-factor	Orientation	Number of Sprinklers	Minimum Operating Pressure (see Note 2)			
		ft	m				psi	bar		
Rubber tire storage, on-side or on-tread, in palletized portable racks, open portable racks, or fixed racks without solid shelves	Up to 25 ft (7.6 m)	30	9.1	14.0 (200)	Upright/pendent	12 (see Note 2)	50	3.4		
				16.8 (240)	Upright/pendent	12 (see Note 2)	35	2.4		
				22.4 (320)	Pendent	12 (see Note 2)	25	1.7		

Piling Method	Pile Height	Maximum Building Height		Nominal K-factor	Orientation	Number of Sprinklers	Minimum Operating Pressure (see Note 2)			
		ft	m				psi	bar		
				25.2 (360)	Pendent	12 (see Note 2)	15	1.0		
Rubber tire storage, on-side, in palletized portable racks, open portable racks, or fixed racks without solid shelves	Up to 25 ft (7.6 m)	35	11	14.0 (200)	Upright/pendent	12 (see Note 2)	75	5.2		
				16.8 (240)	Pendent	12 (see Note 2)	52	3.6		
				22.4 (320)	Pendent	12 (see Note 2)	35	2.4		
				25.2 (360)	Pendent	12 (see Note 2)	25	1.7		
On-tread, on-side, and laced tires in open portable steel racks or palletized portable racks	Up to 25 ft (7.6 m)	30	9.1	14.0 (200)	Pendent	20 (see Notes 3 and 4)	75	5.2		
				16.8 (240)	Pendent	20 (see Notes 3 and 4)	52	3.6		
Rubber tire storage, on-side, in palletized portable racks	Up to 25 ft (7.6 m)	40	12	16.8 (240)	Pendent	12	52	3.6		
Rubber tire storage, on-tread, or laced in open portable steel racks	Up to 25 ft (7.6 m)	40	12	25.2 (360)	Pendent	12	40	2.8		
On-tread, on-side, and laced tires in open portable steel racks or palletized portable racks	Up to 30 ft (9.1 m)	40	12	25.2 (360)	Pendent	12	75	5.2		

Notes:

- (1) Wet systems only.
- (2) The shape of the design area shall be in accordance with 14.4.3.
- (3) Where used in this application, ESFR protection is expected to control rather than to suppress the fire.
- (4) The design area shall consist of the most hydraulically demanding area of 20 sprinklers, consisting of five sprinklers on each of four branch lines. The design shall include a minimum operating area of 1600 ft² (149 m²).

23.9 Early Suppression Fast-Response (ESFR) Sprinklers for Protection of Roll Paper Storage.

Where automatic sprinkler system protection utilizes ESFR sprinklers, hydraulic design criteria shall be as specified in Table 23.9. Design discharge pressure shall be applied to 12 operating sprinklers.

Table 23.9 ESFR Sprinklers for Protection of Roll Paper Storage (Maximum Height of Storage Permitted)

ESFR K-Factor	Orientation	System Type	Pressure		Building Height		Heavyweight						Mediumweight						Tissue All Arrays
							Closed		Standard		Open		Closed		Standard		Open		
			psi	bar	ft	m	ft	m	ft	m	ft	m	ft	m	ft	m	ft	m	
14.0 (201)	Upright/pendent	Wet	50	3.4	30	9.1	25	7.6	25	7.6	25	7.6	25	7.6	25	7.6	25	7.6	NA
16.8 (242)	Upright/pendent	Wet	35	2.4															
22.4 (322)	Pendent	Wet	25	1.7															
25.2 (363)	Pendent	Wet	15	1.0															
14.0 (201)	Upright/pendent	Wet	75	5.2	35	11	30	9.1	30	9.1	30	9.1	NA	NA	NA	NA	NA	NA	
16.8 (242)	Upright/pendent	Wet	52	3.6															
					40	12	30	9.1	30	9.1	30	9.1	NA	NA	NA	NA	NA	NA	
16.8 (242)	Pendent	Wet	52	3.6															
22.4 (322)	Pendent	Wet	40	2.7															
25.2 (363)	Pendent	Wet	25	1.7	45	14	30	9.1	30	9.1	30	9.1	NA	NA	NA	NA	NA		
22.4 (322)	Pendent	Wet	50	3.4															
25.2 (363)	Pendent	Wet	50	3.4															

NA: Not applicable.

23.10 Plastic Motor Vehicle Components.

Group A plastic automotive components and associated packaging material shall be permitted to be protected in accordance with Table 23.10.

Table 23.10 ESFR Sprinkler Design Criteria K-25.2 (360) for Portable Racks (Closed Array^a) Without Solid Shelves Containing Automotive Components

Commodity	Maximum Storage Height		Maximum Ceiling/Roof Height		Type of System	Maximum Sprinkler Spacing ^b		Number of Design Sprinklers by Minimum Operating Pressure ^c		Maximum Deflector Distance Below Ceiling ^d		Hose Stream Allowance		Water Supply Duration (hours)
	ft	m	ft	m		ft ²	m ²	psi	bar	in.	mm	gpm	L/min	
Automotive components and associated packaging material	25	7.6	35	11	Wet	100	9.3	16 at 37 psi	16 at 2.5 bar	18	450	500	1900	2

^aPortable rack array shall be tightly nested without any flue spaces.

^bSprinkler spacing can exceed 100 ft² (9.3 m²) where sprinklers are listed for larger spacing.

^cSystem hydraulic design shall also be capable of delivering a discharge density of 0.60 gpm/ft² (24.4 mm/min) over the most hydraulically remote 4000 ft² (370 m²) area.

^dMaximum deflector distance below ceiling shall be permitted to exceed 18 in. (450 mm) where sprinklers are listed for greater distances.

23.11 Sprinkler Design Criteria for Storage and Display of Class I Through Class IV Commodities, Cartoned Nonexpanded Group A Plastics and Nonexpanded Exposed Group A Plastics in Retail Stores.

23.11.1

A sprinkler system with K-25.2 (360) ESFR sprinklers operating at a minimum pressure of 15 psi (1 bar) shall be permitted to protect single- and double-row racks with solid displays without the use of in-rack sprinklers in retail sales floors where the following conditions are met:

- (1) Storage height shall not exceed 20 ft (6.1 m).
- (2) Solid veneered particleboard/plywood displays shall be permissible, provided that all flues are maintained and only one display is installed per bay.
- (3) A single display shall be permitted to have one or two solid horizontal or slanted members, and a solid back.
- (4) Maximum roof height shall be 30 ft (9.14 m) in the protected area.
- (5) Aisle widths shall be a minimum of 6 ft (1.8 m).
- (6) Minimum transverse flue spaces of 3 in. every 10 ft (76 mm every 3.05 m) horizontally shall be provided.
- (7) Minimum longitudinal flue spaces of 6 in. (152 mm) shall be provided for double-row racks.
- (8) Maximum roof height shall be 30 ft (9.14 m) in the protected area.
- (9) Maximum storage height shall be 22 ft (6.71 m).
- (10) Aisle widths shall be a minimum of 8 ft (2.44 m).
- (11) Minimum transverse flue spaces of 3 in. every 10 ft (76 mm every 3.05 m) horizontally shall be provided.
- (12) Minimum longitudinal flue spaces of 6 in. (152 mm) shall be provided for double-row racks.

(13) Storage in the aisle shall be permitted provided the aisle storage is no more than 4 ft (1.22 m) high and a minimum clear aisle of 4 ft (1.22 m) is maintained.

23.12 Protection of High Bay Records Storage.

23.12.1* Mobile High Bay Records Storage.

The requirements in this section shall be permitted to apply to ceiling-only sprinkler protection of paper products, including paper files, magazines, books, and similar paper documents in corrugated containers either closed or open top, to include corrugated totes, with no more than 5 percent plastics stored in mobile shelving units greater than 12 ft (3.7 m) and up to 34 ft (10 m) high and up to 30 shelving units (storage tiers) high, when the shelving unit structure meets all of the requirements in 23.12.3.

23.12.2 Fixed High Bay Records Storage.

High bay record storage shall be permitted to be fixed in place when meeting the limitations of 23.12.1 and 23.12.3.

23.12.3

A wet pipe sprinkler system with nominal K-25.2 (360) ESFR sprinklers operating at a minimum of 40 psi (2.7 bar) shall be provided. The shelving units shall be subject to the following limitations:

- (1) Back-to-back storage shelving units each no greater than 36 in. (900 mm) deep separated by longitudinal flue space not less than 6 in. (150 mm) wide.
- (2) Solid steel shelving units not exceeding 54 in. (1.4 m) wide separated by steel barriers mechanically fastened to upright steel framing that forms a transverse flue space not less than 3 in. (75 mm) wide.
- (3) Upright steel framing not completely blocking transverse flue space between adjacent shelving units.
- (4) Noncombustible shelving backstops and side shelf supports, also referred to as side box guides, projecting not less than 3 in. (75 mm) above the shelves and that prevent stored commodities from encroaching into transverse and longitudinal flue spaces.
- (5) Solid steel shelving not greater than 18 in. (450 mm) on centers vertically.
- (6) Solid steel tops over top shelving units except at tops of transverse and longitudinal flue spaces.
- (7) Open-ended, hollow tubular steel vertical (upright) shelving columns at top of shelving system.
- (8) Shelving system framing and power tracks not exceeding 3 in. (75 mm) in width and not less than 1 ft (300 mm) on centers and not less than 6 in. (150 mm) below sprinkler deflectors.
- (9) Minimum clearance of 36 in. (900 mm) above top solid steel cover over top storage shelf to the sprinkler deflector.
- (10) Mobile shelving systems arranged to shift automatically to a uniform nominal 6 in. (150 mm) clearance clear space between mobile carriages supporting back-to-back shelving units. Systems shall be arranged to initiate the shifting 60 seconds after activation of ceiling-mounted smoke detectors or upon sprinkler flow, whichever is first. Shelving system carriage electrical motors shall be listed and integral to the mobile carriage systems for normal functions and shall not be required to have emergency power back-up.

23.13 Slatted Shelves.

Chapter 24 Alternative Sprinkler System Designs for Chapters 20 Through 25

24.1* General.

24.1.1

Sprinklers intended to protect storage fire risks shall be permitted to be installed using water supply design criteria that are different from the design criteria specified for the sprinklers described in Chapters 12 through 20 when specifically listed for such use within the limitations described in this chapter.

24.1.2

The requirements of Chapters 12 through 20 shall apply unless modified by this chapter.

24.1.2.1

Sprinklers having standard coverage areas that require up to 20 sprinklers to be included in the hydraulic calculation shall be installed in accordance with 14.2.3, 14.2.4, 14.2.4.1 and 21.12.6.

24.1.2.1.1

Quick-response sprinklers shall also be installed in accordance with 14.2.5.1 and 14.2.5.2.

24.1.2.2

Sprinklers having extended coverage areas that require up to 10 sprinklers to be included in the hydraulic calculation shall be installed in accordance with 14.2.3, 14.2.4, 14.2.4.1 and 21.12.6.

24.1.2.2.1

Quick-response sprinklers shall also be installed in accordance with 14.2.5.1 and 14.2.5.2.

24.1.3

The in-rack protection requirements of Chapters 12 through 20 shall apply when storage racks are equipped with solid shelves and in-rack sprinklers are required per the applicable chapter.

24.1.4

The requirements of the applicable chapter shall apply when ceiling-only protection options are not available per this chapter.

24.1.5

The design criteria in this chapter shall not be used to permit a reduction in the water supply requirements for in-rack sprinkler protection.

24.1.6

A series of large-scale fire tests involving challenging test scenarios that address the range of variables associated with the intended application of the sprinkler shall be conducted to evaluate the ability of the sprinkler to protect storage fire risks that are representative of those described in the manufacturer's installation and design parameter instructions and referenced in the listing.

24.1.7

The manufacturer's installation and design parameter instructions for these sprinklers shall specify in a standardized manner the end-use limitations and sprinkler system design criteria including at least the following:

- (1) Commodity or commodities to be protected
- (2) Storage arrangements allowed
- (3) Installation guidelines including obstruction and ceiling construction limitations
- (4) Maximum ceiling and storage heights with associated minimum operating pressures and number of sprinklers required to be included in the hydraulic calculation
- (5) Hose stream allowance and duration

24.1.8

The number of sprinklers to be used in the sprinkler system design shall be based on the worst-case result obtained from the full-scale fire test series increased by a minimum 50 percent.

24.1.8.1

Regardless of the number of sprinklers that operated during the worst-case full-scale fire test, the number in the sprinkler system demand shall be no less than one of the following:

- (1) Twelve sprinklers for standard coverage sprinklers
- (2) Eight sprinklers for extended-coverage sprinklers based on a spacing of 12 ft × 12 ft (3.7 × 3.7 m)

(3) Six sprinklers for extended-coverage sprinklers based on a spacing of 14 ft × 14 ft (4.3 m × 4.3 m)

24.1.8.2

Once the number of sprinklers for a demand area has been established, the minimum operating area, based on the proposed sprinkler spacing, shall not be less than 768 ft² (71 m²).

24.1.8.3

The design area and number of sprinklers calculated on a branch line shall be in accordance with 19.6.4.2 using an area of sprinkler operation equal to the required number of operating sprinklers and the maximum allowable coverage for the specific design criteria being utilized.

24.1.9

Listed storage sprinklers that are not specifically referenced in Sections 24.2 and 24.3 but are tested in accordance with Chapter 21 with system design criteria based upon Sections 24.1, 24.4, and 24.5 shall be permitted to be used in accordance with their listing limitations, where approved.

24.2* Sprinkler Design Criteria for Palletized and Solid-Piled, Storage of Class I Through Class IV and Plastic Commodities.

24.2.1

Protection of palletized and solid-piled storage of Class I through Class IV and cartoned nonexpanded plastic commodities shall be permitted to be protected in accordance with Table 24.2.1.

Table 24.2.1 Extended Coverage, CMSA [K-factor 25.2 (360)] Sprinkler Design Criteria for Palletized and Solid-Piled Storage of Class I Through Class IV and Cartoned Nonexpanded Plastic Commodities

Storage Arrangement	Commodity Class	Maximum Storage Height		Maximum Ceiling/Roof Height		K-Factor/Orientation	Type of System	Number of Design Sprinklers	Minimum Operating Pressure	Maximum Coverage Area
		ft	m	ft	m					
Palletized and solid-piled	Class I through Class IV, encapsulated and nonencapsulated, and cartoned nonexpanded plastics	20	6.1	30	9.1	25.2 (360) Upright/pendent	Wet	6	30 psi (2.1 bar)	12 ft × 12 ft (3.7 m × 3.7 m) 144 ft ² (13.4 m ²)
		20	6.1	30	9.1	25.2 (360) Upright/pendent	Wet	6	30 psi (2.1 bar)	14 ft × 14 ft (4.3 m × 4.3 m) 196 ft ² (18.2 m ²)
		25	7.6	30	9.1	25.2 (360) Upright/pendent	Wet	6	30 psi (2.1 bar)	12 ft × 12 ft (3.7 m × 3.7 m)

Storage Arrangement	Commodity Class	Maximum Storage Height		Maximum Ceiling/Roof Height		K-Factor/Orientation	Type of System	Number of Design Sprinklers	Minimum Operating Pressure	Maximum Coverage Area
		ft	m	ft	m					
										144 ft ² (13.4 m ²)
		25	7.6	30	9.1	25.2 (360) Upright/pendent	Wet	6	30 psi (2.1 bar)	14 ft × 14 ft (4.3 m × 4.3 m) 196 ft ² (18.2 m ²)
		25	7.6	35	11	25.2 (360) Upright/pendent	Wet	8	40 psi (2.7 bar)	12 ft × 12 ft (3.7 m × 3.7 m) 144 ft ² (13.4 m ²)
		25	7.6	35	11	25.2 (360) Upright	Wet	8	40 psi (2.8 bar)	14 ft × 14 ft (4.3 m × 4.3 m) 196 ft ² (18.2 m ²)
		30	9.1	35	11	25.2 (360) Upright/pendent	Wet	8	40 psi (2.8 bar)	12 ft × 12 ft (3.7 m × 3.7 m) 144 ft ² (13.4 m ²)
		30	9.1	35	11	25.2 (360) Upright	Wet	8	40 psi (2.8 bar)	14 ft × 14 ft (4.3 m × 4.3 m) 196 ft ² (18.2 m ²)

24.3* Sprinkler Protection Criteria for Open-Frame Rack Storage of Class I Through Class IV and Plastic Commodities.

24.3.1

Protection of single-, double-, and multiple-row racks without solid shelves of Class I through Class IV and cartoned nonexpanded plastic commodities shall be permitted to be protected in accordance with Table 24.3.1.

Table 24.3.1 Extended Coverage, CMSA [K-Factor 25.2 (360)] Sprinkler Design Criteria for Single-, Double-, and Multiple-Row Racks Without Solid Shelves of Class I Through Class IV and Cartoned Nonexpanded Plastic Commodities

Storage Arrangement	Commodity Class	Maximum Storage Height		Maximum Ceiling/Roof Height		K-Factor/Orientation	Type of System	Number of Design Sprinklers	Minimum Operating Pressure	Maximum Coverage Area
		ft	m	ft	m					
Single-, double-, and multiple-row racks without solid shelves (no open-top containers)	Class I through Class IV, encapsulated and nonencapsulated, and cartoned nonexpanded plastics	20	6.1	30	9.1	25.2 (360) Upright/pendent	Wet	6	30 psi (2.1 bar)	12 ft × 12 ft (3.7 m × 3.7 m) 144 ft ² (13.4 m ²)
		20	6.1	30	9.1	25.2 (360) Upright/pendent	Wet	6	30 psi (2.1 bar)	14 ft × 14 ft (4.3 m × 4.3 m) 196 ft ² (18.2 m ²)
		25	7.6	30	9.1	25.2 (360) Upright/pendent	Wet	6	30 psi (2.1 bar)	12 ft × 12 ft (3.7 m × 3.7 m) 144 ft ² (13.4 m ²)
		25	7.6	30	9.1	25.2 (360) Upright/pendent	Wet	6	30 psi (2.1 bar)	14 ft × 14 ft (4.3 m × 4.3 m) 196 ft ² (18.2 m ²)
		25	7.6	35	11	25.2 (360) Upright/pendent	Wet	8	40 psi (2.6 bar)	12 ft × 12 ft (3.7 m × 3.7 m) 144 ft ² (13.4 m ²)
		25	7.6	35	11	25.2 (360) Upright	Wet	8	40 psi (2.6 bar)	14 ft × 14 ft

Storage Arrangement	Commodity Class	Maximum Storage Height		Maximum Ceiling/Roof Height		K-Factor/Orientation	Type of System	Number of Design Sprinklers	Minimum Operating Pressure	Maximum Coverage Area
		ft	m	ft	m					
										(4.3 m × 4.3 m) 196 ft ² (18.2 m ²)
		30	9.1	35	11	25.2 (360) Upright/pendant	Wet	8	40 psi (2.7 bar)	12 ft × 12 ft (3.7 m × 3.7 m) 144 ft ² (13.4 m ²)
		30	9.1	35	11	25.2 (360) Upright	Wet	8	40 psi (2.6 bar)	14 ft × 14 ft (4.3 m × 4.3 m) 196 ft ² (18.2 m ²)

24.3.2

Protection of Class I through Class IV and cartoned nonexpanded plastic commodities stored on single-, double-, or multiple-row racks without solid shelves or solid-piled, palletized, shelf, or bin-box storage arrangements shall be permitted to be protected in accordance with Table 24.3.2.

Table 24.3.2 CMSA K-25.2 Pendant Standard Coverage Sprinkler Design Criteria for Single-, Double-, and Multiple-Row Racks Without Solid Shelves and Solid-Piled, Palletized Storage Arrangement of Class I Through IV and Cartoned Nonexpanded Plastic Commodities

Storage Arrangement	Commodity Class	Maximum Storage Height		Maximum Ceiling/Roof Height		K-Factor Orientation	System Type	Number of Design Sprinklers	Minimum Operating Pressure	Sprinkler Linear Spacing		Sprinkler Area Spacing	
		ft	m	ft	m					Min	Max	Min	Max
Solid-piled, palletized, and single-, double-, and multiple-row racks	Class I–IV encapsulated and nonencapsulated, and cartoned nonexpanded plastics	25	7.6	30	9.1	25.2 (360) Pendant	Wet	12	20 psi (1.4 bar)	8 ft (2.4 m)	12 ft (3.6 m)	80 ft ² (7.5 m ²)	100 ft ² (9.0 m ²)

Storage Arrangement	Commodity Class	Maximum Storage Height		Maximum Ceiling/Roof Height		K-Factor Orientation	System Type	Number of Design Sprinklers	Minimum Operating Pressure	Sprinkler Linear Spacing		Sprinkler Area Spacing	
		ft	m	ft	m					Min	Max	Min	Max
without solid shelves (no open top containers)													

24.3.3

Protection of Class I through Class IV and cartoned nonexpanded plastic commodities stored on single-, double-, or multiple-row racks without solid shelves or solid-piled, palletized, shelf, or bin-box storage arrangements shall be permitted to be protected in accordance with Table 24.3.3.

Table 24.3.3 CMSA K-25.2 Pendant Standard Coverage Sprinkler Design Criteria for Single-, Double-, and Multiple-Row Racks Without Solid Shelves and Solid-Piled, Palletized Storage Arrangement of Class I Through IV and Cartoned Nonexpanded Plastic Commodities

Storage Arrangement	Commodity Class	Maximum Storage Height		Maximum Ceiling/Roof Height		K-Factor Orientation	System Type	Number of Design Sprinklers	Minimum Operating Pressure	Sprinkler Linear Spacing		Sprinkler Area Spacing	
		ft	m	ft	m					Min	Max	Min	Max
Solid-piled, palletized, and single-, double-, and multiple-row racks without solid shelves (no open top containers)	Class I–IV encapsulated and nonencapsulated, and cartoned nonexpanded plastics	25	7.6	30	9.1	25.2 (360) Pendant	Wet	12	15 psi (1.0 bar)	8 ft (2.4 m)	12 ft (3.6 m)	80 ft ² (7.5 m ²)	100 ft ² (9.0 m ²)

24.4 Hose Stream Allowance and Water Supply Duration.

24.4.1

The minimum water supply requirements for a hydraulically designed occupancy hazard fire control sprinkler system shall be determined by adding the hose stream allowance from Table 24.4.1 to the water supply for sprinklers obtained from this chapter.

Table 24.4.1 Hose Stream Allowance and Water Supply Duration

Sprinkler Type	Sprinkler Spacing Type	Number of Sprinklers in Design Area	Hose Stream Allowance		Water Supply Duration (minutes)
			gpm	L/min	
Control mode density/area and CMSA	Standard	Up to 12	250	950	60
		Over 12 to 15	500	1900	90
		Over 15 to 25	500	1900	120
		Over 25	500	1900	150
	Extended coverage	Up to 6	250	950	60
		Up to 8 (144 ft ²)	250	950	60
		Over 6 to 8	500	1900	90
		Over 8 to 12	500	1900	120
		Over 12	500	1900	150
ESFR	Standard	Up to 12	250	950	60
		Over 12 to 15	500	1900	90
		Over 15 to 25	500	1900	120
		Over 25	500	1900	150

24.4.1.1

The water supply requirements for a hydraulically designed occupancy hazard fire control sprinkler system shall be available for the minimum duration specified in Table 24.4.1.

24.5 Minimum Obstruction Criteria.**24.5.1 General.**

The installation guidelines for obstructions to ceiling-level sprinklers shall be in accordance with the requirements of Section 24.5 for sprinkler system designs obtained from this chapter.

24.5.2 Standard Coverage Spacing Sprinklers.**24.5.2.1**

Sprinklers having standard coverage areas requiring up to 20 sprinklers to be included in the hydraulic calculation shall be installed in accordance with the obstruction criteria described in 14.2.11, unless large-scale fire testing is conducted with a representative obstruction below the sprinkler that demonstrates equivalent performance.

24.5.2.2

Control mode density/area (CMDA) and CMSA sprinklers having standard coverage areas requiring more than 20 sprinklers in the design area shall be installed in accordance with the obstructions to sprinkler discharge criteria described in 13.2.8.

24.5.2.2.1

ESFR sprinklers having standard-coverage areas requiring more than 20 sprinklers in the design area shall be installed in accordance with the obstructions to sprinkler discharge criteria described in 14.2.11.

24.5.2.2.2

Other obstruction criteria shall be acceptable if large-scale fire testing is conducted with a representative obstruction below the sprinkler that demonstrates equivalent performance.

24.5.3 Extended Coverage Spacing Sprinklers.

24.5.3.1

Sprinklers having extended coverage areas requiring up to 10 sprinklers to be included in the hydraulic calculation shall be installed in accordance with the obstruction criteria described in 11.2.5.1, 14.2.11.2, and 14.2.11.3, unless large-scale fire testing is conducted with a representative obstruction below the sprinkler that demonstrates equivalent performance.

24.5.3.2

CMDA and CMSA sprinklers having extended coverage areas requiring more than 10 sprinklers in the design area shall be installed in accordance with the obstructions to sprinkler discharge criteria described in 13.2.8 and 11.2.5.1.

24.5.3.2.1

ESFR sprinklers having extended coverage areas requiring more than 10 sprinklers in the design area shall be installed in accordance with the obstructions to sprinkler discharge criteria described in 14.2.11.2 and 14.2.11.3.

24.5.3.2.2

Other obstruction criteria shall be acceptable if large-scale fire testing is conducted with a representative obstruction below the sprinkler that demonstrates equivalent performance.

24.5.3.2.3

When utilizing upright CMSA, CMDA, or ESFR sprinklers, any continuous obstruction 4 in. (100 mm) or less shall be permitted to be ignored.

24.6 In-Rack Sprinkler Protection Criteria for Open-Frame Rack Storage of Class I Through Class IV and Plastic Commodities.

24.6.1

Protection of closed-top Class I through Class IV and plastic commodities stored on single-, double-, or multiple-row racks without solid shelves shall be permitted to be protected in accordance with this section.

24.6.2

In-rack sprinkler systems shall be wet-pipe only.

24.6.3

In-rack sprinklers shall be standard-coverage, quick-response, pendent, and 160°F (70°C) nominally rated.

24.6.3.1

Minimum K-14.0 (K-200) sprinklers shall be installed where the minimum required flow is 100 gpm (380 L/min) or less.

24.6.3.2

Minimum K-22.4 (K-320) sprinklers shall be installed where the minimum required flow exceeds 100 gpm (380 L/min).

24.6.4

Depending on the type of storage rack being protected, in-rack sprinklers shall be positioned horizontally in accordance with Figure 24.6.4(a) through Figure 24.6.4(f) and the following:

- (1) The minimum horizontal distance between in-rack sprinklers shall be 27 in. (700 mm), with the maximum horizontal distance being 4.5 ft (1.4 m), unless shown otherwise in the applicable figures.
- (2) Except as shown in Figure 24.6.4(c), all in-rack sprinklers shall be located within the footprint of the rack structure.
- (3) All face sprinklers shall be positioned so that the horizontal distance between the face of the storage rack and the outer edge of storage, if it protrudes into the storage aisle, does not exceed 18 in. (450 mm).

Figure 24.6.4(a) Plan View of In-Rack Sprinkler Arrangement for Open-Frame Single-Row Racks Up to 3 ft (0.9 m) Deep.

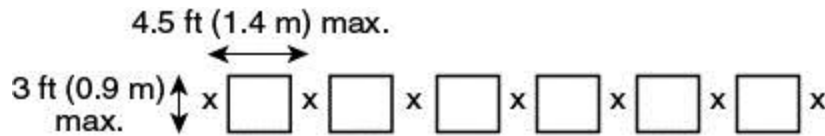


Figure 24.6.4(b) Plan View of In-Rack Sprinkler Arrangement for Open-Frame Single-Row Racks Up to 6 ft (1.8 m) Deep.

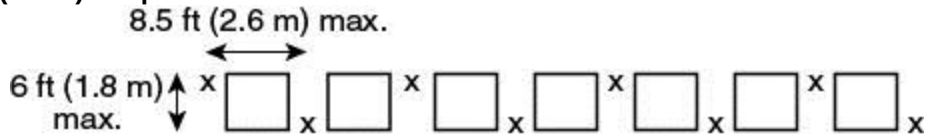


Figure 24.6.4(c) Plan View of In-Rack Sprinkler Arrangement for Open-Frame Single-Row Racks Up to 6 ft (1.8 m) Deep Located Against a Wall.

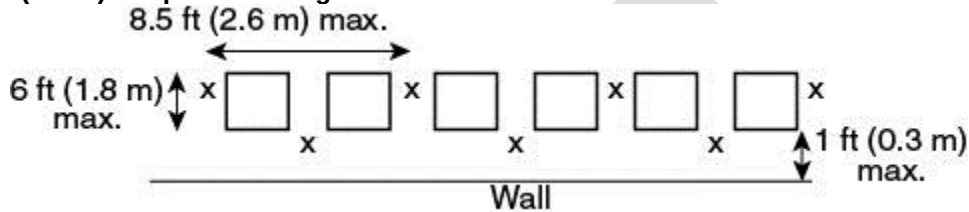


Figure 24.6.4(d) Plan View of In-Rack Sprinkler Arrangement for Open-Frame Double-Row Racks Up to 9 ft (2.7 m) Deep.

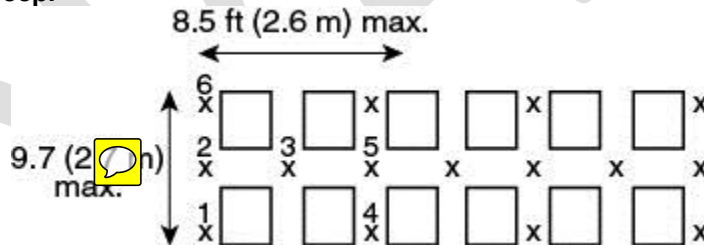


Figure 24.6.4(e) Plan View of In-Rack Sprinkler Arrangement for Open-Frame Double-Row Racks Up to 12 ft (3.7 m) Deep.

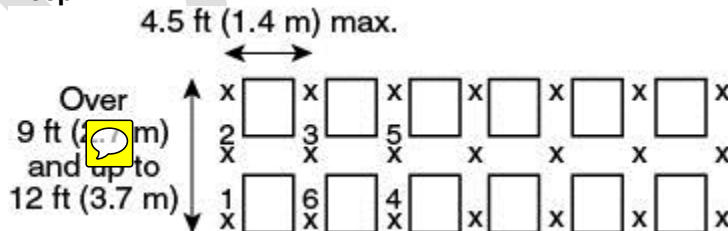


Figure 24.6.4(f) Plan View of In-Rack Sprinkler Arrangement for Open-Frame Multiple-Row Racks.

The minimum flow required in the system design shall be from the most remote in-rack sprinkler in accordance with Table 24.6.7.

Table 24.6.7 Minimum Flow in the In-Rack Sprinkler Design

Maximum Vertical IRAS Installation Increment, ft (m)	Commodity Hazard	Min. K-Factor	Minimum Flow from Most Remote IRAS, gpm (L/min)
30 (9.1)	Class I through IV and cartoned nonexpanded plastic	14.0 (200)	65 (250)
	Cartoned expanded plastic	14.0 (200)	100 (380)
	Exposed plastic	22.4 (320)	120 (455)
40 (12.2) 	Class I through IV and cartoned nonexpanded plastic	22.4 (320)	121 (455)

24.6.8

A hose stream allowance of 250 gpm (950 L/min) shall be included as part of the in-rack sprinkler system design obtained from Section 24.6.

24.6.9

The water supply requirements obtained from Section 24.6 shall be available for a minimum of 60 minutes.

24.6.10*

The water supply for the in-rack sprinkler system shall be capable of providing the required in-rack sprinkler system design obtained from Section 24.6 independent of the design requirements of the ceiling sprinkler system protecting this same area.

24.6.11

The ceiling sprinkler system shall be designed and installed in accordance with the guidelines outlined in Chapters 16 or 17, depending on the commodity hazard, except as modified in Section 24.6.

24.6.11.1

Where the in-rack sprinkler system is designed and installed in accordance with Section 24.6, the top level of in-rack sprinklers shall be considered to be a floor for design purposes of the ceiling sprinkler system.

24.6.11.2

As a result, the storage height above the top level of in-rack sprinklers shall be permitted to be in excess of 10 ft (3.0 m).

24.6.12*

The water supply for the ceiling system shall be capable of providing the required ceiling sprinkler system design obtained from either Chapter 16 or Chapter 17 independent of the design requirements of the in-rack sprinkler system obtained from Section 24.6 and protecting this same area.

Chapter 25 Protection of Rack Storage Using In-Rack Sprinklers**25.1 General Requirements of In-Rack Sprinklers.****25.1.1 Scope.**

This section shall apply where rack storage of Class I through Class IV commodities, Group A plastic commodities, or rubber tires will be protected with in-rack sprinklers.

25.1.2 Open-Frame Storage Racks.

25.1.2.1

The in-rack sprinkler arrangements as well as the ceiling and in-rack sprinkler design criteria for rack storage in this chapter shall be based on open-frame rack configurations as defined in 3.3.141 unless indicated otherwise.

25.1.2.2

Where Group A commodities are being stored in racks with aisles less than 3.5 ft (1.1 m) wide, in-rack sprinkler protection shall be in accordance with the guidelines for multiple-row racks.

25.1.2.3

Where open-frame double-row racks with storage up 25 ft (7.6 m) in height have no longitudinal flue, but have transverse flues at maximum 5 ft (1.5 m) intervals, the double-row rack storage arrangement shall be considered open-frame.

25.1.2.4

Where multiple-row racks of any height have no longitudinal flue, but have transverse flues at maximum 5 ft (1.5 m) intervals, the multiple-row rack storage arrangement shall be considered open-frame.

25.1.3 In-Rack Sprinkler System.

25.1.3.1 In-Rack Sprinkler System Size.

25.1.3.1.1

The area protected by a single in-rack sprinkler system shall not exceed 40,000 ft² (3720 m²) of floor area occupied by the racks, including aisles, regardless of the number of in-rack sprinkler levels.

25.1.3.1.2

An in-rack sprinkler system shall be permitted to be supplied from the overhead ceiling sprinkler system where the area of the racks protected by the in-rack sprinklers, including the adjacent aisles, do not exceed 8,000 ft² (740 m²).

25.1.3.2* In-Rack Sprinkler System Control Valves.

25.1.3.2.1

Unless the requirements of 25.1.3.2.2 or 25.1.3.2.3 are met, separate indicating control valves and drains shall be provided and arranged so that ceiling and in-rack sprinkler systems can be controlled independently.

25.1.3.2.2

Installation of 20 or fewer in-rack sprinklers supplied by any one ceiling sprinkler system shall not require a separate indicating control valve.

25.1.3.2.3

The separate indicating valves shall be permitted to be arranged as sectional control valves supplied from the ceiling sprinkler system where in-rack sprinklers are required and the racks including the adjacent aisles occupy 8000 ft² (740 m²) or less of the area protected by the ceiling sprinklers.

25.1.3.3* Sprinkler Waterflow Alarm for In-Rack Sprinklers.

See Section C.4.

25.1.4 Flue Space Requirements for Racks Protected by In-Rack Sprinklers.

25.1.4.1

Where in-rack sprinklers are protecting rack storage, nominal 6 in. (150 mm) transverse flue spaces between loads and at rack uprights shall be maintained.

25.1.4.2

Where in-rack sprinklers are protecting rack storage, random variations in the width of flue spaces or in their vertical alignment shall be permitted.

25.1.4.3

Where in-rack sprinklers are protecting double- and multiple-row rack storage up to and including 25 ft (7.6 m) in height, a longitudinal (back-to-back clearance between loads) flue space shall not be required.

25.1.4.4

Where in-rack sprinklers are protecting double-row racks over 25 ft (7.6 m) in height, nominal 6 in. (150 mm) longitudinal flue spaces shall be provided.

25.1.5 Building Steel Protection.

Where in-rack sprinklers are installed in accordance with this chapter, building steel shall not require special protection.

25.1.6 Movable Racks.

Rack storage in movable racks shall be protected in the same manner as multiple-row racks.

25.2 Ceiling-Level Sprinkler Design Criteria in Combination with In-Rack Sprinklers.

25.2.1 General.

25.2.1.1*

This section shall apply to storage of materials, such as Class I through Class IV and Group A plastic commodity as well as rubber tires, representing the broad range of combustibles stored in racks that are being protected by in-rack sprinklers. The requirements of Chapter 20 shall apply unless modified by this chapter. (See Section C.9.)

25.2.1.2*

Ceiling-level sprinkler design criteria for single-, double-, and multiple-row racks in 25.2 shall be based on open rack configurations as defined in 3.3.141.

25.2.1.3*

Ceiling-level sprinkler design criteria for Group A plastic commodities in this chapter shall be permitted for the protection of the same storage height and configuration of Class I, II, III, and IV commodities.

25.2.1.4

Ceiling-level sprinkler design criteria for single- and double-row rack storage of Group A plastic commodities shall be applicable where aisles are 3.5 ft (1.1 m) or greater in width.

25.2.1.5

Ceiling-level sprinkler design criteria for rack storage of Group A plastic commodities shall be protected as multiple-row racks where aisles are less than 3.5 ft (1.1 m) in width.

25.2.1.6

The minimum water supply requirements for a hydraulically designed occupancy hazard automatic ceiling-level sprinkler system shall be determined by adding the hose stream allowance from Table 20.12.2.6 to the water supply for in-rack sprinklers determined in Section 25.12, unless indicated otherwise.

25.2.2 Miscellaneous and Low-Piled Storage.

25.2.2.1 Miscellaneous Storage.

25.2.2.1.1

This section shall apply to any of the following situations:

- (1) Miscellaneous storage of Class I through Class IV commodities up to and including 12 ft (3.7 m) in height
- (2) Miscellaneous storage of Group A plastic commodities up to and including 12 ft (3.7 m) in height
- (3) Miscellaneous storage of rubber tires up to and including 12 ft (3.7 m) in height

25.2.2.1.2

Where in-rack sprinklers are installed in accordance with Section 25.4 through Section 25.7 to protect miscellaneous rack storage of Class I through Class IV and Group A plastic commodities, as well as

miscellaneous rack storage of rubber tires, up to and including 12 ft (3.7 m) in height under a maximum 32 ft (10.0 m) high ceiling, the ceiling-level sprinkler design criteria shall be in accordance with Figure 25.2.2.1.2.

Figure 25.2.2.1.2 CMDA Ceiling-Level Sprinkler Design Criteria for Miscellaneous Storage Protected with One Level of In-Rack Sprinklers [missing figure?] 

25.2.2.1.3

Installation criteria as permitted by NFPA 13 and design criteria and modifiers as permitted by the density/area method of Section 19.2 for ordinary hazard Group 2 occupancies shall be applicable.

25.2.2.1.4 Hose Connections.

Hose connections shall not be required for the protection of miscellaneous storage.

25.2.2.2 Low-Piled Storage.

25.2.2.2.1

This section shall apply to any of the following situations:

- (1) Storage of Class I through Class IV commodities up to 12 ft and including (3.7 m) in height.
- (2) *Storage of Group A plastic commodities up to and including 5 ft (1.5 m) in height.

25.2.2.2.2

For low-piled rack storage with solid shelves of Class I through Class IV commodities up to and including 12 ft (3.7 m) in height, in-rack sprinklers shall be provided in accordance with Section 25.6, and the ceiling-level sprinkler design shall be in accordance with Figure 25.2.2.1.2.

25.2.2.2.3

For low-piled rack storage with solid shelves of Group A plastic commodities up to and including 5 ft (1.5 m) in height, in-rack sprinklers shall be provided in accordance with Section 25.6, and the ceiling-level sprinkler design shall be in accordance with Figure 25.2.2.1.2.

25.2.3 CMDA Ceiling Level Sprinkler Design Criteria in Combination with In-Rack Sprinklers.

25.2.3.1 General.

25.2.3.1.1

Ceiling-level sprinkler design criteria for the rack storage of Class I through Class IV commodities shall be in accordance with Section 25.2.3.2 for storage over 12 ft (3.7 m) and up to and including 25 ft (7.6 m) in height and Section 25.2.3.3 for storage over 25 ft (7.6 m) in height.

25.2.3.1.2

Ceiling-level sprinkler design criteria for the rack storage of Group A plastic commodities shall be in accordance with Section 25.2.3.4 for storage over 5 ft (1.5 m) and up to and including 25 ft (7.6 m) in height and Section 25.2.3.5 for storage over 25 ft (7.6 m) in height.

25.2.3.1.3

This chapter also shall be used to determine protection for commodities that are not entirely Group A plastic commodities but contain such quantities and arrangements of Group A plastic commodities that they are deemed more hazardous than Class IV commodities.

25.2.3.2 Rack Storage of Class I Through Class IV Commodities Stored Over 12 ft (3.7 m) and Up to and Including 25 ft (7.6 m) in Height.

25.2.3.2.1* Single- and Double-Row Racks.

For single- or double-row rack storage of Class I through Class IV commodities, encapsulated or nonencapsulated, stored over 12 ft (3.7 m) and up to and including 25 ft (7.6 m) in height, Table

25.2.3.2.1 shall be used to determine the appropriate figure for determining ceiling-level sprinkler design criteria with the provision of one level of in-rack sprinklers.

Table 25.2.3.2.1 Single- or Double-Row Racks — Storage Height Over 12 ft (3.7 m) Up to and Including 25 ft (7.6 m)

Height	Commodity Class	Encapsulated	Aisles*		Sprinklers Mandatory In-Rack	Ceiling Sprinkler Water Demand					
			ft	m		With In-Rack Sprinklers			Without In-Rack Sprinklers		
						Figure	Curves	Apply Figure 16.2.1.3.4.1	Figure	Curves	Apply Figure 16.2.1.3.4.1
Over 12 ft (3.7 m) up to and including 20 ft (6.1 m)	I	No	4	1.2	No	16.2.1.3.2(a)	C and D	Yes	16.2.1.3.2(a)	F and H	Yes
			8	2.4			A and B			E and G	
		Yes	4	1.2	No	16.2.1.3.2(e)	C and D		16.2.1.3.2(e)	G and H	Yes
			8	2.4			A and B			E and F	
	II	No	4	1.2	No	16.2.1.3.2(b)	C and D		16.2.1.3.2(b)	G and H	Yes
			8	2.4			A and B			E and F	
		Yes	4	1.2	No	16.2.1.3.2(e)	C and D		16.2.1.3.2(e)	G and H	Yes
			8	2.4			A and B			E and F	
	III	No	4	1.2	No	16.2.1.3.2(c)	C and D	16.2.1.3.2(c)	G and H	Yes	
			8	2.4			A and B		E and F		
		Yes	4	1.2	1 level	16.2.1.3.2(f)	C and D	—	—	—	
			8	2.4			A and B				

Height	Commodity Class	Encapsulated	Aisles*		Sprinklers Mandatory In-Rack	Ceiling Sprinkler Water Demand					
			ft	m		With In-Rack Sprinklers			Without In-Rack Sprinklers		
						Figure	Curves	Apply Figure 16.2.1.3. 4.1	Figure	Curves	Apply Figure 16.2.1.3. 4.1
	IV	No	4	1.2	No	16.2.1.3. 2(d)	C and D		16.2.1.3. 2(d)	G and H	Yes
			8	2.4			A and B			E and F	
		Yes	4	1.2	1 level	16.2.1.3. 2(g)	C and D		—	—	—
			8	2.4			A and B				
Over 20 ft (6.1 m) up to and including 22 ft (6.7 m)	I	No	4	1.2	No	16.2.1.3. 2(a)	C and D		16.2.1.3. 2(a)	F and H	Yes
			8	2.4			A and B			E and G	
		Yes	4	1.2	1 level	16.2.1.3. 2(e)	C and D		—	—	—
			8	2.4			A and B				
	II	No	4	1.2	No	16.2.1.3. 2(b)	C and D	No	16.2.1.3. 2(b)	G and H	Yes
			8	2.4			A and B			E and F	
		Yes	4	1.2	1 level	16.2.1.3. 2(e)	C and D		—	—	—
			8	2.4			A and B				
	III	No	4	1.2	No	16.2.1.3. 2(c)	C and D		16.2.1.3. 2(c)	G and H	Yes

Height	Commodity Class	Encapsulated	Aisles*		Sprinklers Mandatory In-Rack	Ceiling Sprinkler Water Demand					
			ft	m		With In-Rack Sprinklers			Without In-Rack Sprinklers		
						Figure	Curves	Apply Figure 16.2.1.3. 4.1	Figure	Curves	Apply Figure 16.2.1.3. 4.1
		Yes	8	2.4	1 level	16.2.1.3. 2(f)	A and B		—	E and F	—
			4	1.2			C and D			—	
			8	2.4			A and B			—	
			4	1.2			C and D			—	
	IV	No	8	2.4	No	16.2.1.3. 2(d)	A and B	16.2.1.3. 2(d)	G and H E and F	Yes	
			4	1.2			C and D		—		
			8	2.4			A and B		—		
			4	1.2			C and D		—		
Over 22 ft (6.7 m) up to and including 25 ft (7.6 m)	I	No	8	2.4	No	16.2.1.3. 2(a)	A and B	No	16.2.1.3. 2(a)	F and H E and G	Yes
			4	1.2			C and D			—	
			8	2.4			A and B			—	
			4	1.2			C and D			—	
	II	No	8	2.4	No	16.2.1.3. 2(b)	A and B		16.2.1.3. 2(b)	G and H E and F	Yes
			4	1.2			C and D			—	
			8	2.4			A and B			—	
			4	1.2			C and D			—	

Height	Commodity Class	Encapsulated	Aisles*		Sprinklers Mandatory In-Rack	Ceiling Sprinkler Water Demand					
			ft	m		With In-Rack Sprinklers			Without In-Rack Sprinklers		
						Figure	Curves	Apply Figure 16.2.1.3.4.1	Figure	Curves	Apply Figure 16.2.1.3.4.1
		Yes	4	1.2	1 level	16.2.1.3.2(e)	C and D		—	—	—
			8	2.4			A and B				
		No	4	1.2	No	16.2.1.3.2(c)	C and D		16.2.1.3.2(c)	G and H	Yes
			8	2.4			A and B			E and F	
	III	Yes	4	1.2	1 level	16.2.1.3.2(f)	C and D		—	—	—
			8	2.4			A and B				
		No	4	1.2	1 level	16.2.1.3.2(d)	C and D		—	—	—
			8	2.4			A and B				
	IV	No	4	1.2	1 level	16.2.1.3.2(g)	C and D		—	—	—
			8	2.4			A and B				
		Yes	4	1.2	1 level	16.2.1.3.2(g)	C and D		—	—	—
			8	2.4			A and B				

*See 16.2.1.3.2.1 for interpolation of aisle widths.

25.2.3.2.2 Multiple-Row Racks.

25.2.3.2.2.1

For multiple-row racks, having a rack depth up to and including 16 ft (4.9 m) with aisles 8 ft (2.4 m) or wider, storing Class I through Class IV commodities, encapsulated or nonencapsulated, over 12 ft (3.7 m) and up to and including 25 ft (7.6 m) in height, Table 25.2.3.2.2.1 shall be used to determine the appropriate figure for determining ceiling-level sprinkler design criteria with the provision of one level of in-rack sprinklers.

Table 25.2.3.2.2.1 Multiple-Row Racks — Rack Depth Up to and Including 16 ft (4.9 m), Aisles 8 ft (2.4 m) or Wider and Storage Height Over 12 ft (3.7 m) Up to 25 ft (7.6 m)

Height	Commodity Class	Encapsulated	Sprinklers Mandatory In-Rack	Ceiling Sprinkler Water Demand							
				With In-Rack Sprinklers				Without In-Rack Sprinklers			
				Figure	Curves	Apply Figure 16.2.1.3.4.1	1.25 × Density	Figure	Curves	Apply Figure 16.2.1.3.4.1	1.25 × Density
Over 12 ft (3.7 m) up to and including 15 ft (4.6 m)	I	No	No	16.2.1.3.2(a)	C and D	Yes	No	16.2.1.3.2(a)	I and J	Yes	No
		Yes		16.2.1.3.2(a)			Yes	16.2.1.3.2(a)	I and J		Yes
	II	No		16.2.1.3.2(b)			No	16.2.1.3.2(b)	I and J	Yes	No
		Yes		16.2.1.3.2(b)			Yes	16.2.1.3.2(b)	I and J		Yes
	III	No	No	16.2.1.3.2(c)	A and B		No	16.2.1.3.2(c)	I and J	Yes	No
		Yes	1 level	16.2.1.3.2(c)			Yes		NA	NA	NA
	IV	No	No	16.2.1.3.2(d)			No	16.2.1.3.2(d)	C and D	No	No
		Yes	1 level	16.2.1.3.2(d)			1.50 × density		NA	NA	NA
Over 15 ft (4.6 m) up to and including 20 ft (6.1 m)	I	No	No	16.2.1.3.2(a)	C and D	Yes	No	16.2.1.3.2(a)	I and J	Yes	No
		Yes		16.2.1.3.2(a)			Yes	16.2.1.3.2(a)	I and J		Yes
	II	No		16.2.1.3.2(b)			No	16.2.1.3.2(b)	I and J	Yes	No
		Yes		16.2.1.3.2(b)			Yes	16.2.1.3.2(b)	I and J		Yes
	III	No	No	16.2.1.3.2(c)	A and B		No	16.2.1.3.2(c)	I and J	Yes	No
		Yes	1 level	16.2.1.3.2(c)			Yes				
	IV	No	1 level	16.2.1.3.2(d)			No	NA	NA	NA	NA
		Yes		16.2.1.3.2(d)			A and B				

Height	Commodity Class	Encapsulated	Sprinklers Mandatory In-Rack	Ceiling Sprinkler Water Demand							
				With In-Rack Sprinklers				Without In-Rack Sprinklers			
				Figure	Curves	Apply Figure 16.2.1.3 .4.1	1.25 × Density	Figure	Curves	Apply Figure 16.2.1.3 .4.1	1.25 × Density
Over 20 ft (6.1 m) up to and including 25 ft (7.6 m)	I	No	No	16.2.1.3.2(a)	C and D	No	No	16.2.1.3.2(a)	I and J	Yes	No
		Yes	1 level	16.2.1.3.2(a)			Yes	NA	NA	NA	NA
	II	No	1 level	16.2.1.3.2(b)			No				
		Yes		16.2.1.3.2(b)			Yes				
	III	No		16.2.1.3.2(c)			No				
		Yes		16.2.1.3.2(c)			Yes				
	IV	No		16.2.1.3.2(d)			No				
		Yes	2 levels	16.2.1.3.2(d)	A and B		1.50 × density				

NA: Not applicable.

25.2.3.2.2.2

For multiple-row racks, having a rack depth up to and including 16 ft (4.9 m) with aisles 8 ft (2.4 m) or wider, storing Class I through Class IV commodities, encapsulated or nonencapsulated, over 12 ft (3.7 m) and up to and including 25 ft (7.6 m) in height, Table 25.2.3.2.2.2 shall be used to determine the appropriate figure for determining ceiling-level sprinkler design criteria with the provision of one level of in-rack sprinklers.

Table 25.2.3.2.2.2 Determining Appropriate Ceiling-Level Protection Criteria Figure for Multiple-Row Racks of Class I through Class IV Commodities — Rack Depth Over 16 ft (4.9 m) or Aisles Narrower Than 8 ft (2.4 m), Storage Height Over 12 ft (3.7 m) Up to and Including 25 ft (7.6 m)

Height	Commodity Class	Encapsulated	Sprinklers Mandatory In-Rack	Ceiling Sprinkler Water Demand							
				With In-Rack Sprinklers				Without In-Rack Sprinklers			
				Figure	Curves	Apply Figure 16.2.1.3 .4.1	1.25 × Density	Figure	Curves	Apply Figure 16.2.1.3 .4.1	1.25 × Density
Over 12 ft (3.7 m) up to	I	No	No	16.2.1.3.2(a)	C and D	Yes	No	16.2.1.3.2(a)	I and J	Yes	No
		Yes		16.2.1.3.2(a)			Yes	16.2.1.3.2(a)	I and J		Yes

Height	Commodity Class	Encapsulated	Sprinklers Mandatory In-Rack	Ceiling Sprinkler Water Demand							
				With In-Rack Sprinklers				Without In-Rack Sprinklers			
				Figure	Curves	Apply Figure 16.2.1.3.4.1	1.25 × Density	Figure	Curves	Apply Figure 16.2.1.3.4.1	1.25 × Density
and including 15 ft (4.6 m)	II	No		16.2.1.3.2(b)			No	16.2.1.3.2(b)	I and J	Yes	No
		Yes		16.2.1.3.2(b)			Yes	16.2.1.3.2(b)	I and J		Yes
	III	No		16.2.1.3.2(c)			No	16.2.1.3.2(c)	I and J	Yes	No
		Yes	1 level	16.2.1.3.2(c)			Yes				
	IV	No	No	16.2.1.3.2(d)			No	16.2.1.3.2(d)	C and D	No	No
		Yes	1 level	16.2.1.3.2(d)			1.50 × density				
		No		16.2.1.3.2(a)			No				
		Yes		16.2.1.3.2(a)			Yes				
Over 15 ft (4.6 m) up to and including 20 ft (6.1 m)	II	No		16.2.1.3.2(b)	C and D	Yes	No	NA	NA	NA	NA
		Yes		16.2.1.3.2(b)			Yes				
	III	No		16.2.1.3.2(c)			No				
		Yes	1 level	16.2.1.3.2(c)			Yes				
	IV	No		16.2.1.3.2(d)			No				
		Yes		16.2.1.3.2(d)			1.50 × density				
	I	No		16.2.1.3.2(a)	C and D	No	No	NA	NA	NA	NA
		Yes	1 level	16.2.1.3.2(a)			Yes				
Over 20 ft (6.1 m) up to and including	II	No		16.2.1.3.2(b)			No	NA	NA	NA	NA

Height 25 ft (7.6 m)	Commodity Class	Encapsulated	Sprinklers Mandatory In-Rack	Ceiling Sprinkler Water Demand							
				With In-Rack Sprinklers				Without In-Rack Sprinklers			
		Figure		Curves	Apply Figure 16.2.1.3.4.1	1.25 × Density	Figure	Curves	Apply Figure 16.2.1.3.4.1	1.25 × Density	
		Yes		16.2.1.3.2(b)			Yes				
	III	No		16.2.1.3.2(c)			No				
		Yes		16.2.1.3.2(c)			Yes				
	IV	No		16.2.1.3.2(d)			No				
		Yes	2 levels	16.2.1.3.2(d)			1.50 × density				

NA: Not applicable.

25.2.3.2.3 Ceiling-Level Protection Criteria Figures.

25.2.3.2.3.1*

The ceiling-level sprinkler design criteria in terms of density [gpm/ft² (mm/min)] and area of sprinkler operation [ft² (m²) of ceiling or roof] obtained from the appropriate density/area curves of Figure 25.2.3.2.3.1(a) through Figure 25.2.3.2.3.1(g) shall be modified as appropriate by 25.2.3.2.4. These requirements shall apply to portable racks arranged in the same manner as single-, double- or multiple-row racks. (See Section C.14.)

Figure 25.2.3.2.3.1(a) Sprinkler System Design Curves — 20 ft (6.1 m) High Rack Storage — Class I Nonencapsulated Commodities — Conventional Pallets.

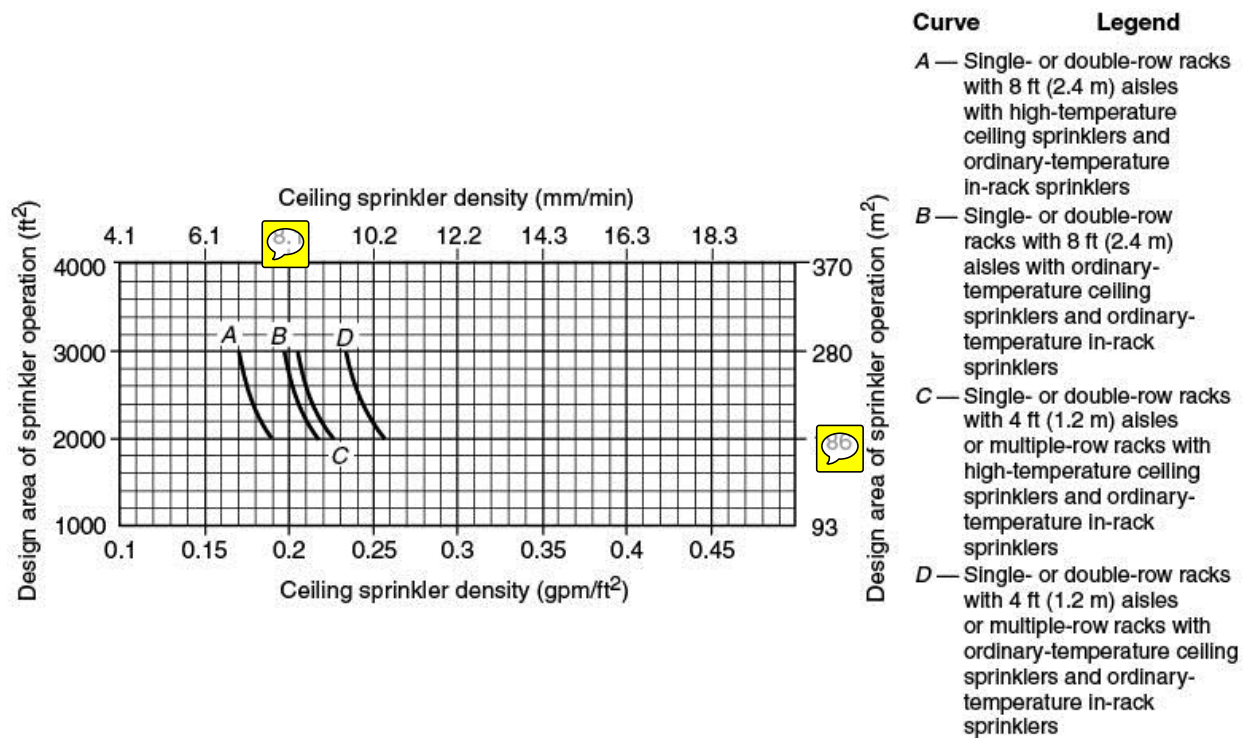


Figure 25.2.3.2.3.1(b) Sprinkler System Design Curves — 20 ft (6.1 m) High Rack Storage — Class II Nonencapsulated Commodities — Conventional Pallets.

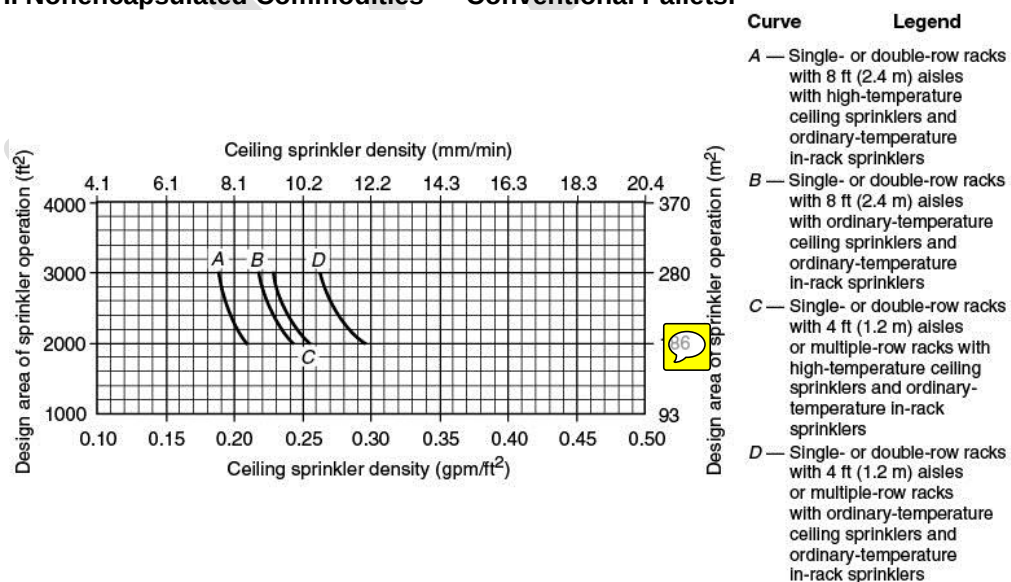


Figure 25.2.3.2.3.1(c) Sprinkler System Design Curves — 20 ft (6.1 m) High Rack Storage — Class III Nonencapsulated Commodities — Conventional Pallets.

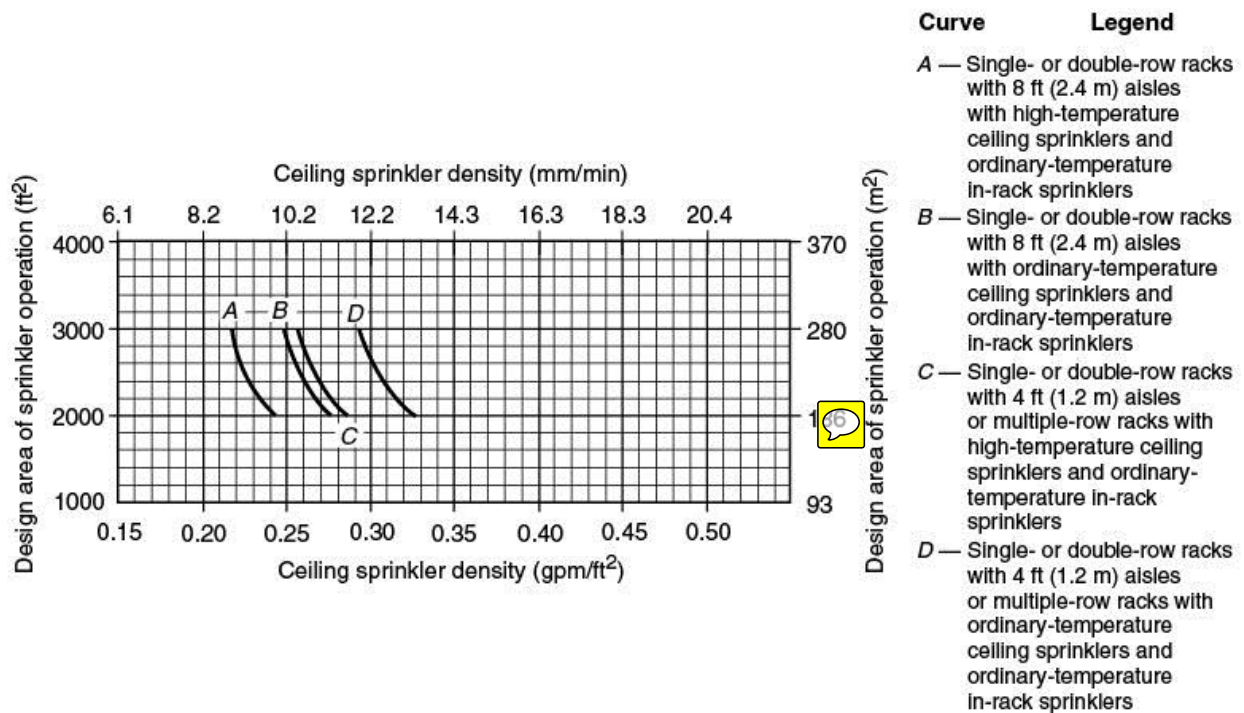


Figure 25.2.3.2.3.1(d) Sprinkler System Design Curves — 20 ft (6.1 m) High Rack Storage — Class IV Nonencapsulated Commodities — Conventional Pallets.

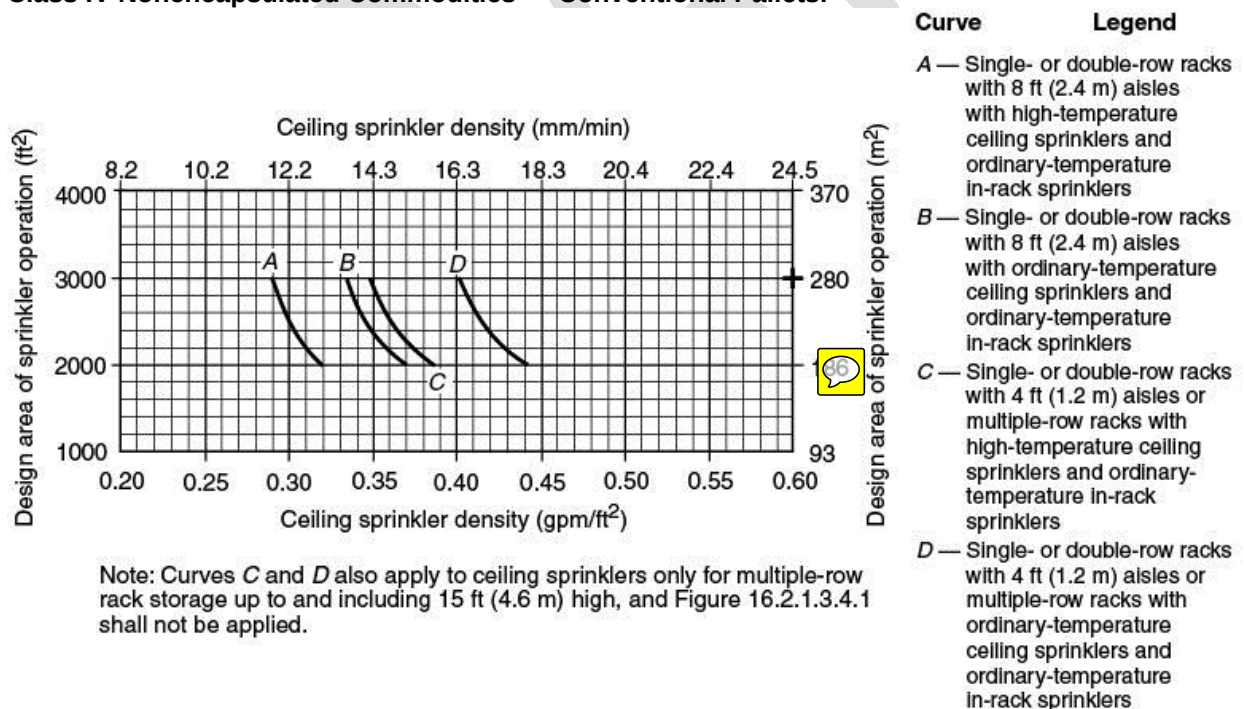


Figure 25.2.3.2.3.1(e) Single- or Double-Row Racks — 20 ft (6.1 m) High Rack Storage — Sprinkler System Design Curves — Class I and Class II Encapsulated Commodities — Conventional Pallets.

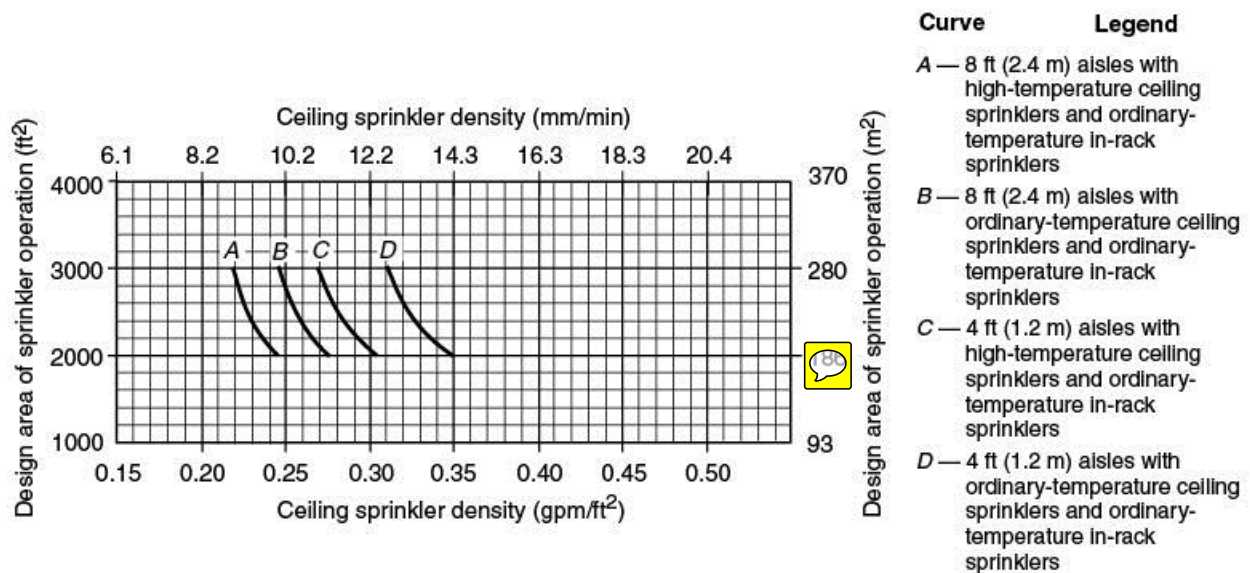


Figure 25.2.3.2.3.1(f) Single- or Double-Row Racks — 20 ft (6.1 m) High Rack Storage — Sprinkler System Design Curves — Class III Encapsulated Commodities — Conventional Pallets.

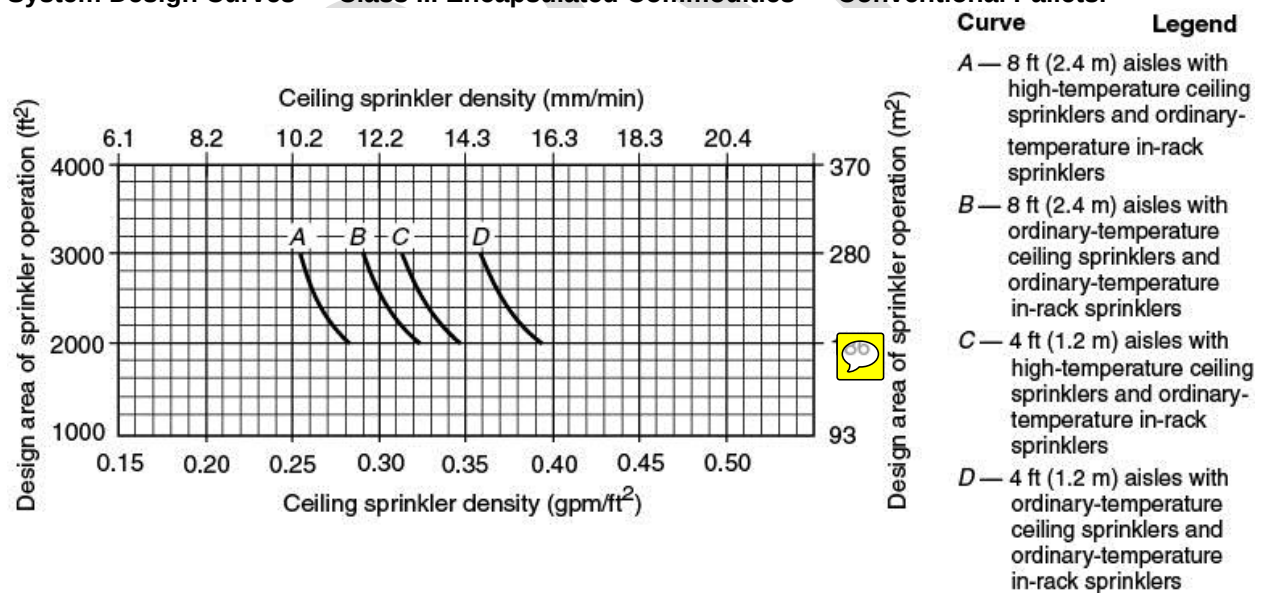
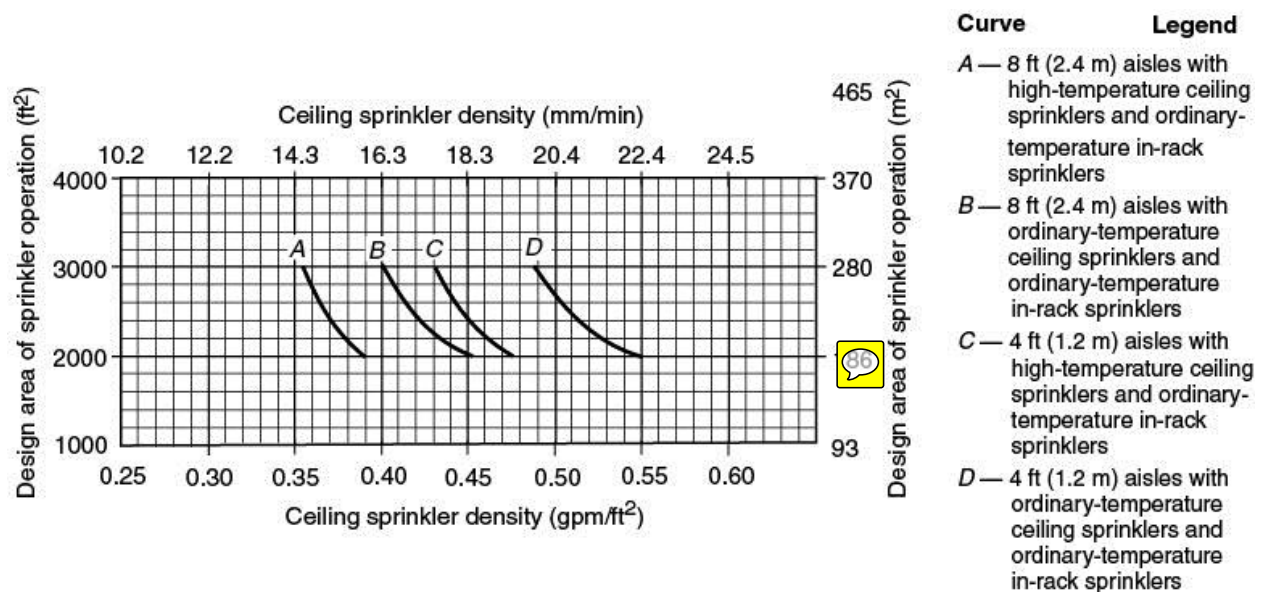


Figure 25.2.3.2.3.1(g) Single- or Double-Row Racks — 20 ft (6.1 m) High Rack Storage — Sprinkler System Design Curves — Class IV Encapsulated Commodities — Conventional Pallets.



25.2.3.2.3.2*

Design densities obtained from Figure 25.2.3.2.3.1(a) through Figure 25.2.3.2.3.1(g) for single- and double-row racks shall be selected to correspond to aisle width. (See Section C.15.)

(A)

For aisle widths between 4 ft (1.2 m) and 8 ft (2.4 m), the rules for 4 ft (1.2 m) aisle width shall be used or direct linear interpolation between the densities shall be permitted.

(B)

The density given for 8 ft (2.4 m) wide aisles shall be applied to aisles wider than 8 ft (2.4 m).

(C)

The density given for 4 ft (1.2 m) wide aisles shall be applied to aisles more narrow than 4 ft (1.2 m) down to 3-½ ft (1.1 m).

(D)

Where aisles are more narrow than 3-½ ft (1.1 m), racks shall be considered to be multiple-row racks.

25.2.3.2.4* Ceiling Sprinkler Density Adjustments.

25.2.3.2.4.1

Where Class I, Class II, and Class III commodities are encapsulated in multiple-row racks over 12 ft (3.7 m) and up to and including 25 ft (7.6 m) in height, the ceiling sprinkler density obtained from the applicable figure in 25.2.3.2.3.1 shall be increased by 25 percent over that required for nonencapsulated commodities.

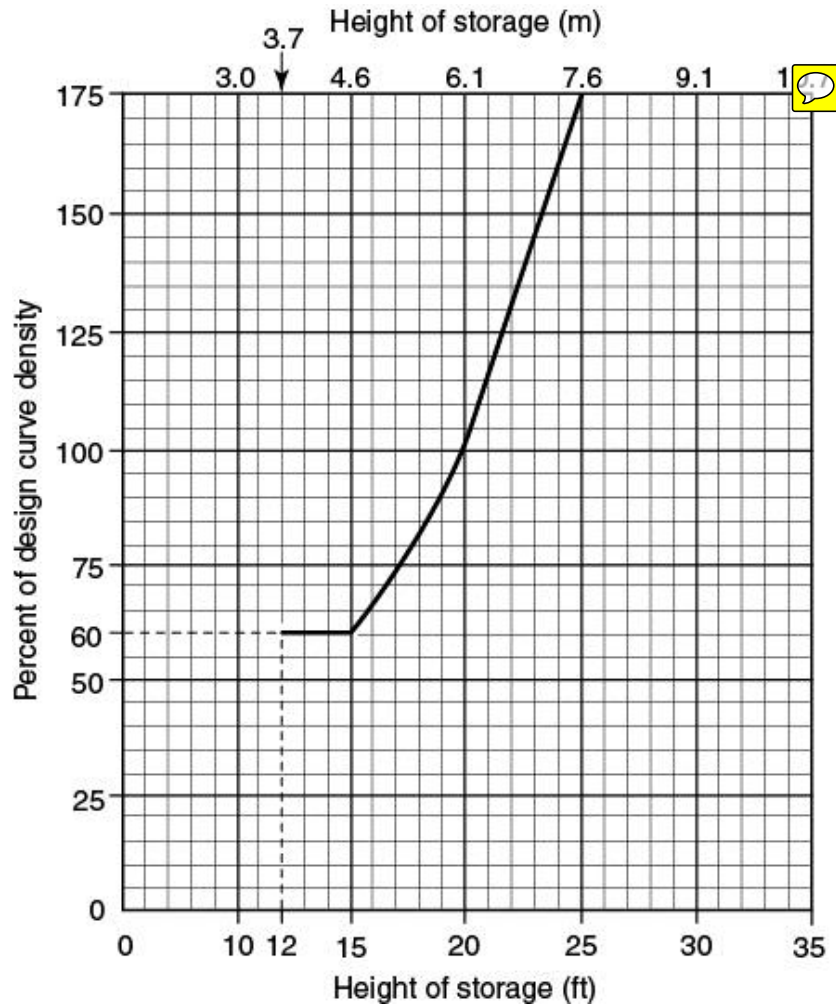
25.2.3.2.4.2

Where Class IV commodities are encapsulated in multiple-row racks over 12 ft (3.7 m) and up to and including 25 ft (7.6 m) in height, the ceiling sprinkler density obtained from the applicable figure in 25.2.3.2.3.1 shall be increased by 50 percent over that required for nonencapsulated.

25.2.3.2.4.3

Where in-rack sprinklers are being installed within racks of Class I through Class IV commodities stored over 12 ft (3.7 m) up to and including 20 ft (6.1 m) protected with CMDA sprinklers at ceiling level along with the minimum number of required in-rack sprinkler levels, densities obtained from design curves shall be adjusted in accordance with Figure 25.2.3.2.4.3.

Figure 25.2.3.2.4.3 Adjustment to Ceiling-Level Sprinkler Density Due to Storage Height.



25.2.3.2.4.4

Where in-rack sprinklers are being installed within racks of Class I through Class IV commodities stored over 12 ft (3.7 m) and up to and including 20 ft (6.1 m) in height protected with CMDA sprinklers at ceiling level along with more than one level of in-rack sprinklers, but not in every tier, densities obtained from design curves and adjusted in accordance with Figure 25.2.3.2.4.3 shall be permitted to be reduced an additional 20 percent, as indicated in Table 25.2.3.2.4.4.

Table 25.2.3.2.4.4 Adjustment to Ceiling Sprinkler Density for Storage Height and In-Rack Sprinklers

Storage Height	In-Rack Sprinklers	Apply Figure 16.2.1.3.4.1 for Storage Height Adjustment	Permitted Ceiling Sprinklers Density Adjustments Where In-Rack Sprinklers Are Installed
Over 12 ft (3.7 m) through 25 ft (7.6 m)	None	Yes	None
Over 12 ft (3.7 m) through 20 ft (6.1 m)	Minimum required	Yes	None
	More than minimum, but not in every tier	Yes	Reduce density 20% from that of minimum in-rack sprinklers

Storage Height	In-Rack Sprinklers	Apply Figure 16.2.1.3.4.1 for Storage Height Adjustment	Permitted Ceiling Sprinklers Density Adjustments Where In-Rack Sprinklers Are Installed
	In every tier except above the top tier	Yes	Reduce density 40% from that of minimum in-rack sprinklers
	Minimum required	No	None
Over 20 ft (6.1 m) through 25 ft (7.3 m)	More than minimum, but not in every tier	No	Reduce density 20% from that of minimum in-rack sprinklers
	In every tier except above the top tier	No	Reduce density 40% from that of minimum in-rack sprinklers

25.2.3.2.4.5*

Where in-rack sprinklers are being installed within racks of Class I through Class IV commodities stored over 12 ft (3.7 m) and up to and including 20 ft (6.1 m) in height protected with CMDA sprinklers at ceiling level along with in-rack sprinklers at each tier level, densities obtained from design curves and adjusted in accordance with Figure 25.2.3.2.4.3 shall be permitted to be reduced an additional 40 percent, as indicated in Table 25.2.3.2.4.4.

25.2.3.2.4.6

Where in-rack sprinklers are being installed within racks of Class I through Class IV commodities stored over 20 ft (6.1 m) and up to and including 25 ft (7.6 m) in height protected with CMDA sprinklers at ceiling level along with the minimum number of required in-rack sprinkler levels, densities obtained from design curves shall be used. Densities shall not be adjusted in accordance with Figure 25.2.3.2.4.3.

25.2.3.2.4.7

Where in-rack sprinklers are being installed within racks of Class I through Class IV commodities stored over 20 ft (6.1 m) and up to and including 25 ft (7.6 m) in height protected with CMDA sprinklers at ceiling level along with more than the minimum required level of in-rack sprinklers, but not in every tier, densities obtained from design curves shall be permitted to be reduced 20 percent, as indicated in Table 25.2.3.2.4.4. Densities shall not be adjusted in accordance with Figure 25.2.3.2.4.3 for storage height.

25.2.3.2.4.8

Where in-rack sprinklers are being installed within racks of Class I through Class IV commodities stored over 20 ft (6.1 m) and up to and including 25 ft (7.6 m) in height protected with CMDA sprinklers at ceiling level along with in-rack sprinklers at each tier level, except above the top tier, densities obtained from design curves shall be permitted to be reduced 40 percent, as indicated in Table 25.2.3.2.4.4. Densities shall not be adjusted in accordance with Figure 25.2.3.2.4.3 for storage height.

25.2.3.3 Rack Storage of Class I Through Class IV Commodities Over 25 ft (7.6 m) in Height.

25.2.3.3.1 Single- and Double-Row Racks.

25.2.3.3.1.1*

Where in-rack sprinklers are being installed within single- and double-row racks separated by aisles at least 4 ft (1.2 m) wide and with a clearance to ceiling up to and including 10 ft (3.0 m) of nonencapsulated Class I through Class IV commodities stored over 25 ft (7.6 m) in height protected by CMDA sprinklers at ceiling level, the ceiling sprinkler designs shall be in accordance with Table 25.2.3.3.1.1.

25.2.3.3.1.2

Where storage as described in 25.2.3.3.1.1 is encapsulated, the ceiling sprinkler density obtained from Table 25.2.3.3.1.1 shall be increased by 25 percent over that required for nonencapsulated commodities.

25.2.3.3.2 Multiple-Row Racks.

25.2.3.3.2.1

Where in-rack sprinkler are being installed within multiple-row racks separated by aisles at least 4 ft (1.2 m) wide and with a clearance to ceiling up to and including 10 ft (3.0 m) of nonencapsulated Class I through Class IV commodities stored over 25 ft (7.6 m) in height protected by CMDA sprinklers at ceiling level, the ceiling sprinkler designs shall be in accordance with Table 25.2.3.3.2.1.

25.2.3.3.2.2

Where storage as described in 25.2.3.3.2.1 is encapsulated, the ceiling sprinkler density obtained from Table 25.2.3.3.2.1 shall be increased by 25 percent over that required for nonencapsulated commodities.

25.2.3.4 Rack Storage of Group A Plastic Commodities Stored Over 5 ft (1.5 m) and Up to and Including 25 ft (7.6 m) in Height.

25.2.3.4.1 Cartoned Group A Plastic Commodities.

25.2.3.4.1.1

Where rack storage of cartoned Group A plastic commodities, encapsulated or nonencapsulated, having a clearance to ceiling up to and including 10 ft (3.0 m) is protected by in-rack sprinklers, ceiling-level sprinkler designs in terms of density [gpm/ft² (mm/min)] and area of operation [ft² (m²)] shall be selected from Figure 25.9.3.1(a) through Figure 25.9.3.1(e).

25.2.3.4.1.2

Linear interpolation of design densities and areas of application shall be permitted between storage heights with the same clearance to ceiling.

25.2.3.4.1.3

No interpolation between clearance to ceiling shall be permitted.

25.2.3.4.2 Exposed Nonexpanded Group A Plastic Commodities.

Where in-rack sprinkler protection is installed to protect rack storage of exposed nonexpanded Group A plastic commodities, encapsulated or nonencapsulated, stored over 5 ft (1.5 m) and up to and including 25 ft (7.6 m) in height protected by CMDA sprinklers at ceiling-level, the ceiling sprinkler design shall be in accordance with one of the following:

- (1) Where in-rack sprinklers are installed in accordance with Figure 25.9.3.3(a), the ceiling-level sprinkler design shall be a minimum 0.45 gpm/ft² (18.3 mm/min) density over a 2000 ft² (186 m²) demand area.
- (2) Where in-rack sprinklers are installed in accordance with Figure 25.9.3.3(b), the ceiling-level sprinkler design shall be a minimum 0.30 gpm/ft² (12.2 mm/min) density over a 2000 ft² (186 m²) demand area.
- (3) Where in-rack sprinklers are installed in accordance with Figure 25.9.3.3(c), the ceiling-level sprinkler design shall be a minimum 0.45 gpm/ft² (18.3 mm/min) density over a 2000 ft² (186 m²) demand area.
- (4) Where in-rack sprinklers are installed in accordance with Figure 25.9.3.3(d), the ceiling-level sprinkler design shall be a minimum 0.30 gpm/ft² (12.2 mm/min) density over a 2000 ft² (186 m²) demand area.
- (5) Where in-rack sprinklers are installed in accordance with Figure 25.9.3.3(e), the ceiling-level sprinkler design shall be a minimum 0.6 gpm/ft² (24.4 mm/min) density over a 2000 ft² (186 m²) demand area.
- (6) Where in-rack sprinklers are installed in accordance with Figure 25.9.3.3(f), the ceiling-level sprinkler design shall be a minimum 0.45 gpm/ft² (18.3 mm/min) density over a 2000 ft² (186 m²) demand area.
- (7) Where in-rack sprinklers are installed in accordance with Figure 25.9.3.3(g), the ceiling-level sprinkler design shall be a minimum 0.8 gpm/ft² (32.6 mm/min) density over a 1500 ft² (139 m²) demand area.
- (8) Where in-rack sprinklers are installed in accordance with Figure 25.9.3.3(h), the ceiling-level sprinkler design shall be a minimum 0.6 gpm/ft² (24.4 mm/min) density over a 1500 ft² (139 m²) demand area.
- (9) Where in-rack sprinklers are installed in accordance with Figure 25.9.3.3(i), the ceiling-level sprinkler design shall be a minimum 0.30 gpm/ft² (12.2 mm/min) density over a 2000 ft² (186 m²) demand area.
- (10) Where in-rack sprinklers are installed in accordance with Figure 25.9.3.3(j), the ceiling-level sprinkler design shall be a minimum 0.8 gpm/ft² (32.6 mm/min) density over a 1500 ft² (139 m²) demand area.

(11) Where in-rack sprinklers are installed in accordance with Figure 25.9.3.3(k), the ceiling-level sprinkler design shall be a minimum 0.30 gpm/ft² (12.2 mm/min) density over a 2000 ft² (186 m²) demand area.

25.2.3.5* Rack Storage of Group A Plastic Commodities Stored Over 25 ft (7.6 m) in Height.

Where rack storage of Group A plastic commodities, encapsulated or not encapsulated, over 25 ft (7.6 m) in height are protected by in-rack sprinklers in accordance with 25.9.4.1, ceiling-level sprinkler designs, in terms of density [gpm/ft² (mm/min)] and area of operation [ft² (m²)], shall be selected from Table 25.2.3.5 based on the storage height of commodity above the top level of in-rack sprinklers.

Table 25.2.3.5 Control Mode Density/Area Sprinkler Discharge Criteria for Single-, Double-, and Multiple-Row Racks of Group A Plastic Commodities with Storage Over 25 ft (7.6 m) in Height

Storage Height Above Top Level In-Rack Sprinklers		Ceiling Sprinklers Density	
ft	m	gpm/ft ² over ft ²	mm/min over m ²
5 or less	1.5 or less	0.30/2000	12.2/186
Over 5 up to 10	Over 1.5 up to 3.0	0.45/2000	18.3/186

25.2.3.6 Rack Storage of Rubber Tires Stored Over 12 ft (3.7 m) in Height.

25.2.3.6.1 General.

The requirements of Chapter 20 shall apply unless modified in this section.

25.2.3.6.2* Ceiling Systems.

Where rack storage of rubber tires, either on-side or on-tread, over 5 ft (1.5 m) and up to and including 20 ft (6.1 m) in height protected by CMDA sprinklers at ceiling-level with a maximum clearance to ceiling of 10 ft (3.0 m) along with one level of in-rack sprinklers, the ceiling-level sprinkler system design density and area of application shall be a minimum 0.40 gpm/ft² (16.3 mm/min) density over a 3000 ft² (279 m²) demand area.

25.2.3.6.3 Reduced-Discharge Density.

Where high-expansion foam systems are installed in accordance with NFPA 11 to protect rack storage of rubber tires, either on-side or on-tread, over 5 ft (1.5 m) and up to and including 20 ft (6.1 m) in height protected by CMDA sprinklers at ceiling-level with a maximum clearance to ceiling of 10 ft (3.0 m) and one level of in-rack sprinklers, the ceiling-level sprinkler system design density shall be permitted to be reduced from 0.40 gpm/ft² (16.3 mm/min) 0.24 gpm/ft² (9.8 mm/min).

25.2.3.6.4 Water Supplies.

Total water supplies shall be capable of providing flow for automatic sprinklers, hose streams, and foam systems (if provided) for the duration required in Table 20.12.2.6.

25.2.4 CMSA Ceiling Level Sprinkler Design Criteria in Combination with In-Rack Sprinklers.

25.2.4.1 General.

25.2.4.1.1 Open Wood Joist Construction with CMSA Sprinklers at Ceiling-Level.

25.2.4.1.1.1

Where CMSA sprinklers are installed under open wood joist construction, fire-stopping in accordance with 25.2.4.1.1.3 shall be provided or the minimum operating pressure of the sprinklers shall be 50 psi (3.4 bar) for a K-11.2 (160) sprinkler or 22 psi (1.5 bar) for a K-16.8 (240) sprinkler.

25.2.4.1.1.2

Where each joist channel of open wood joist construction is fully fire-stopped to its full depth at intervals not exceeding 20 ft (6.1 m), the lower pressures specified in Table 25.2.4.2.1 shall be permitted to be used.

25.2.4.1.2 Preaction Systems for CMSA Sprinklers.

For the purpose of using Table 25.2.4.2.1, preaction systems shall be classified as dry pipe systems.

25.2.4.2 Rack Storage of Class I Through Class IV Commodities.

25.2.4.2.1

Where rack storage of Class I through Class IV commodities is protected by CMSA sprinklers at ceiling level along with one level of in-rack sprinklers, the ceiling-level sprinkler design criteria shall be in accordance with Table 25.2.4.2.1.

25.2.4.2.2

Protection shall be provided as specified in Table 25.2.4.2.1 or appropriate NFPA standards in terms of minimum operating pressure and the number of ceiling-level sprinklers to be included in the design area.

25.2.4.3 Rack Storage of Group A Plastic Commodities.

25.2.4.3.1

Where rack storage of nonexpanded, cartoned and uncartoned, Group A plastic commodities is protected by CMSA sprinklers at ceiling level along with one level of in-rack sprinklers, the ceiling-level sprinkler system design criteria shall be in accordance with Table 25.2.4.3.1.

Table 25.2.4.3.1 CMSA Ceiling-Level Sprinkler Design Criteria for Rack Storage of Group A Plastic Commodities Stored Up and Including 25 ft (7.6 m) in Height Supplemented with In-Rack Sprinklers

Storage Arrangement	Commodity Class	Maximum Storage Height		Maximum Ceiling/Roof Height		K-Factor/ Orientation	Type of System	Number of Design Sprinklers	Minimum Operating Pressure	
		ft	m	ft	m				psi	bar
Single-, double-, and multiple-row racks (no open-top containers)	Cartoned nonexpanded plastics	20	6.1	25	7.6	11.2 (160) Upright	Wet	15	50	3.4
						16.8 (240) Upright	Wet	15	22	1.5
						19.6 (280) Pendent	Wet	15	16	1.1
				30	9.1	11.2 (160) Upright	Wet	30	50	3.4
						16.8 (240) Upright	Wet	20	75	5.2
						19.6 (280) Pendent	Wet	15*	22	1.5
		25	7.6	30	9.1	11.2 (160) Upright	Wet	15	16	1.1
						16.8 (240) Upright	Wet	15	16	1.1
						19.6 (280) Pendent	Wet	15	16	1.1
						11.2 (160) Upright	Wet	15 + 1 level of in-rack	50	3.4
						16.8 (240) Upright	Wet	15*	22	1.5
						19.6 (280) Pendent	Wet	15	16	1.1

Storage Arrangement	Commodity Class	Maximum Storage Height		Maximum Ceiling/Roof Height		K-Factor/ Orientation	Type of System	Number of Design Sprinklers	Minimum Operating Pressure	
		ft	m	ft	m				psi	bar
		25	7.6	35	11	11.2 (160) Upright	Wet	30 + 1 level of in-rack	50	3.4
						16.8 (240) Upright	Wet	20 + 1 level of in-rack	75	5.2
							Wet	30 + 1 level of in-rack	22	1.5
						19.6 (280) Pendent	Wet	20 + 1 level of in-rack	35	2.4
							Wet	15	25	1.7
	Exposed nonexpanded plastics	20	6.1	25	7.6	11.2 (160) Upright	Wet	15	50	3.4
						16.8 (240) Upright	Wet	15	22	1.5
		20	6.1	30	9.1	11.2 (160) Upright	Wet	30	50	3.4
						16.8 (240) Upright	Wet	20	75	5.2
							Wet	15*	22	1.5
		25	7.6	30	9.1	11.2 (160) Upright	Wet	15 + 1 level of in-rack	50	3.4
						16.8 (240) Upright	Wet	15*	22	1.5
		25	7.6	35	11	11.2 (160) Upright	Wet	30 + 1 level of in-rack	50	3.4
							Wet	20 + 1 level of in-rack	75	5.2
						16.8 (240) Upright	Wet	30 + 1 level of in-rack	22	1.5
							Wet	20 + 1 level of in-rack	35	2.4

*Minimum 8 ft (2.4 m) aisle.

25.2.4.3.2

Protection shall be provided as specified in Table 25.2.4.3.1 or appropriate NFPA standards in terms of minimum operating pressure and the number of ceiling-level sprinklers to be included in the design area.

25.2.5 ESFR Ceiling Level Sprinkler Design Criteria in Combination with In-Rack Sprinklers.

25.2.5.1 Rack Storage of Class I Through Class IV Commodities.

25.2.5.1.1

Where rack storage of Class I through Class IV commodities is protected by ESFR sprinklers at ceiling level along with one level of in-rack sprinklers, the ceiling-level sprinkler design criteria shall be in accordance with Table 25.2.5.1.1.

25.2.5.1.2

ESFR sprinkler systems, when supplemented with in-rack sprinklers, shall be designed such that the minimum operating pressure is not less than that indicated in Table 25.2.5.1.1 for type of storage, commodity, storage height, and building height involved.

25.2.5.1.3

The design area applicable to the ceiling-level design options listed in Table 25.xx shall consist of the most hydraulically demanding area of 12 sprinklers, consisting of four sprinklers on each of three branch lines.

25.2.5.2 Rack Storage of Group A Plastic Commodities.

25.2.5.2.1

Where rack storage of cartoned or exposed nonexpanded Group A plastic and cartoned expanded Group A plastic commodity is protected by ESFR sprinklers at ceiling level along with one level of in-rack sprinklers, the ceiling-level sprinkler design criteria shall be in accordance with Table 25.2.5.2.1.

Table 25.2.5.2.1 ESFR Ceiling-Level Sprinkler Design Criteria for Rack Storage of Group A Plastic Commodities Supplemented with In-Rack Sprinklers

Storage Arrangement	Commodity	Maximum Storage Height		Maximum Ceiling/Roof Height		Nominal K-Factor	Orientation	Minimum Operating Pressure		In-Rack Sprinkler Requirements
		ft	m	ft	m			psi	bar	
Single-, double-, and multiple-row racks (no open-top containers)	Cartoned nonexpanded	20	6.1	25	7.6	14.0 (200)	Upright/pendent	50	3.4	No
						16.8 (240)	Upright/pendent	35	2.4	No
						22.4 (320)	Pendent	25	1.7	No
						25.2 (360)	Pendent	15	1.0	No
				30	9.1	14.0 (200)	Upright/pendent	50	3.4	No
						16.8 (240)	Upright/pendent	35	2.4	No
						22.4 (320)	Pendent	25	1.7	No
						25.2	Pendent	15	1.0	No

Storage Arrangement	Commodity	Maximum Storage Height		Maximum Ceiling/Roof Height		Nominal K-Factor	Orientation	Minimum Operating Pressure		In-Rack Sprinkler Requirements
		ft	m	ft	m			psi	bar	
						(360)				
				35	11	14.0 (200)	Upright/pendent	75	5.2	No
						16.8 (240)	Upright/pendent	52	3.6	No
						22.4 (320)	Pendent	35	2.4	No
						25.2 (360)	Pendent	20	1.4	No
				40	12	16.8 (240)	Pendent	52	3.6	No
						22.4 (320)	Pendent	40	2.7	No
						25.2 (360)	Pendent	25	1.7	No
				45	14	14.0 (200)	Pendent	90	6.2	Yes
						16.8 (240)	Pendent	63	4.3	Yes
						22.4 (320)	Pendent	40	2.7	No
						25.2 (360)	Pendent	40	2.7	No
		25	7.6	30	9.1	14.0 (200)	Upright/pendent	50	3.4	No
						16.8 (240)	Upright/pendent	35	2.4	No
						22.4 (320)	Pendent	25	1.7	No
						25.2 (360)	Pendent	15	1.0	No
				32	10	14.0 (200)	Upright/pendent	60	4.1	No
						16.8 (240)	Upright/pendent	42	2.9	No
				35	11	14.0 (200)	Upright/pendent	75	5.2	No

Storage Arrangement	Commodity	Maximum Storage Height		Maximum Ceiling/Roof Height		Nominal K-Factor	Orientation	Minimum Operating Pressure		In-Rack Sprinkler Requirements
		ft	m	ft	m			psi	bar	
						16.8 (240)	Upright/pendent	52	3.6	No
						22.4 (320)	Pendent	35	2.4	No
						25.2 (360)	Pendent	20	1.4	No
				40	12	16.8 (240)	Pendent	52	3.6	No
						22.4 (320)	Pendent	40	2.7	No
						25.2 (360)	Pendent	25	1.7	No
				45	14	14.0 (200)	Pendent	90	6.2	Yes
						16.8 (240)	Pendent	63	4.3	Yes
						22.4 (320)	Pendent	40	2.7	No
						25.2 (360)	Pendent	40	2.7	No
	Exposed nonexpanded	20	6.1	25	7.6	14.0 (200)	Pendent	50	3.4	No
						16.8 (240)	Pendent	35	2.4	No
				30	9.1	14.0 (200)	Pendent	50	3.4	No
						16.8 (240)	Pendent	35	2.4	No
				35	11	14.0 (200)	Pendent	75	5.2	No
						16.8 (240)	Pendent	52	3.6	No
				40	12	16.8 (240)	Pendent	52	3.6	No
				45	14	14.0 (200)	Pendent	90	6.2	Yes
						16.8	Pendent	63	4.3	Yes

Storage Arrangement	Commodity	Maximum Storage Height		Maximum Ceiling/Roof Height		Nominal K-Factor	Orientation	Minimum Operating Pressure		In-Rack Sprinkler Requirements
		ft	m	ft	m			psi	bar	
		25	7.6	30	9.1	(240)				
						14.0 (200)	Pendent	50	3.4	No
				32	10	16.8 (240)	Pendent	35	2.4	No
						14.0 (200)	Pendent	60	4.1	No
				35	11	16.8 (240)	Pendent	42	2.9	No
						14.0 (200)	Pendent	75	5.2	No
				40	12	16.8 (240)	Pendent	52	3.6	No
						22.4 (320)	Pendent	50	3.4	No
				45	14	25.2 (360)	Pendent	50	3.4	No
						14.0 (200)	Pendent	90	6.2	Yes
				25	7.6	16.8 (240)	Pendent	63	4.3	Yes
						14.0 (200)	Upright/pendent	50	3.4	No
				30	9.1	16.8 (240)	Upright/pendent	35	2.4	No
						14.0 (200)	Upright/pendent	50	3.4	No
				30	9.1	16.8 (240)	Upright/pendent	35	2.4	No
						14.0 (200)	Upright/pendent	50	3.4	No
				32	10	16.8 (240)	Upright/pendent	35	2.4	No
						14.0 (200)	Pendent	60	4.1	No
	Cartoned expanded	20	6.1	25	7.6	16.8 (240)	Upright/pendent	35	2.4	No
						14.0 (200)	Upright/pendent	50	3.4	No
				30	9.1	16.8 (240)	Upright/pendent	35	2.4	No
						14.0 (200)	Upright/pendent	50	3.4	No

Storage Arrangement	Commodity	Maximum Storage Height		Maximum Ceiling/Roof Height		Nominal K-Factor	Orientation	Minimum Operating Pressure		In-Rack Sprinkler Requirements
		ft	m	ft	m			psi	bar	
						16.8 (240)	Upright/pendent	42	2.9	No

25.2.5.2.2

ESFR sprinkler systems, when supplemented with in-rack sprinklers, shall be designed such that the minimum operating pressure is not less than that indicated in Table 25.2.5.2.1 for type of storage, commodity, storage height, and building height involved.

25.2.5.2.3

The design area applicable to the ceiling-level design options listed in Table 25.2.5.2.1 shall consist of the most hydraulically demanding area of 12 sprinklers, consisting of four sprinklers on each of three branch lines.

25.3 In-Rack Sprinkler Characteristics.

25.3.1

In-rack sprinklers shall be pendent or upright, standard- or quick-response, ordinary-temperature rated and have a nominal K-factor of K-5.6 (80), K-8.0 (115), or K-11.2 (160).

25.3.2

In-rack sprinklers protecting open-frame rack storage where ESFR sprinklers are installed at ceiling level shall be quick-response, ordinary-temperature rated, and either K-8.0 (115) or K-11.2 (160).

25.3.3

In-rack sprinklers with intermediate- and high-temperature ratings shall be used near heat sources as required by 9.4.2.

25.3.4

In-rack sprinklers shall be permitted to have a different RTI rating than the ceiling sprinklers under which they are installed.

25.3.5 In-Rack Sprinkler Water Shields.

25.3.5.1 In-Rack Sprinkler Water Shields for Storage of Class I Through Class IV Commodities.

Water shields shall be provided directly above in-rack sprinklers, or listed intermediate level/rack storage sprinklers shall be used where there is more than one level, if not shielded by horizontal barriers. (See Section C.3.)

25.3.5.2 In-Rack Sprinkler Water Shields for Plastic Storage.

Where in-rack sprinklers are not shielded by horizontal barriers, water shields shall be provided above the sprinklers, or listed intermediate level/rack storage sprinklers shall be used.

25.4 Vertical Spacing and Location of In-Rack Sprinklers.

25.4.1

In-rack sprinklers shall not be required to meet the obstruction criteria and clearance from storage requirements of Section 9.5.

25.4.2

A minimum 6 in. (150 mm) vertical clear space shall be maintained between in-rack sprinkler deflectors and the top of storage located below them.

25.4.3*

Where in-rack sprinklers are being installed within single- and double-row racks of Class I through Class IV commodities up to and including 20 ft (6.1 m) in height, the vertical clear space of in-rack sprinkler deflectors with respect to the top of storage located below them shall be permitted to be less than 6 in. (150 mm). (See Section C.16.)

25.4.4

In-rack sprinkler discharge shall not be obstructed by horizontal rack members.

25.4.5*

Where one level of in-rack sprinklers are required by the guidelines of this chapter, in-rack sprinklers shall be installed at the first tier level at or above one-half of the highest expected storage height.

25.4.6

Where two levels of in-rack sprinklers are required by the guidelines of this chapter for rack storage of Class I through Class IV commodities up to and including 25 ft (7.6 m) in height, in-rack sprinklers shall be installed at the first tier level at or above one-third and two-thirds of the highest expected storage height.

25.4.7 Maximum Storage Height Above Top In-Rack Sprinkler Level.

25.4.7.1

Where in-rack sprinklers are required for single- and double-row rack storage of Class I through Class IV commodities over 25 ft (7.6 m) in height and protected by CMDA sprinklers at ceiling level, storage above the top level of in-rack sprinklers shall not exceed 10 ft (3.0 m)

25.4.7.2

Where in-rack sprinklers are required for multiple-row rack storage of Class I through Class IV commodities over 25 ft (7.6 m) in height and protected by CMDA sprinklers at ceiling level, storage above the top level of in-rack sprinklers shall not exceed 10 ft (3.0 m) for Class I, Class II, or Class III commodities or 5 ft (1.5 m) for Class IV commodities.

25.4.7.3

Where in-rack sprinklers are required for rack storage of plastic commodities over 25 ft (7.6 m) in height and protected by CMDA sprinklers at ceiling level, storage above the top level of in-rack sprinklers shall not exceed 10 ft (3.0 m).

25.4.8

Where single- and double-row rack storage of Class I through Class IV commodities is over 25 ft (7.6 m) in height and protected by CMDA sprinklers at ceiling level, in-rack sprinklers shall be staggered vertically where installed in accordance with Table 25.9.2.1.1, Figure 25.9.2.2(A)(a) through Figure 25.9.2.2(A)(j), and Figure 25.9.2.1.1(A)(a) through Figure 25.9.2.1.1(A)(e).

25.4.9*

Where multiple-row rack storage of Class I through Class IV commodities is over 25 ft (7.6 m) in height and protected by CMDA sprinklers at ceiling level, in-rack sprinklers shall be staggered vertically where installed in accordance with Table 25.9.2.1.1, Figure 25.9.2.2(A)(a) through Figure 25.9.2.2(A)(j), and Figure 25.9.2.1.1(A)(a) through Figure 25.9.2.1.1(A)(e).

25.5 Horizontal Spacing and Location of In-Rack Sprinklers.

25.5.1 Horizontal Spacing of In-Rack Sprinklers.

25.5.1.1 General.

25.5.1.1.1

In-rack sprinklers shall be permitted to be installed horizontally less than 6 ft (1.8 m) apart.

25.5.1.1.2

For miscellaneous and low piled rack storage, the maximum allowable horizontal spacing of in-rack sprinklers shall be 8 ft (2.4 m).

25.5.1.1.3

For rack storage of rubber tires, the maximum allowable horizontal spacing of in-rack sprinklers shall be 8 ft (2.4 m).

25.5.1.2 CMDA Sprinklers Installed at Ceiling Level.

25.5.1.2.1*

Where single- and double-row rack storage of Class I through Class IV commodities is up to and including 25 ft (7.6 m) in height and protected by CMDA sprinklers at ceiling level, the maximum allowable horizontal spacing of in-rack sprinklers shall be in accordance with Table 25.5.1.2.1.

Table 25.5.1.2.1 In-Rack Sprinkler Horizontal Spacing for Class I, II, III, and IV Commodities Stored in Single- or Double-Row Racks Up to 25 ft (7.6 m) in Height Protected by Control Mode Density/Area Sprinklers at Ceiling Level

Encapsulated	Aisle Widths		Commodity Class					
			I and II		III		IV	
	ft	m	ft	m	ft	m	ft	m
No	8	2.4	12	3.7	12	3.7	10	3.0
No	4	1.2	12	3.7	10	3.0	10	3.0
Yes	—	—	8	2.4	8	2.4	8	2.4

25.5.1.2.2

Where multiple-row rack storage of Class I through Class IV commodities is up to and including 25 ft (7.6 m) in height and protected by CMDA sprinklers at ceiling level, the maximum allowable horizontal spacing of in-rack sprinklers shall be in accordance with Table 25.5.1.2.2.

Table 25.5.1.2.2 In-Rack Sprinkler Horizontal Spacing for Class I, II, III, and IV Commodities Stored in Multiple-Row Racks Up to 25 ft (7.6 m) in Height Protected by Control Mode Density/Area Sprinklers at Ceiling Level

Commodity Class							
I, II, III				IV			
Spacing		Area		Spacing		Area	
ft	m	ft ²	m ²	ft	m	ft ²	m ²
12	3.7	100	9.3	8	2.4	80	7.4

(A)

The rack plan view shall be considered in determining the area covered by each sprinkler.

(B)

The aisles shall not be included in area calculations.

25.5.1.2.3*

Where rack storage of plastic commodities is up to and including 25 ft (7.6 m) in height and protected by CMDA sprinklers at ceiling level, the maximum allowable horizontal spacing of in-rack sprinklers shall be in accordance with Figure 25.9.3.1(a) through Figure 25.9.3.1(e).

25.5.1.2.4

Where single- and double-row rack storage of Class I through Class IV commodities is over 25 ft (7.6 m) in height and protected by CMDA sprinklers at ceiling level, the maximum allowable horizontal spacing of in-rack sprinklers shall be in accordance with Table 25.9.2.1.1 and Figure 25.9.2.2(a) through Figure 25.9.2.2(j).

25.5.1.2.5

Where multiple-row rack storage of Class I through Class IV commodities is over 25 ft (7.6 m) in height and protected by CMDA sprinklers at ceiling level, the maximum allowable horizontal spacing of in-rack sprinklers shall be in accordance with Table 25.9.2.3.1 and Figure 25.9.2.3.1(a) through Figure 25.9.2.3.1(c).

25.5.1.2.6

Where single-row rack storage of cartoned Group A plastic commodities, expanded or nonexpanded, encapsulated or nonencapsulated, is over 25 ft (7.6 m) in height and protected by CMDA sprinklers at ceiling level, the maximum allowable horizontal spacing of in-rack sprinklers shall be in accordance with Figure 25.9.4.1.1(a) through Figure 25.9.4.1.1(d) or Figure 25.9.4.2.2.

25.5.1.2.7

Where double-row rack storage of cartoned Group A plastic commodities, expanded or nonexpanded, encapsulated or nonencapsulated, is over 25 ft (7.6 m) in height and protected by CMDA sprinklers at ceiling level, the maximum allowable horizontal spacing of in-rack sprinklers shall be in accordance with Figure 25.9.4.2.1(a) through Figure 25.9.4.2.1(c).

25.5.1.2.8

Where single- and double-row rack storage of exposed nonexpanded Group A plastic commodities, whether encapsulated or nonencapsulated, is over 25 ft (7.6 m) in height and protected by CMDA sprinklers at ceiling level, the maximum allowable horizontal spacing of in-rack sprinklers shall be in accordance with Figure 25.9.4.2.2.

25.5.1.2.9*

Where multiple-row rack storage of exposed nonexpanded Group A plastic commodities, whether encapsulated or nonencapsulated, or cartoned Group A plastic commodities, expanded or nonexpanded, encapsulated or nonencapsulated, is over 25 ft (7.6 m) in height and protected by CMDA sprinklers at ceiling level, the maximum allowable horizontal spacing of in-rack sprinklers shall be in accordance with Figure 25.9.4.3.1(a) through Figure 25.9.4.3.1(f).

25.5.1.3 CMSA Sprinklers Installed at Ceiling Level.

25.5.1.3.1

Where rack storage of Class I through Class IV commodities is up to and including 25 ft (7.6 m) in height and protected by CMSA sprinklers at ceiling level, the maximum allowable horizontal spacing of in-rack sprinklers shall be 8 ft (2.4 m).

25.5.1.3.2

Where rack storage of plastic commodities is up to and including 25 ft (7.6 m) in height and protected by CMSA sprinklers at ceiling level, the maximum allowable horizontal spacing of in-rack sprinklers shall be 5 ft (1.5 m).

25.5.1.3.3

Where rack storage of Class I through Class IV commodities is over 25 ft (7.6 m) in height and protected by CMSA sprinklers at ceiling level, the maximum allowable horizontal spacing of in-rack sprinklers shall be 5 ft (1.5 m).

25.5.1.4 ESFR Sprinklers Installed at Ceiling Level.

Where rack storage is protected by ESFR sprinklers at ceiling level, the maximum allowable horizontal spacing of in-rack sprinklers shall be 5 ft (1.5 m).

25.5.2 Horizontal Location of In-Rack Sprinklers.

25.5.2.1

In-rack sprinklers shall not be required to meet the obstruction criteria and clearance from storage requirements of Section 9.5.

25.5.2.2*

Where in-rack sprinklers are installed in longitudinal flues, they shall be located at an intersection of transverse and longitudinal flues while not exceeding the maximum horizontal spacing rules.

25.5.2.3

Where horizontal distances between transverse flues exceed the maximum allowable horizontal linear spacing for in-rack sprinklers, in-rack sprinklers shall be installed at the intersection of the transverse and longitudinal flues, and additional in-rack sprinklers shall be installed between transverse flues to meet the maximum allowable horizontal linear spacing rules for in-rack sprinklers.

25.5.2.4

Where no transverse flues exist, horizontal spacing of in-rack sprinklers shall not exceed the maximum allowable spacing rules.

25.5.2.5

Where in-rack sprinklers are installed to protect a higher-hazard commodity that occupies only a portion of the length of a rack, in-rack sprinklers shall be extended a minimum of 8 ft (2.4 m) or one bay, whichever is greater, in each direction along the rack on either side of the higher hazard. The in-rack sprinklers protecting the higher hazard shall not be required to extend across the aisle.

25.5.2.6

The in-rack sprinkler arrangement protecting the higher hazard outlined in 25.5.2.5 shall not be required to be extended across the aisle.

25.5.2.7*

Where rack storage is over 25 ft (7.6 m) in height, in-rack sprinklers shall be a minimum 3 in. (75 mm) radially from the side of rack uprights.

25.5.2.8

Where rack storage of Class I through Class IV commodities is up to and including 25 ft (7.6 m), in-rack sprinklers shall be permitted to be installed horizontally without regard to rack uprights. (See Section C.17.)

25.5.2.9

Where rack storage is over 25 ft (7.6 m) in height, face sprinklers shall be located within the rack a minimum 3 in. (75 mm) from rack uprights and no more than 18 in. (450 mm) from the aisle face of storage.

25.5.2.10

Where single- and double-row rack storage of Class I through Class IV commodities is over 25 ft (7.6 m) in height and protected by CMDA sprinklers at ceiling level, in-rack sprinklers shall be staggered horizontally where installed in accordance with Table 25.9.2.1.1, Figure 25.9.2.2(a) through Figure 25.9.2.2(j), and Figure 25.9.2.1.1(a) through Figure 25.9.2.1.1(e).

25.5.2.11

Where multiple-row rack storage of Class I through Class IV commodities is over 25 ft (7.6 m) in height and protected by CMDA sprinklers at ceiling level, in-rack sprinklers shall be staggered horizontally where installed in accordance with Table 25.9.2.3.1 and Figures 25.9.2.3.1(a) through Figure 25.9.2.3.1(c).

25.5.2.12

Where rack storage of plastic commodities is over 25 ft (7.6 m) in height, in-rack sprinklers in longitudinal flues shall be installed with the deflector located at or below the bottom of horizontal load beams or above or below other adjacent horizontal rack members.

25.5.2.13

Where miscellaneous and low piled single- and double-row rack storage does not have a longitudinal flue, in-rack sprinklers shall be located within 12 in. (300 mm) of the center of the rack while not exceeding the maximum allowable horizontal in-rack sprinkler spacing.

25.6 Protection of Racks with Solid Shelves.

25.6.1 General.

The requirements of Section 25.625.6 shall apply to racks with solid shelves except as modified in this section.

25.6.2

Ceiling-level sprinkler design criteria for CMDA, CMSA, and ESFR sprinklers shall be an applicable option for open racks combined with in-rack sprinklers installed in accordance with the criteria for solid shelving.

25.6.3 Vertical Spacing and Location of In-Rack Sprinklers in Racks with Solid Shelves.

25.6.3.1

Where CMDA sprinklers are at ceiling level protecting racks with solid shelving that exceeds 20 ft² (1.9 m²) in area but not 64 ft² (5.9 m²), in-rack sprinklers shall not be required below every shelf, but shall be installed below solid shelves at intermediate levels not more than 6 ft (1.8 m) apart vertically. (See Section C.11.)

25.6.3.2

Where CMDA sprinklers are at ceiling level protecting racks with solid shelving that exceeds 64 ft² (5.9 m²) in area or where the levels of storage exceed 6 ft (1.8 m), in-rack sprinklers shall be installed below each level of solid shelving.

25.6.3.3

Where CMSA sprinklers are at ceiling level and protect racks with solid shelving, in-rack sprinklers shall be installed beneath all tiers under the highest solid shelf.

25.6.3.4

Where ESFR sprinklers are at ceiling level and protect racks with solid shelving, in-rack sprinklers shall be installed beneath all tiers under the highest solid shelf.

25.6.3.5

Where racks with solid shelves obstruct only a portion of an open-frame rack, in-rack sprinklers shall be installed vertically as follows:

- (1) In accordance with Section 25.6.3.125.6.3.1 and 25.6.3.225.6.3.2 where CMDA sprinklers are installed at ceiling level
- (2) In accordance with 25.6.3.325.6.3.3 where CMSA sprinklers are installed at ceiling level
- (3) In accordance with 25.6.3.425.6.3.4 where ESFR sprinklers are installed at ceiling level

25.6.3.6

Where CMDA sprinklers are at ceiling level and protecting single- or double-row racks with solid shelves of Class I through Class IV commodities stored up to and including 25 ft (7.6 m) in height, a minimum 6 in. (150 mm) vertical clear space shall be maintained between in-rack sprinkler deflectors and the top of storage located below them.

25.6.4 Horizontal Spacing and Location of In-Rack Sprinklers in Racks with Solid Shelves.

25.6.4.1

Where racks with solid shelves contain storage of Class I through Class IV commodities, the maximum allowable horizontal spacing of in-rack sprinklers shall be 10 ft (3.0 m).

25.6.4.2

Where racks with solid shelves contain storage of plastic commodities, the maximum allowable horizontal spacing of in-rack sprinklers shall be 5 ft (1.5 m).

25.6.4.3

Where racks with solid shelves obstruct only a portion of an open-frame rack, in-rack sprinklers shall be extended beyond the end of the solid shelf a minimum of 4 ft (1.2 m) to the nearest flue space intersection.

25.7 Horizontal Barriers in Combination with In-Rack Sprinklers.

25.7.1*

Where required by sections of this chapter, horizontal barriers used in combination with in-rack sprinklers to impede vertical fire development shall be constructed of sheet metal, wood, or similar material and shall extend the full length and depth of the rack.

25.7.2

Barriers shall be fitted within 2 in. (50 mm) horizontally around rack uprights.

25.8 In-Rack Sprinkler Arrangements and Designs, Independent of Ceiling-Level Sprinklers.

25.8.1 Alternative In-Rack Sprinkler Protection Option 1.

25.8.1.1

Where Class I, II, III, IV and Group A plastic commodities are protected in accordance with the guidelines of this section, the in-rack sprinkler system shall not be required to be hydraulically balanced with the ceiling-level sprinkler system.

25.8.1.2

Where a storage rack will not be solely dedicated to the in-rack sprinkler system outlined in this section, either of the following shall apply:

(1) Extend the protection outlined in this section horizontally one pallet load in all directions beyond the commodity storage area that is being protected by the alternative in-rack sprinkler arrangement.

(2) Install a vertical barrier to segregate the commodities that are being protected by the alternative in-rack sprinkler arrangement.

25.8.1.3

Where a storage rack is partially protected by the in-rack sprinkler system outlined in this section, commodities that can be protected by the ceiling-level sprinkler system shall be permitted to be stored vertically above and horizontally adjacent to the portions of the storage rack protected in accordance with this section.

25.8.1.4 Horizontal Barriers for Alternative In-Rack Sprinkler Protection Option 1.

25.8.1.4.1

The barrier shall be constructed of minimum 22 gauge (0.7 mm) sheet metal or of minimum 3/8 in. (10 mm) plywood.

25.8.1.4.2

The barrier shall span horizontally to both aisle faces of the rack, covering up all flue spaces of the rack bays in which they are installed.

25.8.1.4.3

A maximum 3 in. (75 mm) wide horizontal gap shall be permitted at rack uprights or other equipment that would create an opening, such as vertical in-rack sprinkler pipe drops.

25.8.1.4.4

Where the dedicated storage is in open-frame racks, horizontal barriers shall be installed at vertical increments not exceeding 12 ft (3.6 m).

25.8.1.4.5

Where the dedicated storage is in racks with solid shelves, horizontal barriers shall be installed at every tier level of the dedicated storage rack.

25.8.1.5

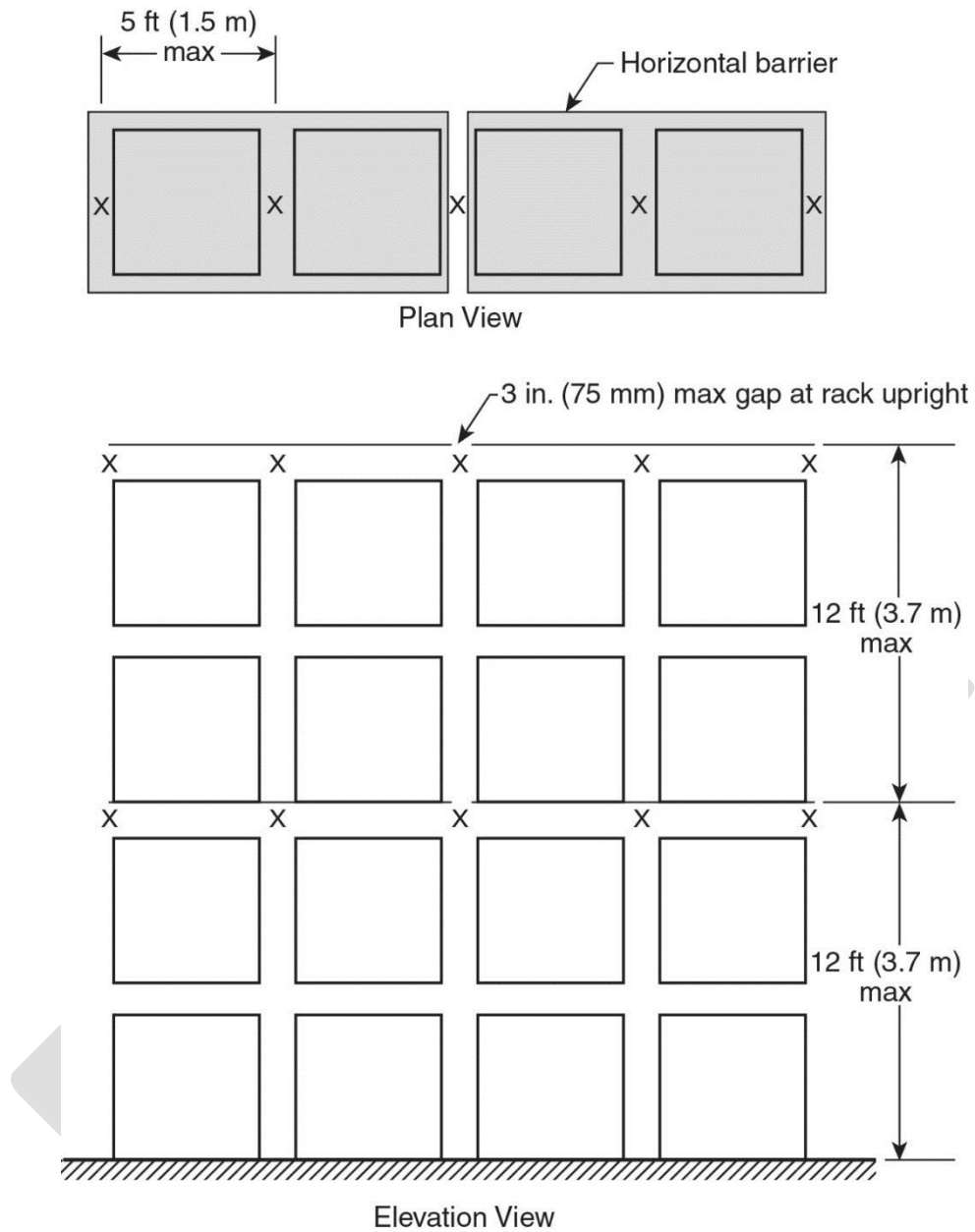
In-rack sprinklers shall be quick-response, minimum K-8.0 (K-115) installed as close to the underside of the horizontal barrier as possible.

25.8.1.6 Alternative In-Rack Sprinkler Protection Option 1 for Single-Row Racks.

25.8.1.6.1

For single-row racks, in-rack sprinklers shall be installed beneath horizontal barriers at each rack upright and within the rack bay as shown in Figure 25.8.1.6.1.

Figure 25.8.1.6.1 Alternative In-Rack Sprinkler Protection Option 1 for Single-Row Racks.



25.8.1.6.2

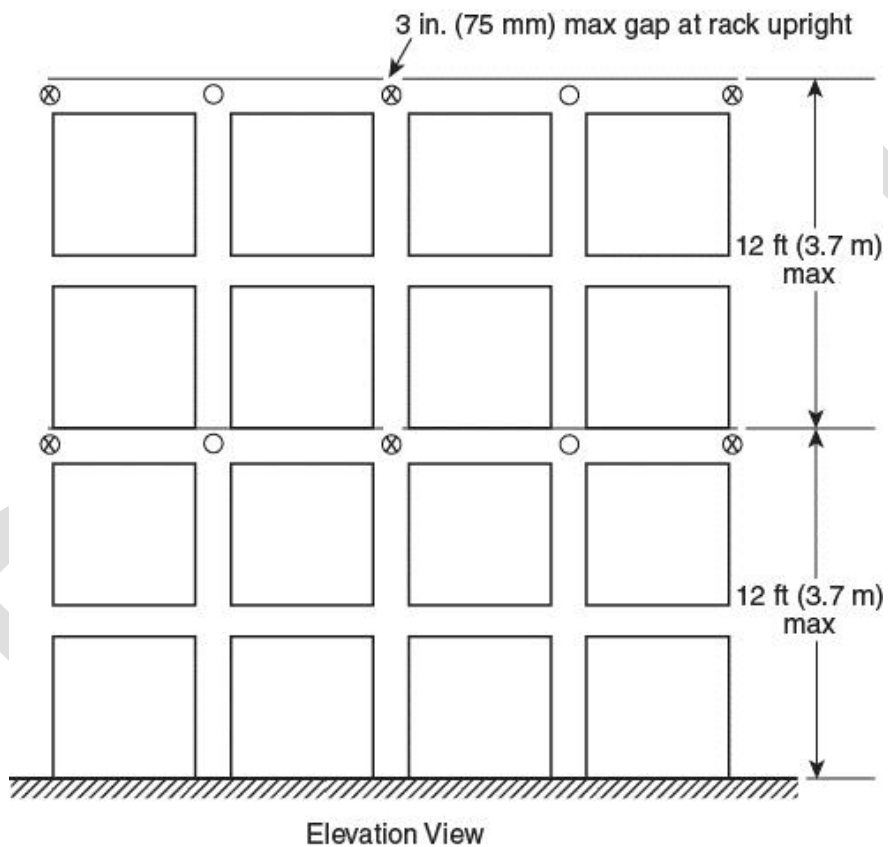
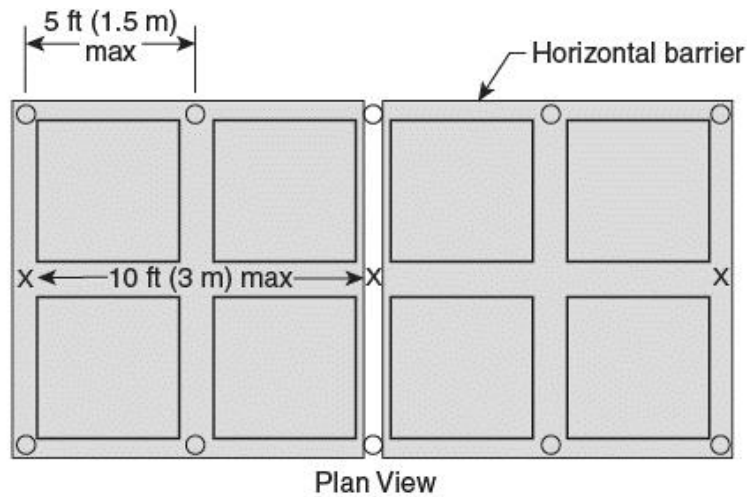
The maximum allowable horizontal spacing between in-rack sprinklers shall not exceed 5 ft (1.5 m).

25.8.1.7 Alternative In-Rack Sprinkler Protection Option 1 for Double-Row Racks.

25.8.1.7.1

For double-row racks, in-rack sprinklers shall be installed beneath horizontal barriers at each rack upright within the longitudinal flue space and at the face of the rack as well as at the face of each rack bay as shown in Figure 25.8.1.7.1.

Figure 25.8.1.7.1 Alternative In-Rack Sprinkler Protection Option 1 for Double-Row Racks.



25.8.1.7.2

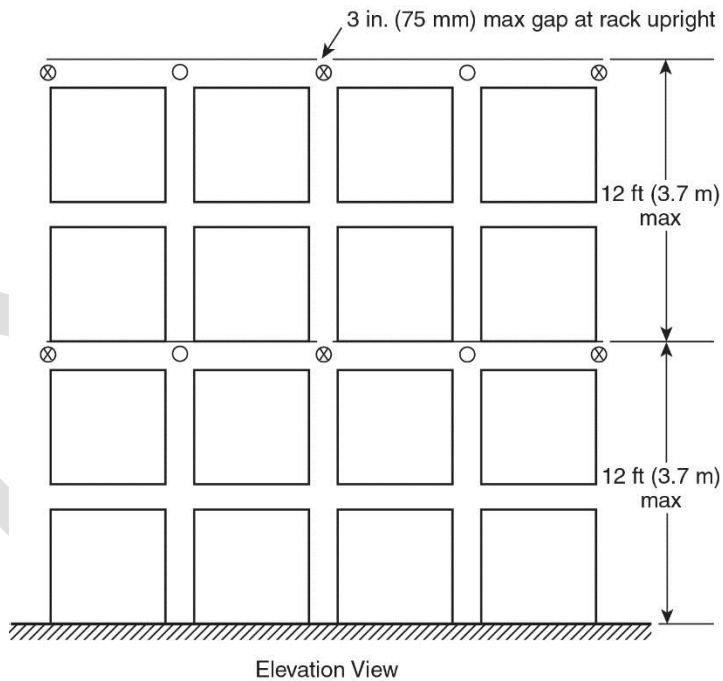
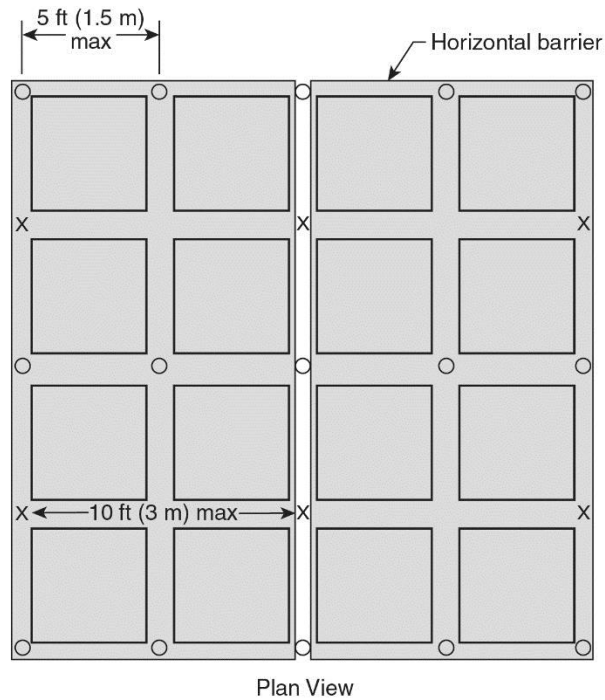
The maximum allowable horizontal spacing between in-rack sprinklers shall not exceed 5 ft (1.5 m) at the rack face and 10 ft (3.0 m) within the longitudinal flue space.

25.8.1.8 Alternative In-Rack Sprinkler Protection Option 1 for Multiple-Row Racks.

25.8.1.8.1

For multiple-row racks, an alternating in-rack sprinkler arrangement shall be installed within adjacent transverse flue spaces and with sprinklers at the face of each flue space as shown in Figure 25.8.1.8.1.

Figure 25.8.1.8.1 Alternative In-Rack Sprinkler Protection Option 1 for Multiple-Row Racks.



25.8.1.8.2

The maximum allowable horizontal spacing between in-rack sprinklers at the face and at each alternating rack bay shall not exceed 5 ft (1.5 m) and shall not exceed 10 ft (3.0 m) between in-rack sprinklers at every other rack bay.

25.8.1.9 In-Rack Sprinkler System Design.

The in-rack sprinkler system design outlined in this section shall be based on a minimum flow of 60 gpm (230 L/min) from the most remote six in-rack sprinklers for single-row racks or the most remote eight in-rack sprinklers for both double-row and multiple-row racks.

25.8.1.10 Ceiling-Level Sprinkler System Design.

The ceiling-level sprinkler system shall be designed based on the highest commodity hazard not protected by the in-rack sprinkler system outlined in this section.

25.8.2 Alternative In-Rack Sprinkler Protection Option 2.

25.8.2.1

Where Class I, II, III, IV and Group A plastic commodities are protected in accordance with this section, the in-rack sprinkler system shall not be required to be hydraulically balanced with the ceiling-level sprinkler system.

25.8.2.2

For open-frame storage racks, install horizontal barriers as outlined in 25.7 as well as in-rack sprinklers a maximum of every 6 ft (1.8 m) vertically.

25.8.2.3

For storage racks having solid shelves with shelf areas that exceed 20 ft² (1.9 m²) but not 64 ft² (5.9 m²) and CMDA sprinklers are installed at ceiling level, in-rack sprinklers shall be installed below shelves at intermediate levels not more than 6 ft (1.8 m) apart vertically.

25.8.2.4

For storage racks having solid shelves with shelf areas that exceed 20 ft² (1.9 m²) but not 64 ft² (5.9 m²) and CMSA or ESFR sprinklers are installed at ceiling level, in-rack sprinklers shall be installed below each level of shelving.

25.8.2.5

For storage racks having solid shelves with shelf areas that exceed 64 ft² (5.9 m²), in-rack sprinklers shall be installed below each level of shelving.

25.8.2.6

Where CMDA sprinklers are at ceiling level and protecting single- or double-row racks with solid shelves of Class I through Class IV commodities stored up to and including 25 ft (7.6 m) in height, a minimum 6 in. (150 mm) vertical clear space shall be maintained between in-rack sprinkler deflectors and the top of storage located below them.

25.8.2.7

Where racks contain storage of Class I through Class IV commodities, the maximum allowable horizontal spacing of in-rack sprinklers shall be 10 ft (3.0 m).

25.8.2.8

Where racks with solid shelves contain storage of plastic commodities, the maximum allowable horizontal spacing of in-rack sprinklers shall be 5 ft (1.5 m).

25.8.2.9

Face sprinklers shall be installed under each solid shelf or horizontal barrier at rack uprights.

25.8.2.10 In-Rack Sprinkler System Design.

The in-rack sprinkler design for the in-rack sprinkler arrangement outlined in this section shall be based on a minimum flow of 60 gpm (230 L/min) from the most remote eight in-rack sprinklers.

25.8.2.11

Where a storage rack will not be solely dedicated to the in-rack sprinkler system outlined in this section, either of the following shall apply:

25.8.2.11.1

Extend the protection outlined in this section horizontally one pallet load in all directions beyond the commodity storage area that is being protected by the alternative in-rack sprinkler arrangement.

25.8.2.11.2

Install a vertical barrier to segregate the commodities that are being protected by the alternative in-rack sprinkler arrangement.

25.8.2.12

Where a storage rack is partially protected by the in-rack sprinkler system outlined in this section, commodities that can be protected by the ceiling-level sprinkler system shall be permitted to be stored vertically above and horizontally adjacent to the portions of the storage rack protected in accordance with this section.

25.9 In-Rack Sprinkler Arrangements in Combination with CMDA Sprinklers at Ceiling-Level.

25.9.1 Rack Storage of Class I through Class IV Commodities Up to and Including 25 ft (7.6 m) in Height.

The in-rack arrangements for rack storage up to and including 25 ft (7.6 m) in height shall be in accordance with the guidelines outlined in Section 25.4 through 25.7 as applicable.

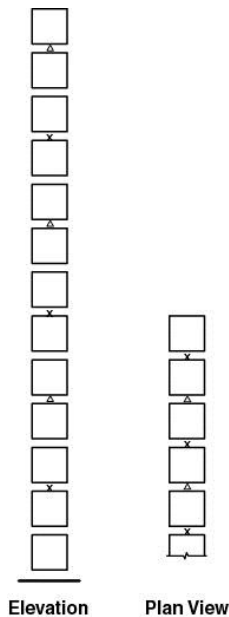
25.9.2 Rack Storage of Class I through Class IV Commodities Over 25 ft (7.6 m) in Height.

25.9.2.1 Single-Row Racks.

25.9.2.1.1*

In single-row racks with a maximum of 10 ft (3.0 m) between the top of storage and the ceiling, in-rack sprinklers shall be installed in accordance with Table 25.9.2.1.1 and Figure 25.9.2.1.1(a) through Figure 25.9.2.1.1(e).

Figure 25.9.2.1.1(a) In-Rack Sprinkler Arrangement, Class I, II, III, or IV Commodities, Single-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 1.

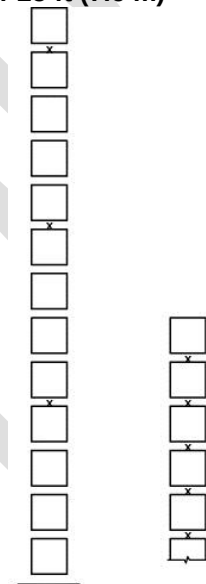


Elevation Plan View

Notes:

1. For all storage heights, sprinklers shall be installed in every other tier and staggered as indicated.
2. Symbol Δ or x indicates sprinklers on vertical or horizontal stagger.
3. Each square represents a storage cube measuring 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. (450 mm) up to 10 ft (3.0 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.0 m) apart vertically.

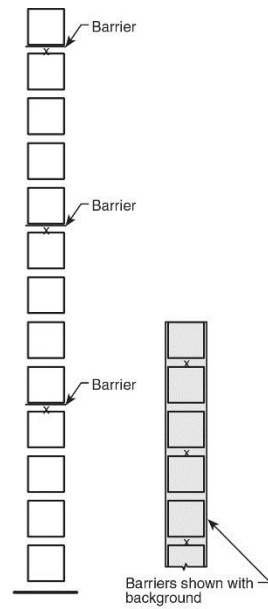
Figure 25.9.2.1.1(b) In-Rack Sprinkler Arrangement, Class I, II, or III Commodities, Single-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 1.



Elevation Plan View

Note: Each square represents a storage cube measuring 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. (450 mm) up to 10 ft (3.0 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.0 m) apart vertically.

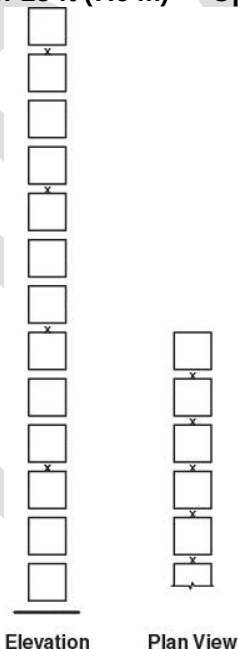
Figure 25.9.2.1.1(c) In-Rack Sprinkler Arrangement, Class I, II, or III Commodities, Single-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 1.



Elevation Plan View

Note: Each square represents a storage cube measuring 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. (450 mm) up to 10 ft (3.0 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.0 m) apart vertically.

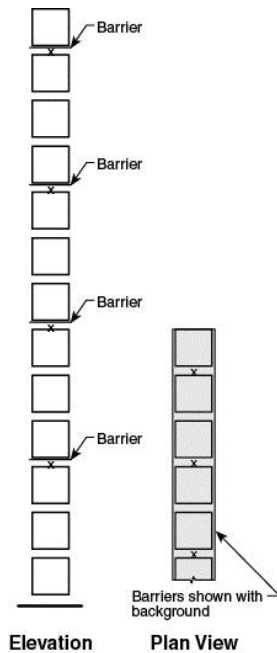
Figure 25.9.2.1.1(d) In-Rack Sprinkler Arrangement, Class I, II, III, or IV Commodities, Single-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 2.



Elevation Plan View

Note: Each square represents a storage cube measuring 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. (450 mm) up to 10 ft (3.0 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.0 m) apart vertically.

Figure 25.9.2.1.1(e) In-Rack Sprinkler Arrangement, Class I, II, III, or IV Commodities, Single-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 3.



Elevation **Plan View**

Note: Each square represents a storage cube measuring 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. (450 mm) up to 10 ft (3.0 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.0 m) apart vertically.

25.9.2.1.2

Where a single-row rack is located against a wall, the in-rack sprinkler arrangement shall be permitted to be in accordance with Figure 25.9.2.2(a) through Figure 25.9.2.2(j).

25.9.2.1.3

Where in-rack sprinkler arrangement figures for single-row racks show in-rack sprinklers in transverse flue spaces centered between the rack faces, it shall be permitted to position these in-rack sprinklers in the transverse flue at any point between the load faces.

25.9.2.2 Double-Row Racks.

25.9.2.2.1*

In double-row racks with a maximum of 10 ft (3.0 m) between the top of storage and the ceiling, in-rack sprinklers shall be installed in accordance with Table 25.9.2.2.1 and Figure 25.9.2.2.1(a) through Figure 25.9.2.2.1(j).

Table 25.9.2.2.1 Single- or Double-Row Racks of Class I Through Class IV Commodities Stored Over 25 ft (7.6 m) in Height with Aisles 4 ft (1.2 m) or More in Width

Commo dity Class	In-Rack Sprinklers Approximate Vertical Spacing at Tier Nearest the Vertical Distance and Maximum Horizontal Spacing ^{a,b,c}		Figure	Maxim um Storag e Height	Stagg er	Ceiling Sprinkl er Operati ng Area		Ceiling Sprinkler Density Clearance to Ceiling Up to 10 ft (3 m) ⁹			
	Longitudi nal Flue ^d	Face ^{e,f}				Ordinary Temperature		High Temperature			
						gpm/ ft ²	mm/m in	gpm/ ft ²	mm/m in		
I	Vertical 20 ft (6.1 m) Horizontal 10 ft (3.0 m) under horizontal barriers	None	16.3.1.3.1.1(A)(a)	30 ft (9.1 m)	No	200 0	18 6	0.25	10.2	0.35	14.2 
	Vertical 20 ft (6.1 m) Horizontal 10 ft (3.0 m)	Vertical 20 ft (6.1 m) Horizon tal 10 ft (3.0 m)	16.3.1.3.1.1(A)(b)	Higher than 25 ft (7.6 m)	Yes			0.25	10.2	0.35	14.2 
I, II, III	Vertical 10 ft (3.0 m) or at 15 ft (4.6 m) and 25 ft (7.6 m)	None	16.3.1.3.1.1(A)(c)	30 ft (9.1 m)	Yes	200 0	18 6	0.3	12.2	0.4	16.3
	Vertical 10 ft (3.0 m m) Horizontal 10 ft (3.0 m m)	Vertical 30 ft (9.1 m) Horizon tal 10 ft (3.0 m)	16.3.1.3.1.1(A)(d)	Yes	0.3			12.2	0.4	16.3	
	Vertical 20 ft (6.1 m) Horizontal 10 ft (3.0 m)	Vertical 20 ft (6.1 m) Horizon tal 5 ft (1.5 m)	16.3.1.3.1.1(A)(e)	Yes	0.3			12.2	0.4	16.3	
	Vertical 25 ft (7.6 m) Horizontal 5 ft (1.5 m)	Vertical 25 ft (7.6 m) Horizon tal 5 ft (1.5 m)	16.3.1.3.1.1(A)(f)	No	0.3			12.2	0.4	16.3	

Commodity Class	In-Rack Sprinklers Approximate Vertical Spacing at Tier Nearest the Vertical Distance and Maximum Horizontal Spacing ^{a,b,c}		Figure	Maximum Storage Height	Stagger	Ceiling Sprinkler Operating Area		Ceiling Sprinkler Density Clearance to Ceiling Up to 10 ft (3 m) ^g			
	Longitudi nal Flue ^d	Face ^{e,f}				Ordinary Temperature		High Temperature			
						gpm/ ft ²	mm/m in	gpm/ ft ²	mm/m in		
	spacing 10 ft (3.0 m), staggered										

^aMinimum in-rack sprinkler discharge, 30 gpm (114 L/min).

^bWater shields required.

^cAll in-rack sprinkler spacing dimensions start from the floor.

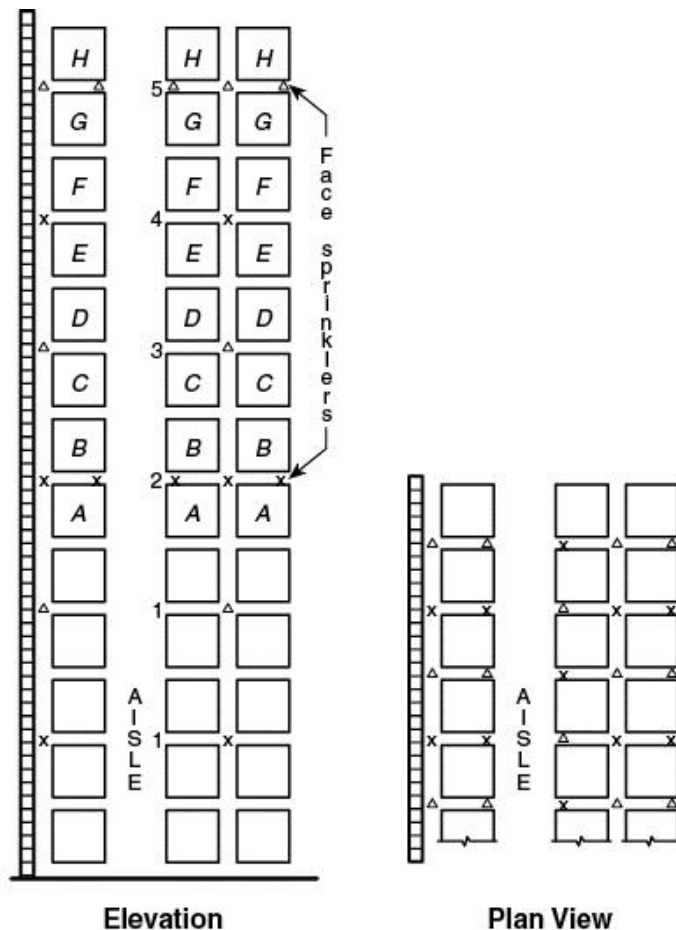
^dInstall sprinklers at least 3 in. (75 mm) from uprights.

^eFace sprinklers shall not be required for a Class I commodity consisting of noncombustible products on wood pallets (without combustible containers), except for arrays shown in Figure 16.3.1.3.1.1(A)(g) and Figure 16.3.1.3.1.1(A)(j).

^fIn Figure 16.3.1.3.1.1(A)(a) through Figure 16.3.1.3.1.1(A)(j), each square represents a storage cube that measures 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. to 10 ft (450 mm to 3.0 m). Therefore, there can be one load to six or seven loads between in-rack sprinklers that are spaced 10 ft (3.0 m) apart vertically.

^gFor encapsulated commodity, increase density 25 percent.

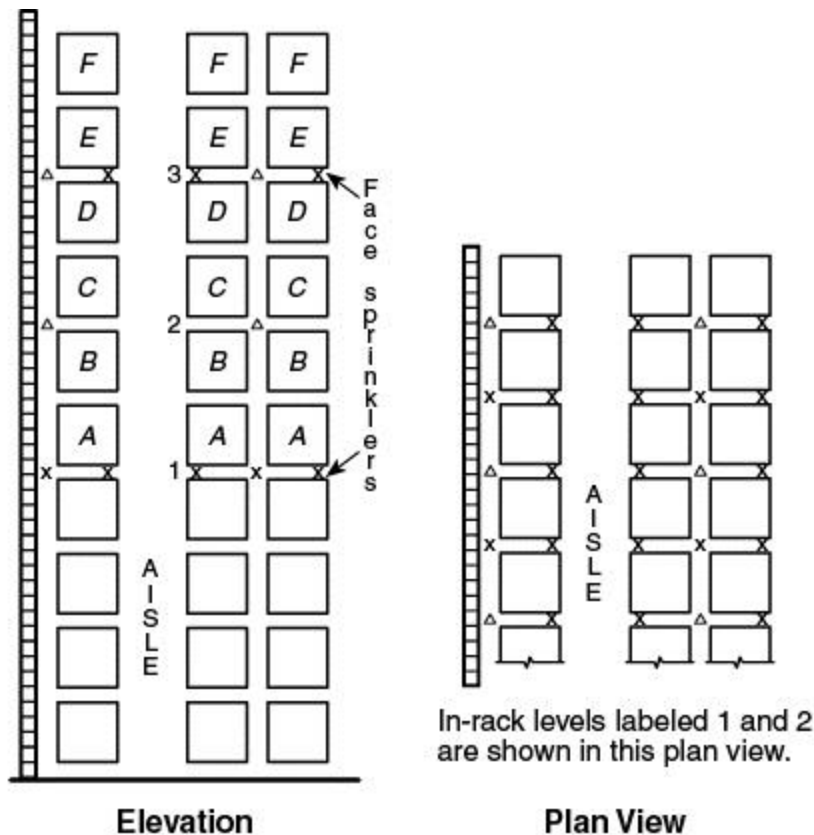
Figure 25.9.2.2.1(a) In-Rack Sprinkler Arrangement, Class I, II, or III Commodities, Storage Height Over 25 ft (7.6 m) — Option 1.



Notes:

1. Sprinklers labeled 1 shall be required where loads labeled A represent the top of storage.
2. Sprinklers labeled 1 and 2 shall be required where loads labeled B or C represent top of storage.
3. Sprinklers labeled 1, 2, and 3 shall be required where loads labeled D or E represent top of storage.
4. Sprinklers labeled 1, 2, 3, and 4 shall be required where loads labeled F or G represent top of storage.
5. Sprinklers labeled 1, 2, 3, 4, and 5 shall be required where 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 shall be permitted to be omitted where commodity consists of unwrapped or unpackaged metal parts on wood pallets.
8. Symbol Δ or x indicates sprinklers on vertical or horizontal stagger.
9. Each square represents a storage cube measuring 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. (450 mm) up to 10 ft (3.0 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.0 m) apart vertically.

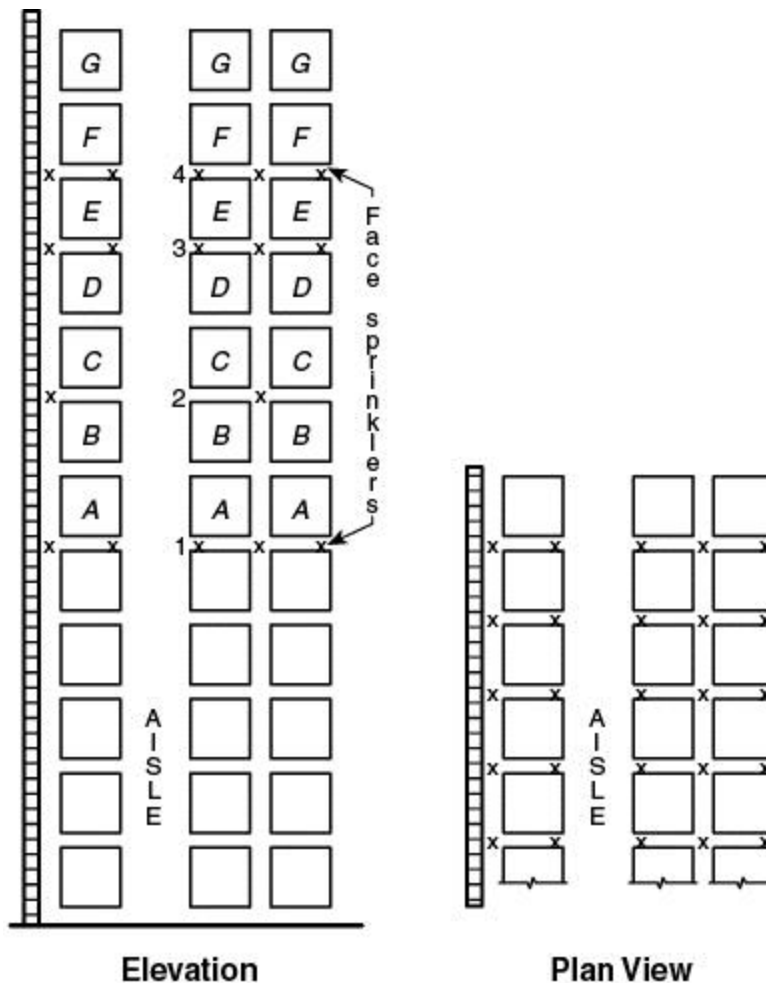
Figure 25.9.2.2.1(b) In-Rack Sprinkler Arrangement, Class I, II, or III Commodities, Storage Height Over 25 ft (7.6 m) — Option 2.



Notes:

1. Sprinklers labeled 1 (the selected array from Table 16.3.1.1) shall be required where loads labeled *A* or *B* represent top of storage.
2. Sprinklers labeled 1 and 2 shall be required where loads labeled *C* or *D* represent top of storage.
3. Sprinklers labeled 1 and 3 shall be required where 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. Symbol Δ or x indicates sprinklers on vertical or horizontal stagger.
6. Each square represents a storage cube measuring 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. (450 mm) up to 10 ft (3.0 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.0 m) apart vertically.

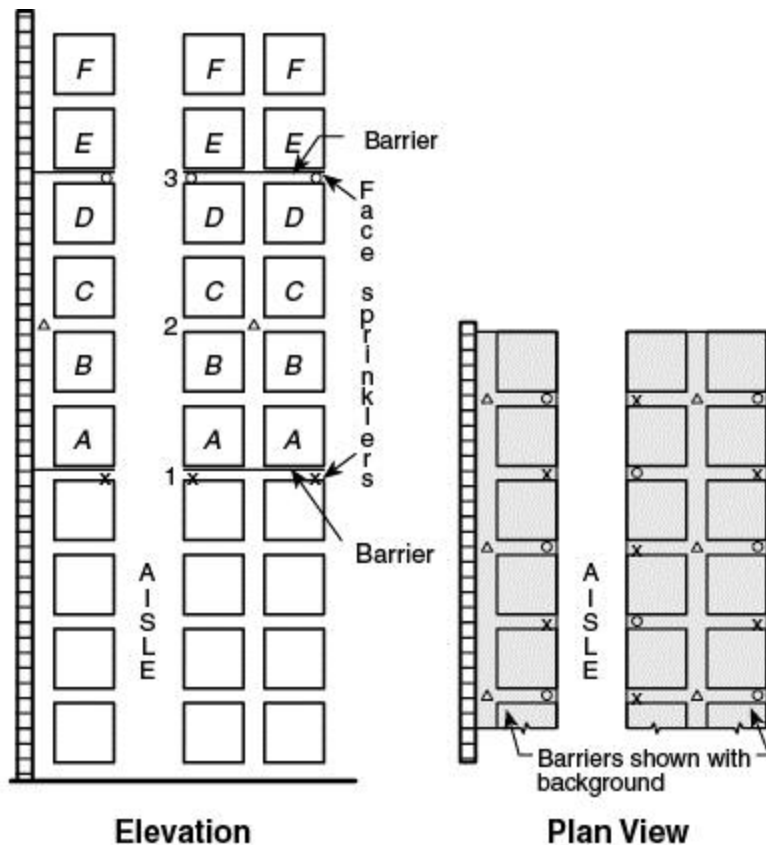
Figure 25.9.2.2.1(c) In-Rack Sprinkler Arrangement, Class I, II, or III Commodities, Storage Height Over 25 ft (7.6 m) — Option 3.



Notes:

1. Sprinklers labeled 1 (the selected array from Table 16.3.1.1) shall be required where loads labeled *A* or *B* represent top of storage.
2. Sprinklers labeled 1 and 2 shall be required where loads labeled *C* or *D* represent top of storage.
3. Sprinklers labeled 1 and 3 shall be required where loads labeled *E* represent top of storage.
4. Sprinklers labeled 1 and 4 shall be required where 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.
7. Each square represents a storage cube measuring 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. (450 mm) up to 10 ft (3.0 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.0 m) apart vertically.

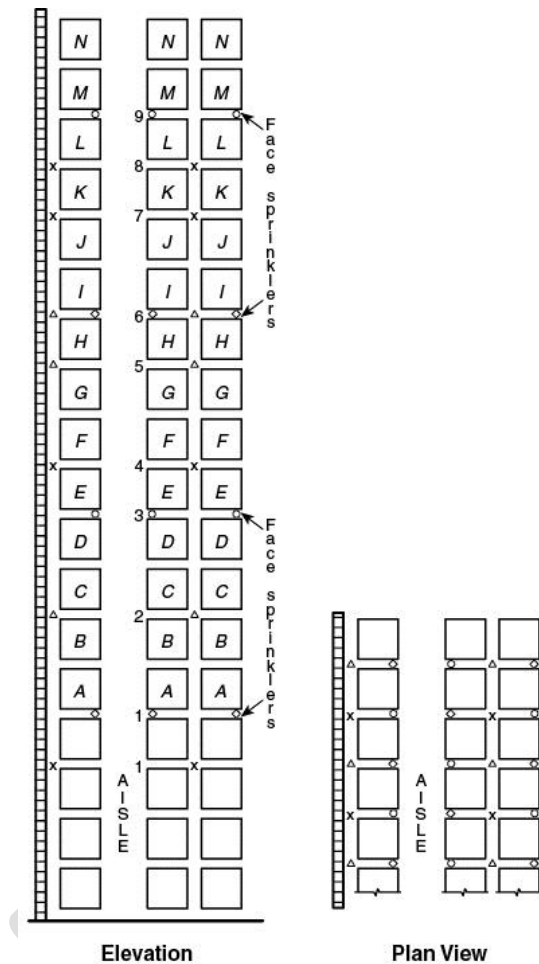
Figure 25.9.2.2.1(d) In-Rack Sprinkler Arrangement, Class I, II, or III Commodities, Storage Height Over 25 ft (7.6 m) — Option 4.



Notes:

1. Sprinklers labeled 1 (the selected array from Table 16.3.1.1) shall be required where loads labeled *A* or *B* represent top of storage.
2. Sprinklers labeled 1 and 2 shall be required where loads labeled *C* or *D* represent top of storage.
3. Sprinklers labeled 1 and 3 shall be required where 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. Symbols *o*, *Δ*, and *x* indicate sprinklers on vertical or horizontal stagger.
6. Each square represents a storage cube measuring 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. (450 mm) up to 10 ft (3.0 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.0 m) apart vertically.

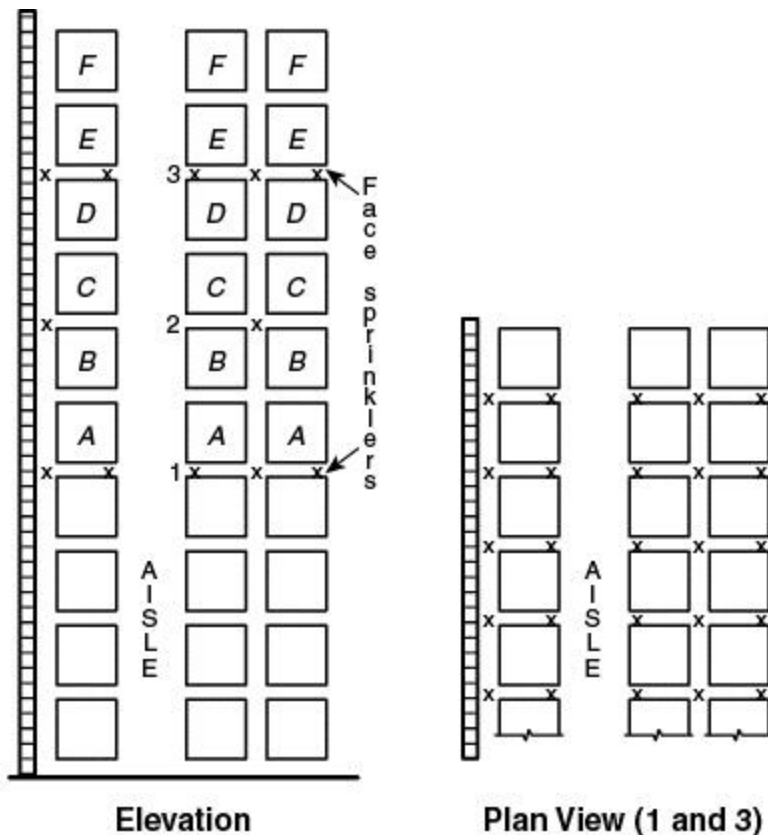
Figure 25.9.2.2.1(e) In-Rack Sprinkler Arrangement, Class I, II, III, or IV Commodities, Storage Height Over 25 ft (7.6 m) — Option 1.



Notes:

1. Sprinklers labeled 1 (the selected array from Table 16.3.1.1) shall be required where loads labeled *A* or *B* represent top of storage.
2. Sprinklers labeled 1 and 2 shall be required where loads labeled *C* or *D* represent top of storage.
3. Sprinklers labeled 1, 2, and 3 shall be required where loads labeled *E* or *F* represent top of storage.
4. Sprinklers labeled 1, 2, 3, and 4 shall be required where loads labeled *G* represent top of storage.
5. Sprinklers labeled 1, 2, 3, 4, and 5 shall be required where loads labeled *H* represent top of storage.
6. Sprinklers labeled 1, 2, 3, 4, and 6 (not 5) shall be required where loads labeled *I* or *J* represent top of storage.
7. Sprinklers labeled 1, 2, 3, 4, 6, and 7 shall be required where loads labeled *K* represent top of storage.
8. Sprinklers labeled 1, 2, 3, 4, 6, and 8 shall be required where loads labeled *L* represent top of storage.
9. Sprinklers labeled 1, 2, 3, 4, 6, 8, and 9 shall be required where 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*, and Δ indicate sprinklers on vertical or horizontal stagger.
12. Each square represents a storage cube measuring 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. (450 mm) up to 10 ft (3.0 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.0 m) apart vertically.

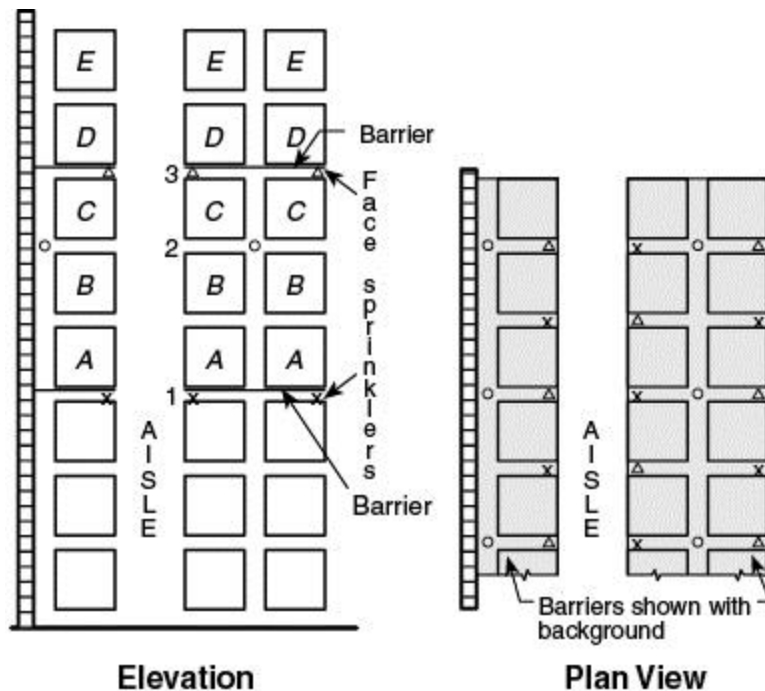
Figure 25.9.2.2.1(f) In-Rack Sprinkler Arrangement, Class I, II, III, or IV Commodities, Storage Height Over 25 ft (7.6 m) — Option 2.



Notes:

1. Sprinklers labeled 1 (the selected array from Table 16.3.1.1) shall be required where loads labeled *A* or *B* represent top of storage.
2. Sprinklers labeled 1 and 2 shall be required where loads labeled *C* or *D* represent top of storage.
3. Sprinklers labeled 1 and 3 shall be required where 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.
6. Each square represents a storage cube measuring 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. (450 mm) up to 10 ft (3.0 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.0 m) apart vertically.

Figure 25.9.2.2.1(g) In-Rack Sprinkler Arrangement, Class I, II, III, or IV Commodities, Storage Height Over 25 ft (7.6 m) — Option 3.



Notes:

1. Sprinklers labeled 1 (the selected array from Table 16.3.1.1) shall be required where loads labeled A or B represent top of storage.
2. Sprinklers labeled 1 and 2 and barrier labeled 1 shall be required where loads labeled C represent top of storage.
3. Sprinklers and barriers labeled 1 and 3 shall be required where 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. Symbol Δ or x indicates sprinklers on vertical or horizontal stagger.
6. Symbol o indicates longitudinal flue space sprinklers.
7. Each square represents a storage cube measuring 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. (450 mm) up to 10 ft (3.0 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.0 m) apart vertically.

25.9.2.3 Multiple-Row Racks.

25.9.2.3.1*

In multiple-row racks with a maximum of 10 ft (3.0 m) between the top of storage and the ceiling, in-rack sprinklers shall be in accordance with Table 25.9.2.3.1 and Figure 25.9.1.3.1(a) through Figure 25.9.2.3.1(c).

Table 25.9.2.3.1 Multiple-Row Racks of Class I Through Class IV Commodities Stored Over 25 ft (7.6 m) in Height

Commodity Class	Encapsulated	In-Rack Sprinklers ^{a,b,c}						Height Limit (ft)	Stagger	Figure	Maximum Spacing from Top of Storage to Highest In-Rack Sprinklers		Ceiling Sprinkler Operating Area		Ceiling Sprinklers Density Clearance to Ceiling Up to 10 ft			
		Maximum Vertical Spacing		Maximum Horizontal Spacing in A Flue		Maximum Horizontal Spacing across Flue					ft ²	m ²	165°F (74°C) Rating		286°F (141°C) Rating			
		ft	m	ft	m	ft	m						gpm/ft ²	mm/min	gpm/ft ²	mm/min		
I	No	20	6.1	12	3.7	10	3.0	None	Between adjacent flues	16.3.1.3.1.3(A)(a)	10	3.0	2000	186	0.25	10.2	0.35	14.3
	Yes									0.31	12.6	0.44			17.9			
I, II, and III	No	15	4.6	10	3.0	10	3.0			16.3.1.3.1.3(A)(b)	10	3.0			0.30	12.2	0.40	16.3
	Yes									0.37	15.1	0.50			20.4			
I, II, III, and IV	No	10	3.1	10	3.0	10	3.0			16.3.1.3.1.3(A)(c)	5	1.5			0.35	14.3	0.45	18.3
	Yes														0.44	17.9	0.56	22.8

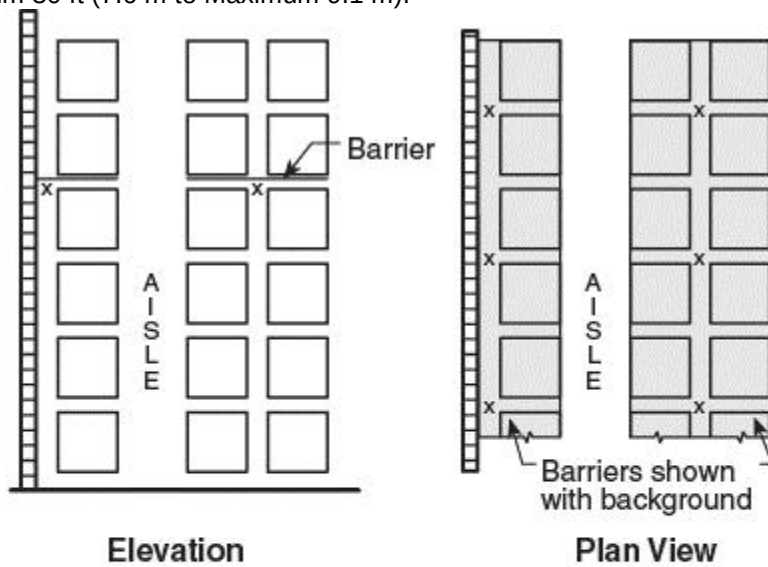
For SI units, °C = $\frac{5}{9}$ (°F-32); 1 gpm/ft² = 40.746 mm/min.

^aAll four rack faces shall be protected by sprinklers located within the racks and no more than 18 in. (450 mm) from the faces, as indicated in Figure 16.3.1.3.1.3(A)(a) through Figure 16.3.1.3.1.3(A)(c). It shall not be required for each sprinkler level to protect all faces.

^bAll in-rack sprinkler spacing dimensions start from the floor.

^cIn Figure 16.3.1.3.1.3(A)(a) through Figure 16.3.1.3.1.3(A)(c), each square represents a storage cube measuring 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. to 10 ft (450 mm to 3.0 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.1 m) apart vertically.

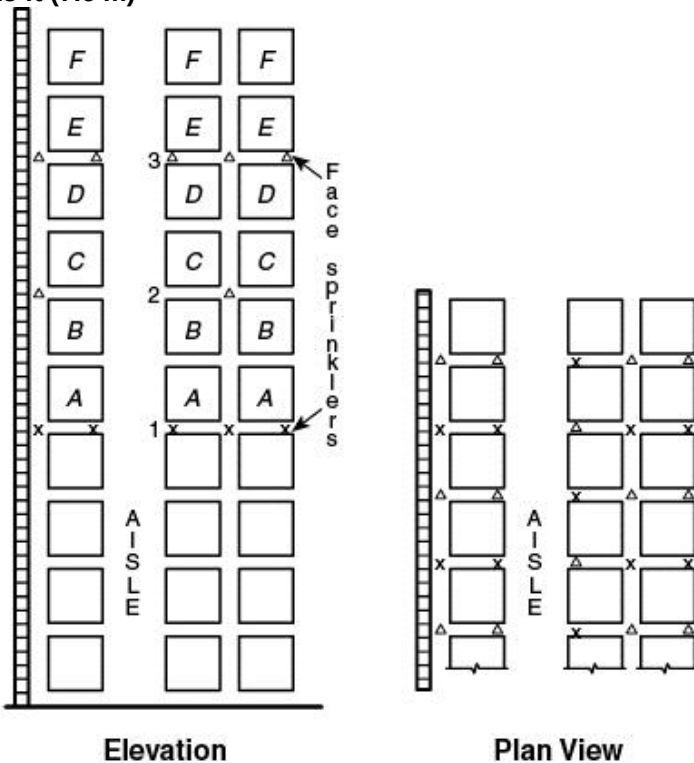
Figure 25.9.2.3.1(a) In-Rack Sprinkler Arrangement, Class I Commodities, Storage Height 25 ft to Maximum 30 ft (7.6 m to Maximum 9.1 m).



Notes:

1. Symbol x indicates in-rack sprinklers.
2. Each square represents a storage cube measuring 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. (450 mm) up to 10 ft (3.0 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.0 m) apart vertically.

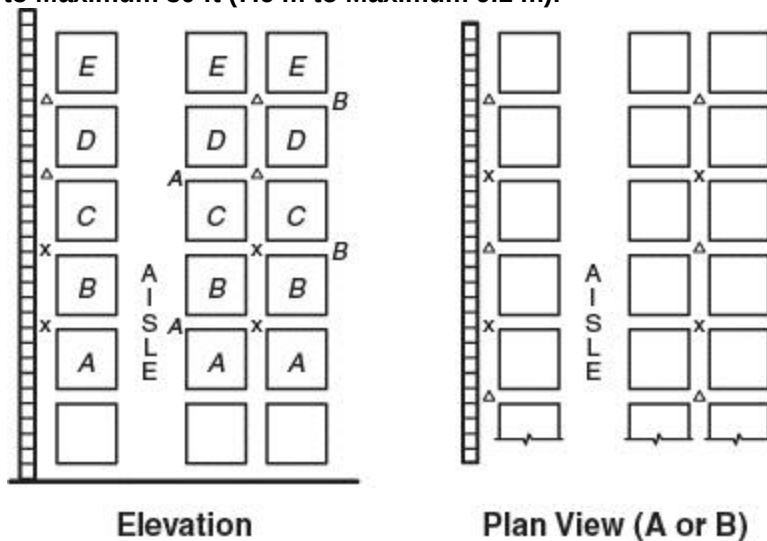
Figure 25.9.2.3.1(b) In-Rack Sprinkler Arrangement, Class I Commodities, Storage Height Over 25 ft (7.6 m)



Notes:

1. Sprinklers labeled 1 (the selected array from Table 16.3.1.1) shall be required where loads labeled *A* or *B* represent top of storage.
2. Sprinklers labeled 1 and 2 shall be required where loads labeled *C* or *D* represent top of storage.
3. Sprinklers labeled 1 and 3 shall be required where 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. Symbol Δ or x indicates sprinklers on vertical or horizontal stagger.
6. Each square represents a storage cube measuring 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. (450 mm) up to 10 ft (3.0 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.0 m) apart vertically.

Figure 25.9.2.3.1(c) In-Rack Sprinkler Arrangement, Class I, II, or III Commodities, Storage Height 25 ft to Maximum 30 ft (7.6 m to Maximum 9.1 m).



Notes:

1. Alternate location of in-rack sprinklers. Sprinklers shall be permitted to be installed above loads *A* and *C* or above loads *B* and *D*.
2. Symbol Δ or *x* indicates sprinklers on vertical or horizontal stagger.
3. Each square represents a storage cube measuring 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. (450 mm) up to 10 ft (3.0 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.0 m) apart vertically.

25.9.3 Rack Storage of Group A Plastic Commodities Up to and Including 25 ft (7.6 m) in Height.

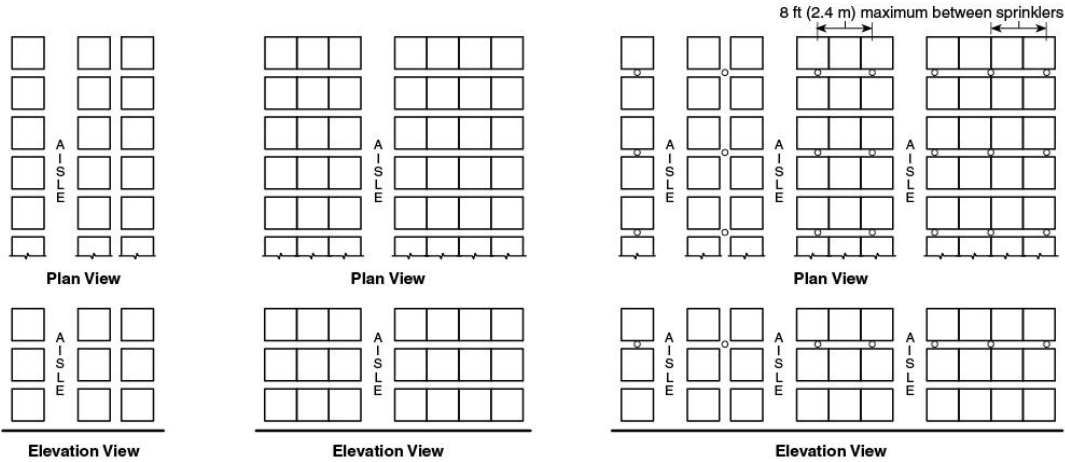
25.9.3.1

Where rack storage of cartoned Group A plastic commodities, encapsulated or nonencapsulated, having a clearance to ceiling up to and including 10 ft (3.1 m) require in-rack sprinklers, in-rack sprinkler arrangements shall be selected from Figure 25.9.3.1(a) through Figure 25.9.3.1(e).

Figure 25.9.3.1(a) In-Rack Sprinkler Arrangement, Cartoned Group A Plastic Storage Up to 15 ft (4.6 m) in Height with Up to 10 ft (3.0 m) Clearance to Ceiling.

Single-, double-, and multiple-row racks
 0.60 gpm/ft² per 2000 ft²
 (24.4 mm/min per 2000 ft²)
 Up to 10 ft (3.0 m)
 clearance to ceiling
 See Note 2

Single-, double-, and multiple-row racks
 0.30 gpm/ft² per 2000 ft²
 (12.2 mm/min per 2000 ft²)
 Up to 10 ft (3.0 m)
 clearance to ceiling
 See Note 1

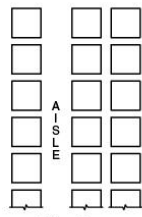


Notes:

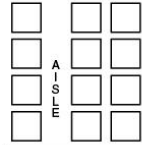
1. Single level of in-rack sprinklers [K-5.6 (80) or K-8.0 (115) operating at 15 psi (1.0 bar) minimum] installed as indicated in the transverse flue spaces.
2. Where sprinklers listed for storage use are installed at the ceiling only and the ceiling height in the protected area does not exceed 22 ft (6.7 m) and a minimum clearance of 5 ft (1.5 m) and the storage height does not exceed 15 ft (4.6 m), the ceiling sprinkler discharge criteria shall be permitted to be reduced to 0.45 gpm/ft² per 2000 ft² (18.3 mm/min per 2000 ft²).
3. Each square represents a storage cube measuring 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. (450 mm) up to 10 ft (3.0 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.0 m) apart vertically.

Figure 25.9.3.1(b) In-Rack Sprinkler Arrangement, Cartoned Group A Plastic Storage Up to Storage 20 ft (6.1 m) in Height with <5 ft (1.5 m) Clearance to Ceiling.

Single- and double-row racks
 0.60 gpm/ft² per 2000 ft²
 (24.4 mm/min per 186 m²)
 <5 ft (1.5 m) clearance to ceiling



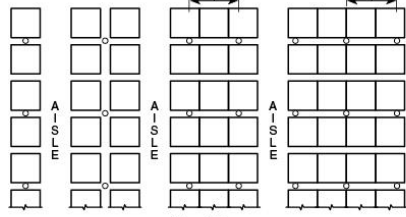
Plan View



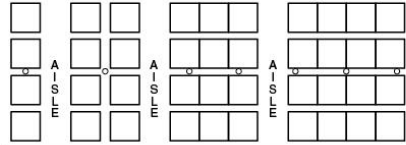
Elevation View

Single-, double-, and multiple-row racks
 0.45 gpm/ft² per 2000 ft²
 (18.3 mm/min per 186 m²)
 <5 ft (1.5 m) clearance to ceiling
 See Notes 1 and 2

8 ft (2.4 m) maximum between sprinklers



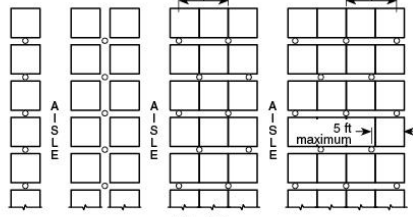
Plan View



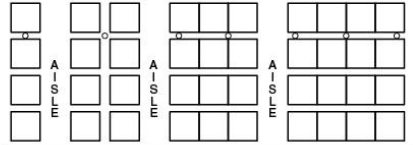
Elevation View

Single-, double-, and multiple-row racks
 0.30 gpm/ft² per 2000 ft²
 (12.2 mm/min per 186 m²)
 <5 ft (1.5 m) clearance to ceiling
 See Notes 2 and 3

8 ft (2.4 m) maximum between sprinklers



Plan View



Elevation View

Notes:

1. Single level of in-rack sprinklers [K-5.6 (80) or K-8.0 (115) operating at 15 psi (1.0 bar) minimum] installed as indicated in the transverse flue spaces.
2. Ceiling-only protection is not permitted for this storage configuration except where K-11.2 or larger spray sprinklers listed for storage use are installed. In-rack sprinklers are not required, provided the ceiling sprinkler discharge criterion is increased to 0.6 gpm/ft² (24 mm/min) over 2000 ft² (186 m²).
3. Single level of in-rack sprinklers [K-8.0 (115) operating at 15 psi (1.0 bar) minimum or K-5.6 (80) operating at 30 psi (2.1 bar) minimum] installed on 4 ft to 5 ft (1.2 m to 1.5 m) spacings located, as indicated, in the longitudinal flue space at the intersection of every transverse flue space.
4. Each square represents a storage cube measuring 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. (450 mm) up to 10 ft (3.0 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.0 m) apart vertically.

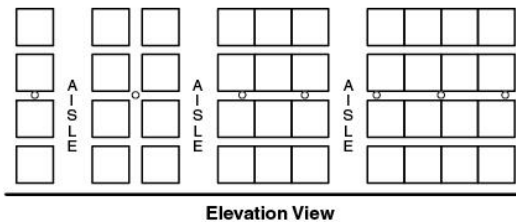
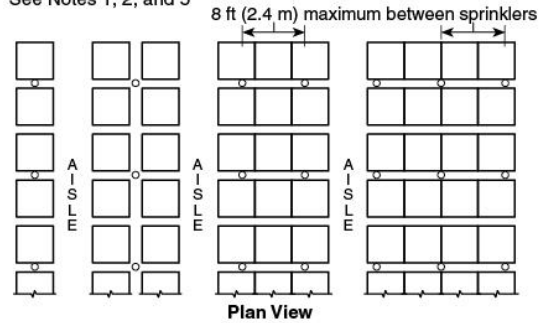
Figure 25.9.3.1(c) In-Rack Sprinkler Arrangement, Cartoned Group A Plastic Storage Up to Storage 20 ft (6.1 m) in Height with 5 ft to 10 ft (1.5 m to 3.0 m) Clearance to Ceiling.

Single-, double-, and multiple-row racks

0.45 gpm/ft² per 2000 ft²
(18.3 mm/min per 186 m²)

5 ft to 10 ft (1.5 m to 3.0 m) clearance to ceiling

See Notes 1, 2, and 5

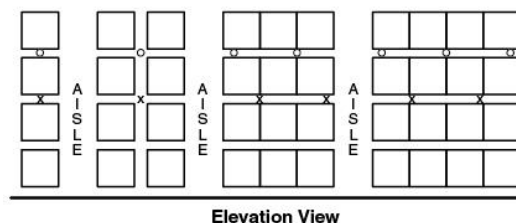
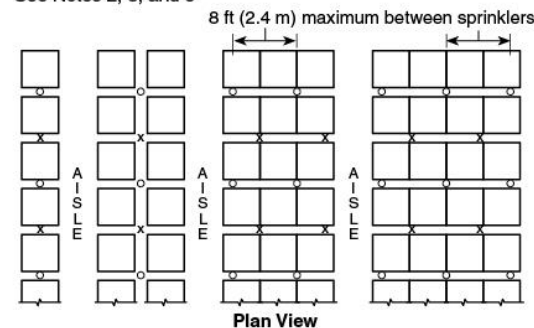


Single-, double-, and multiple-row racks

0.30 gpm/ft² per 2000 ft²
(12.2 mm/min per 186 m²)

5 ft to 10 ft (1.5 m to 3.0 m) clearance to ceiling

See Notes 2, 3, and 5

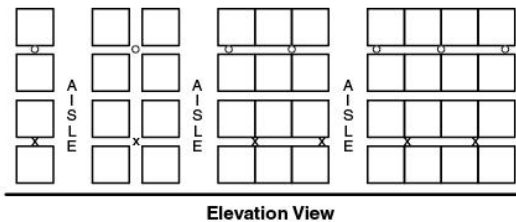
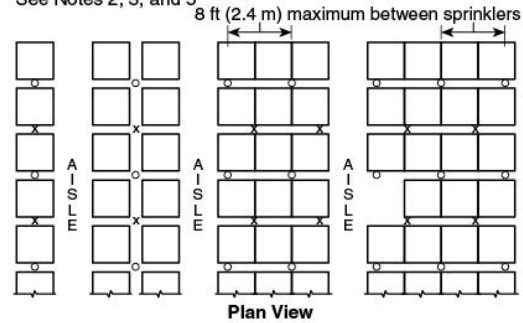


Single-, double-, and multiple-row racks

0.30 gpm/ft² per 2000 ft²
(12.2 mm/min per 186 m²)

5 ft to 10 ft (1.5 m to 3.0 m) clearance to ceiling

See Notes 2, 3, and 5

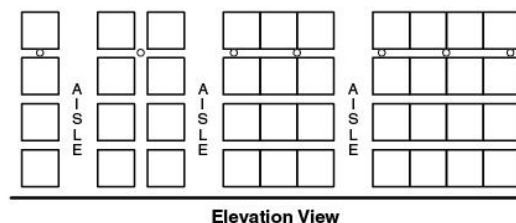
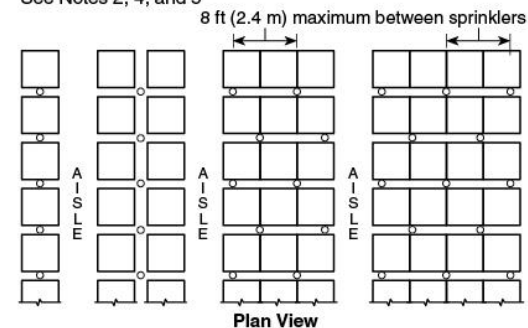


Single-, double-, and multiple-row racks

0.30 gpm/ft² per 2000 ft²
(12.2 mm/min per 186 m²)

5 ft to 10 ft (1.5 m to 3.0 m) clearance to ceiling

See Notes 2, 4, and 5

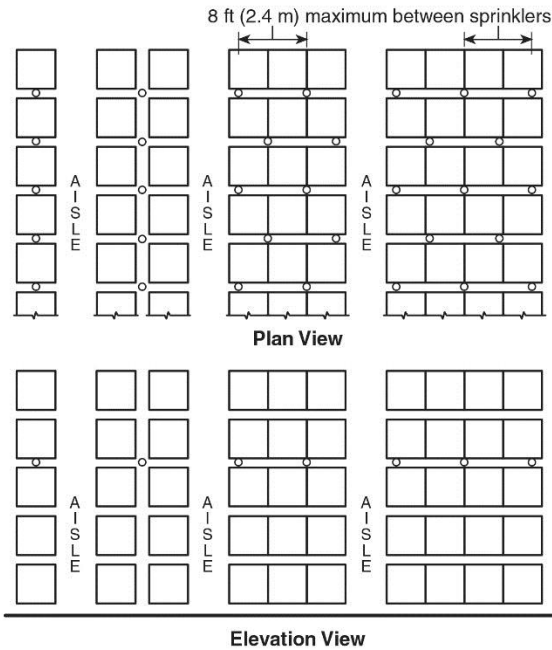


Notes:

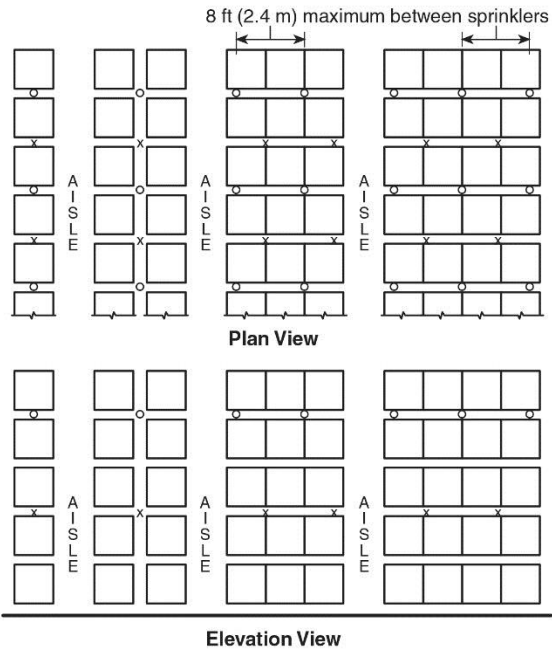
1. Single level of in-rack sprinklers [K-5.6 (80) or K-8.0 (115) operating at 15 psi (1.0 bar) minimum] installed as indicated in the transverse flue spaces.
2. Ceiling-only protection shall not be permitted for this storage configuration except where K-11.2 or larger orifice spray sprinklers listed for storage use are installed. In-rack sprinklers shall not be required, provided the ceiling sprinkler discharge criterion is increased to 0.6 gpm/ft² (24.4 mm/min) over 2000 ft² (186 m²) and the ceiling height in the protected area does not exceed 27 ft (8.2 m).
3. Two levels of in-rack sprinklers [K-5.6 (80) or K-8.0 (115) operating at 15 psi (1.0 bar) minimum] installed as indicated and staggered in the transverse flue space.
4. Single level of in-rack sprinklers [K-8 (115) operating at 15 psi (1.0 bar) or K-5.6 (80) operating at 30 psi (2.1 bar) minimum] installed on 4 ft to 5 ft (1.2 m to 1.5 m) spacings located, as indicated, in the longitudinal flue space at the intersection of every transverse flue space.
5. Each square represents a storage cube measuring 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. (450 mm) up to 10 ft (3.0 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.0 m) apart vertically.

Figure 25.9.3.1(d) In-Rack Sprinkler Arrangement, Cartoned Group A Plastic Storage Up to Storage 25 ft (7.6 m) in Height with <5 ft (1.5 m) Clearance to Ceiling. (See Note 2.)

Single-, double-, and multiple-row racks
 0.45 gpm/ft² per 2000 ft²
 (18.3 mm/min per 186 m²)
 <5 ft (1.5 m) clearance to ceiling
 See Notes 1, 2, and 4



Single-, double-, and multiple-row racks
 0.30 gpm/ft² per 2000 ft²
 (12.2 mm/min per 186 m²)
 <5 ft (1.5 m) clearance to ceiling
 See Notes 2, 3, and 4



Notes:

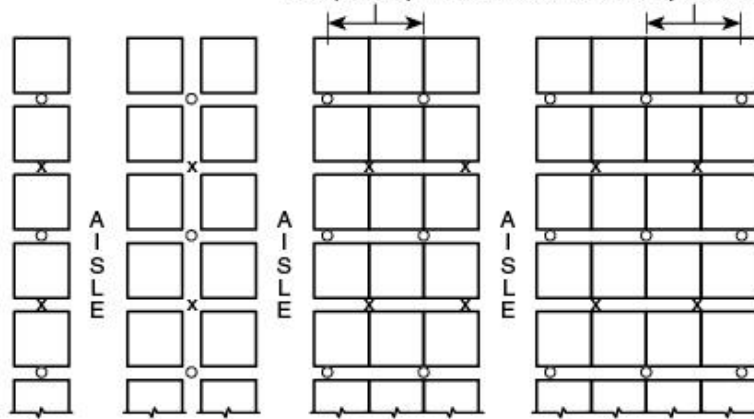
1. Single level of in-rack sprinklers [K-8.0 (115) operating at 15 psi (1.0 bar) minimum or K-5.6 (80) operating at 30 psi (2.1 bar) minimum] installed on 4 ft to 5 ft (1.2 m to 1.5 m) spacings located, as indicated, in the longitudinal flue space at the intersection of every transverse flue space.
2. Ceiling-only protection shall not be permitted for this storage configuration except where K-16.8 spray sprinklers listed for storage use are installed. In-rack sprinklers shall not be required, provided the ceiling sprinkler discharge criterion is increased to 0.8 gpm/ft² (32.6 mm/min) over 2000 ft² (186 m²) for wet systems and 4500 ft² (418 m²) for dry systems and the ceiling height in the protected area does not exceed 30 ft (9.1 m).
3. Two levels of in-rack sprinklers [K-5.6 (80) or K-8.0 (115) operating at 15 psi (1.0 bar) minimum] installed as indicated and staggered in the transverse flue space.
4. Each square represents a storage cube measuring 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. (450 mm) up to 10 ft (3.0 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.0 m) apart vertically.

Figure 25.9.3.1(e) In-Rack Sprinkler Arrangement, Cartoned Group A Plastic Storage Up to Storage 25 ft (7.6 m) in Height with 5 ft to 10 ft (1.5 m to 3.0 m) Clearance to Ceiling. (See Note 2.)

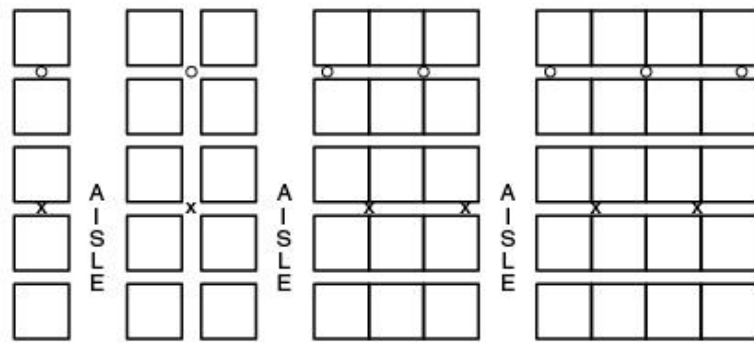
Single-, double-, and multiple-row racks
 0.30 gpm/ft² per 2000 ft²
 (12.2 mm/min per 186 m²)

5 ft to 10 ft (1.5 m to 3.0 m) clearance to ceiling
 See Notes 1, 2, and 3

8 ft (2.4 m) maximum between sprinklers



Plan View



Elevation View

Notes:

1. Two levels of in-rack sprinklers [K-5.6 (80) or K-8.0 (115) operating at 15 psi (1.0 bar) minimum] installed on 8 ft to 10 ft (2.4 m to 3.0 m) spacings located as indicated and staggered in the transverse flue space.
2. Ceiling-only protection shall not be permitted for this storage configuration except where K-16.8 spray sprinklers listed for storage use are installed. In-rack sprinklers shall not be required, provided the ceiling sprinkler discharge criterion is increased to 0.8 gpm/ft² (32.6 mm/min) over 2000 ft² (186 m²) for wet systems and 4500 ft² (418 m²) for dry systems and the ceiling height in the protected area does not exceed 30 ft (9.1 m).
3. Each square represents a storage cube measuring 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. (450 mm) up to 10 ft (3.0 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.0 m) apart vertically.

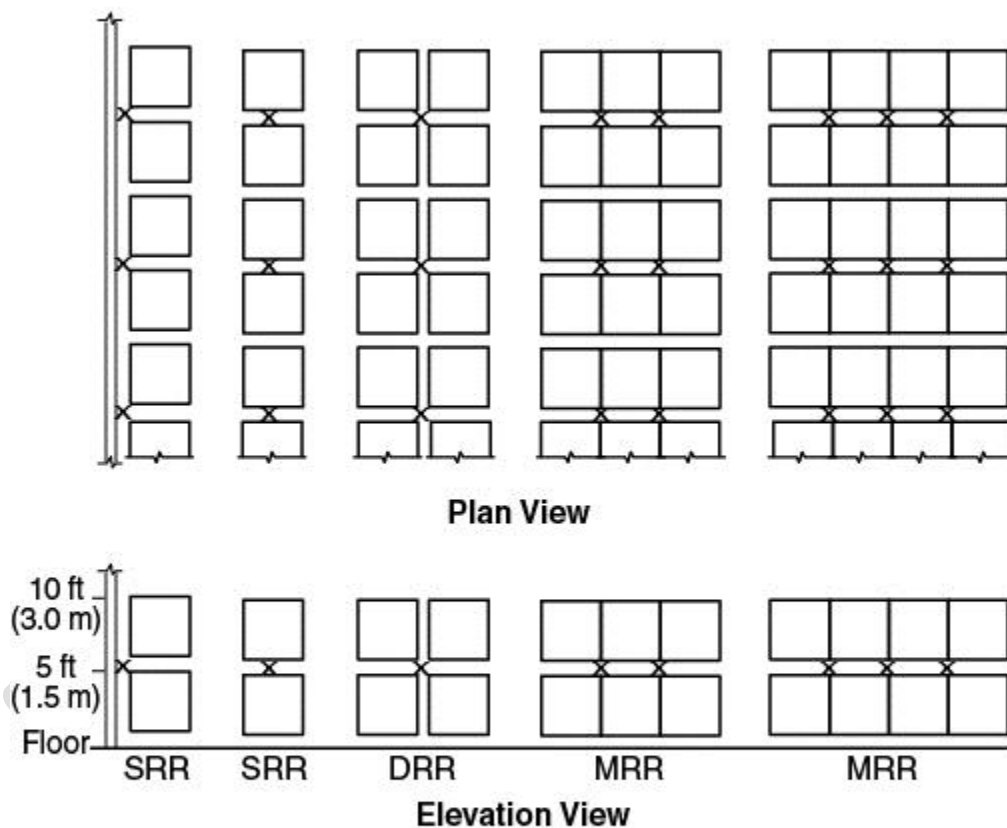
Notes in each figure shall be permitted to clarify options or to present additional options not shown in the figures.

25.9.3.3*

Where rack storage of exposed nonexpanded Group A plastic commodities, encapsulated or nonencapsulated, require in-rack sprinklers, in-rack sprinkler arrangements shall be selected from Figure 25.9.3.3(a) through Figure 25.9.3.3(k).

Figure 25.9.3.3(a) In-Rack Sprinkler Arrangement, Exposed Nonexpanded Group A Plastic Commodities Up to 10 ft (3.0 m) in Height in Up to a 20 ft (6.1 m) High Building — Option 1.

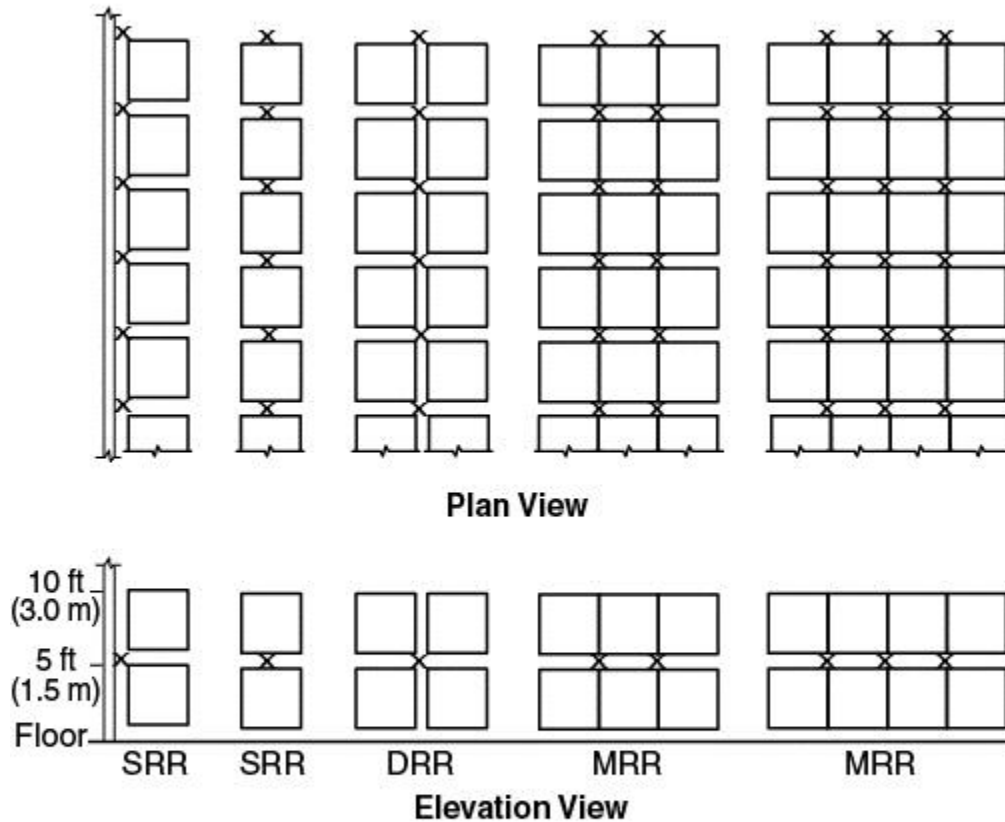
Single-, double-, and multiple-row racks 0.45 gpm/ft²
over 2000 ft² (18.3 mm/min over 18 m²)



Note: Each square represents a storage cube measuring 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. to 10 ft (450 mm to 3.0 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.0 m) apart vertically.

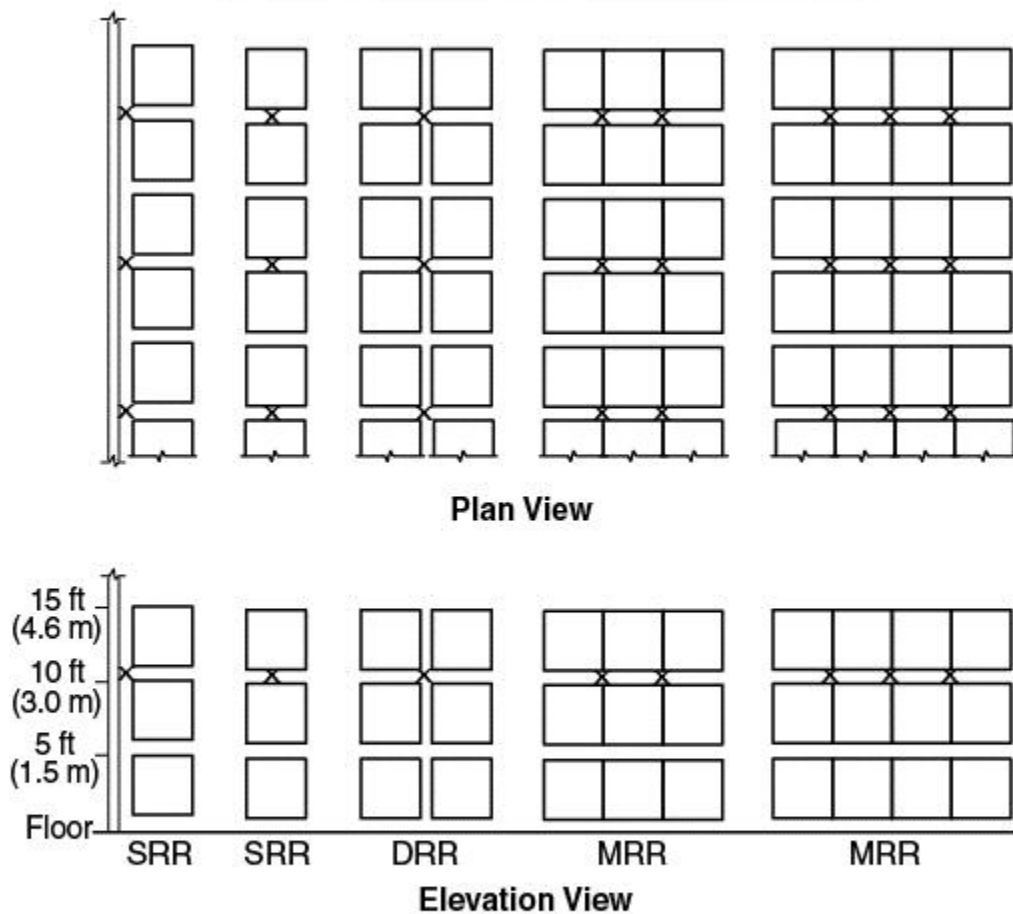
Figure 25.9.3.3(b) In-Rack Sprinkler Arrangement, Exposed Nonexpanded Group A Plastic Commodities Up to 10 ft (3.0 m) in Height in Up to a 20 ft (6.1 m) High Building — Option 2.

Single-, double-, and multiple-row racks 0.30 gpm/ft²
over 2000 ft² (12.2 mm/min over 18 m²)



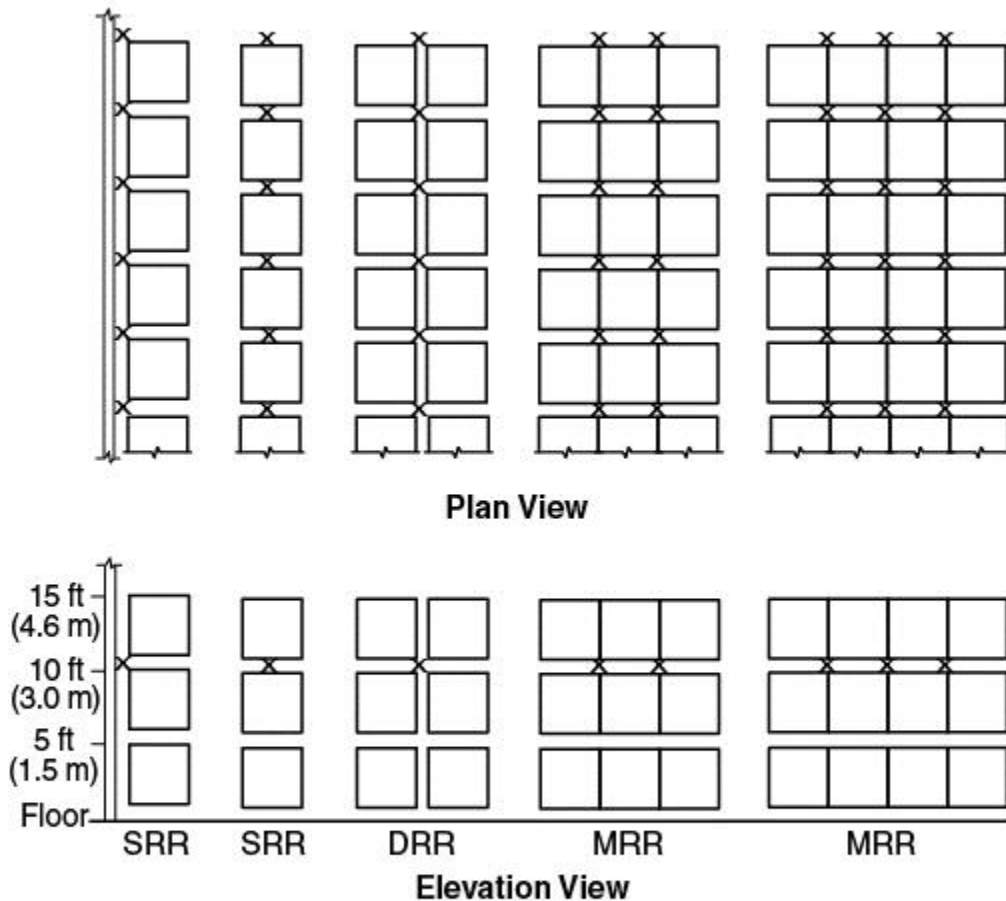
Note: Each square represents a storage cube measuring 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. to 10 ft (450 mm to 3.0 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.0 m) apart vertically.

Figure 25.9.3.3(c) In-Rack Sprinkler Arrangement, Exposed Nonexpanded Group A Plastic Commodities Up to 15 ft (4.6 m) in Height in Up to a 25 ft (7.6 m) High Building - Option 1.
Single-, double-, and multiple-row racks
0.45 gpm/ft² over 2000 ft² (18.3 mm/min over 183 m²)



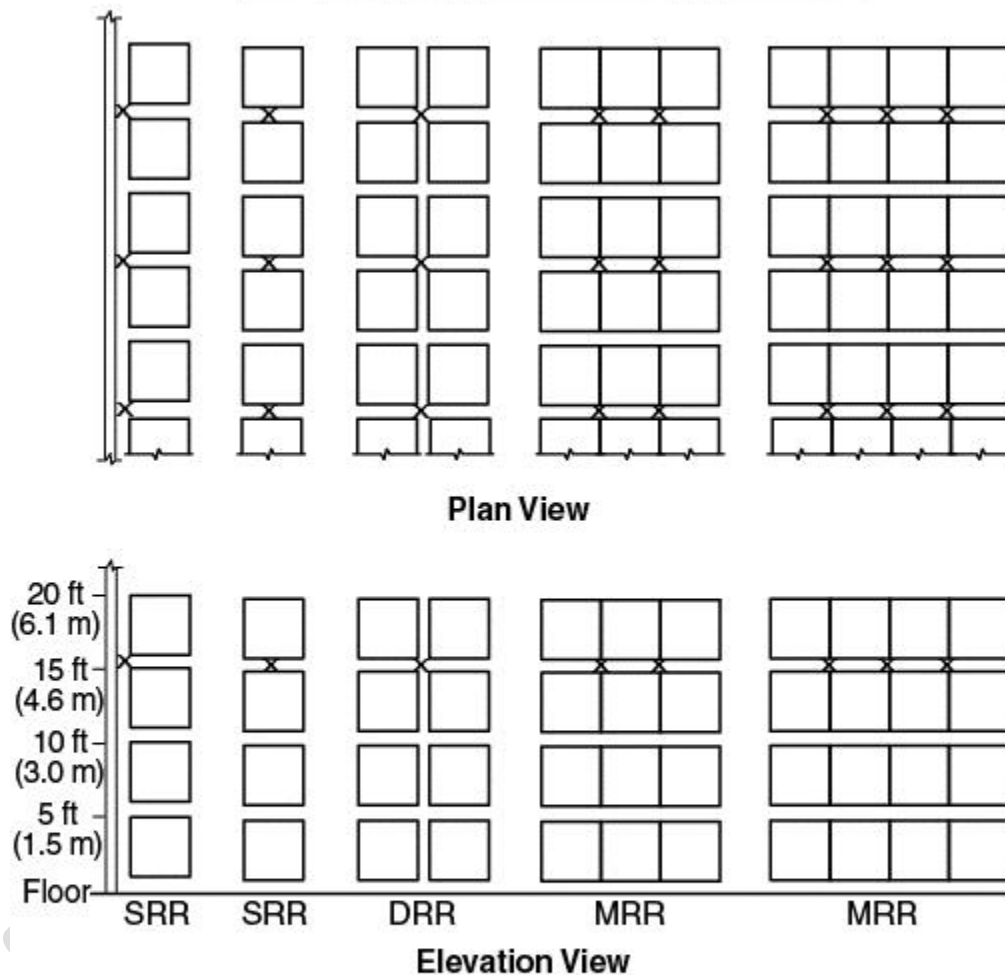
Note: Each square represents a storage cube measuring 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. to 10 ft (450 mm to 3.0 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.0 m) apart vertically.

Figure 25.9.3.3(d) In-Rack Sprinkler Arrangement, Exposed Nonexpanded Group A Plastic Commodities Up to 15 ft (4.6 m) in Height in Up to a 25 ft (7.6 m) High Building — Option 2.
Single-, double-, and multiple-row racks
0.30 gpm/ft² over 2000 ft² (12.2 mm/min over 1 m²)



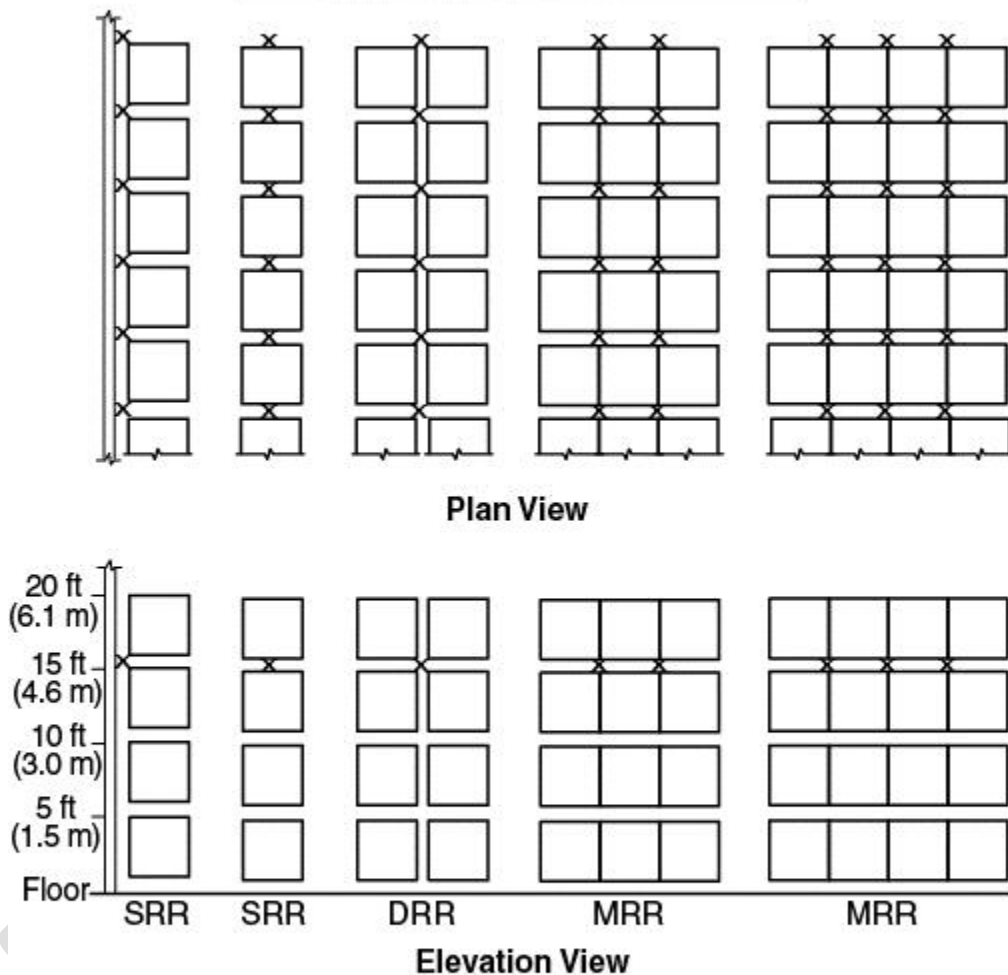
Note: Each square represents a storage cube measuring 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. to 10 ft (450 mm to 3.0 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.0 m) apart vertically.

Figure 25.9.3.3(e) In-Rack Sprinkler Arrangement, Exposed Nonexpanded Group A Plastic Commodities Up to 20 ft (6.1 m) in Height in Up to a 25 ft (7.6 m) High Building - Option 1.
Single-, double-, and multiple-row racks
0.60 gpm/ft² over 2000 ft² (24 mm/min over 180 m²)



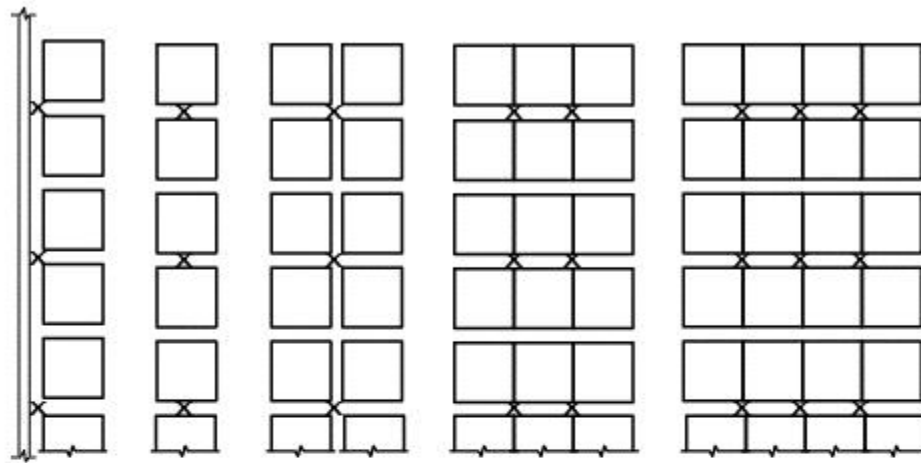
Note: Each square represents a storage cube measuring 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. to 10 ft (450 mm to 3.0 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.0 m) apart vertically.

Figure 25.9.3.3(f) In-Rack Sprinkler Arrangement, Exposed Nonexpanded Group A Plastic Commodities Up to 20 ft (6.1 m) in Height in Up to a 25 ft (7.6 m) High Building — Option 2.
Single-, double-, and multiple-row racks
0.45 gpm/ft² over 2000 ft² (18.3 mm/min over 18 m²)

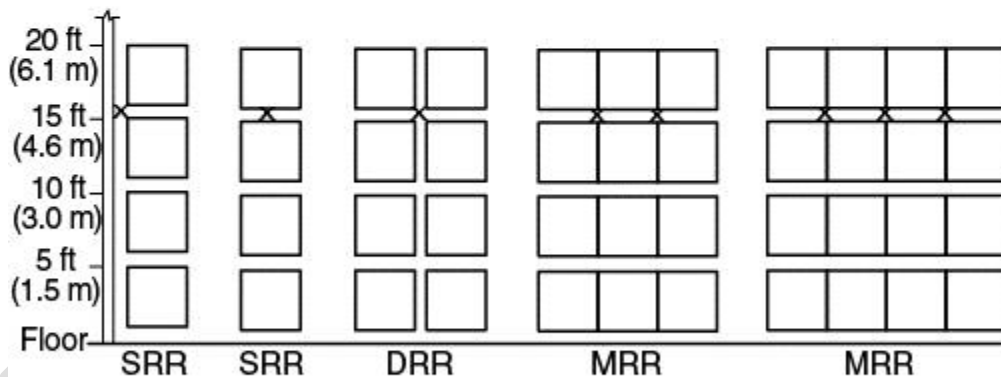


Note: Each square represents a storage cube measuring 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. to 10 ft (450 mm to 3.0 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.0 m) apart vertically.

Figure 25.9.3.3(g) In-Rack Sprinkler Arrangement, Exposed Nonexpanded Group A Plastic Commodities Up to 20 ft (6.1 m) in Height in Up to a 30 ft (9.1 m) High Building — Option 1.
Single-, double-, and multiple-row racks
0.80 gpm/ft² over 1500 ft² (32.6 mm/min over 141.6 m²)



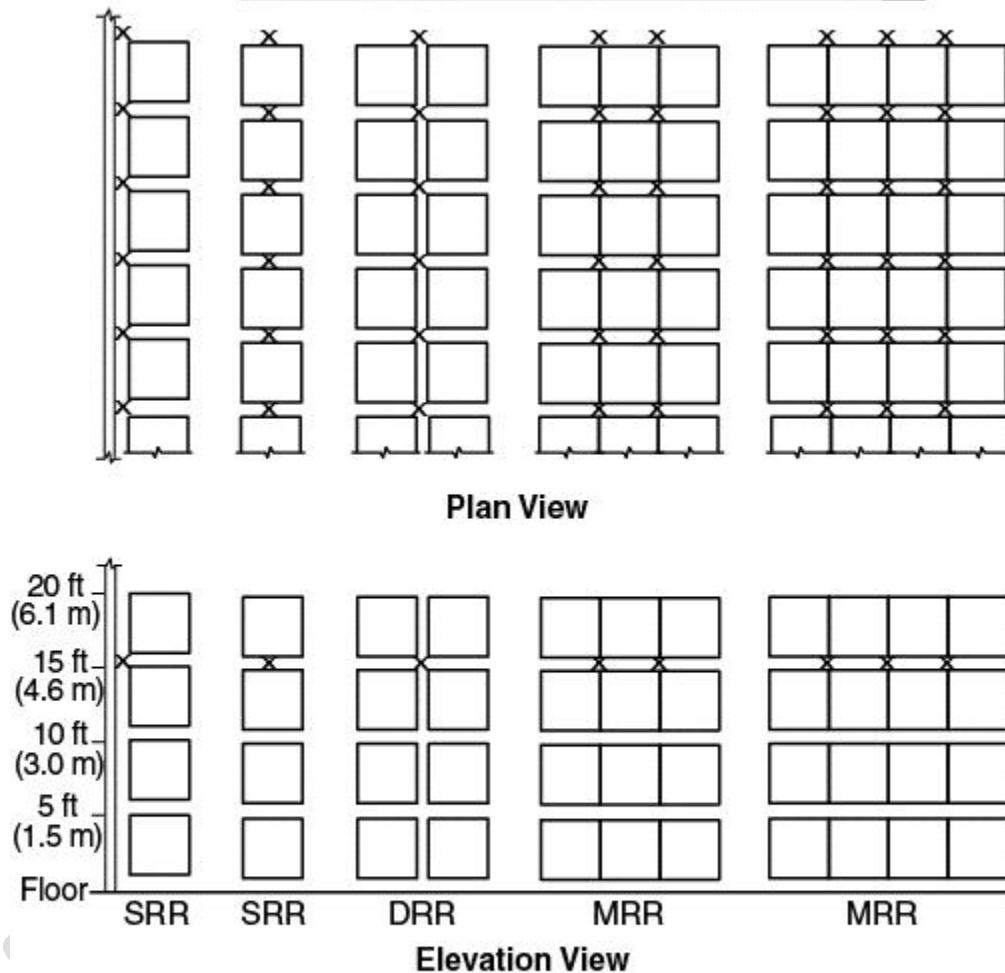
Plan View



Elevation View

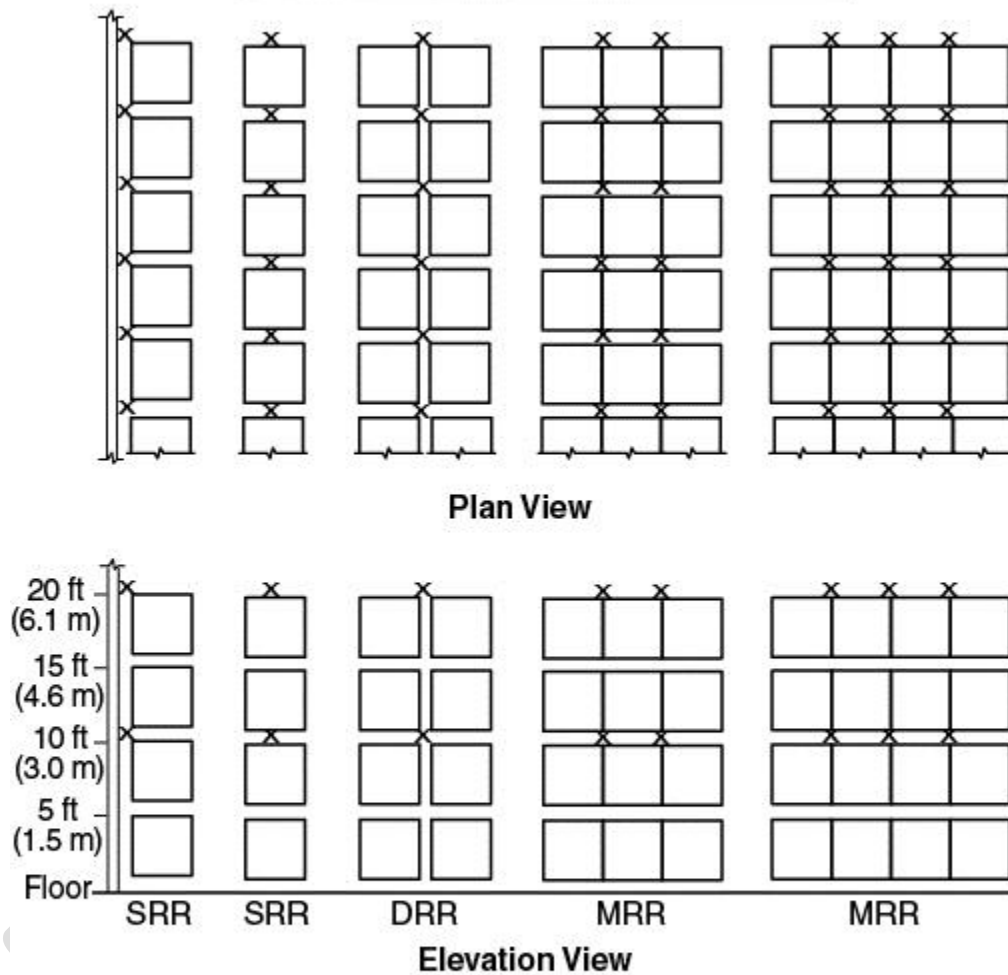
Note: Each square represents a storage cube measuring 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. to 10 ft (450 mm to 3.0 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.0 m) apart vertically.

Figure 25.9.3.3(h) In-Rack Sprinkler Arrangement, Exposed Nonexpanded Group A Plastic Commodities Up to 20 ft (6.1 m) in Height in Up to a 30 ft (9.1 m) High Building — Option 2.
 Single-, double-, and multiple-row racks
 0.60 gpm/ft² over 1500 ft² (24.4 mm/min over 139 m²)



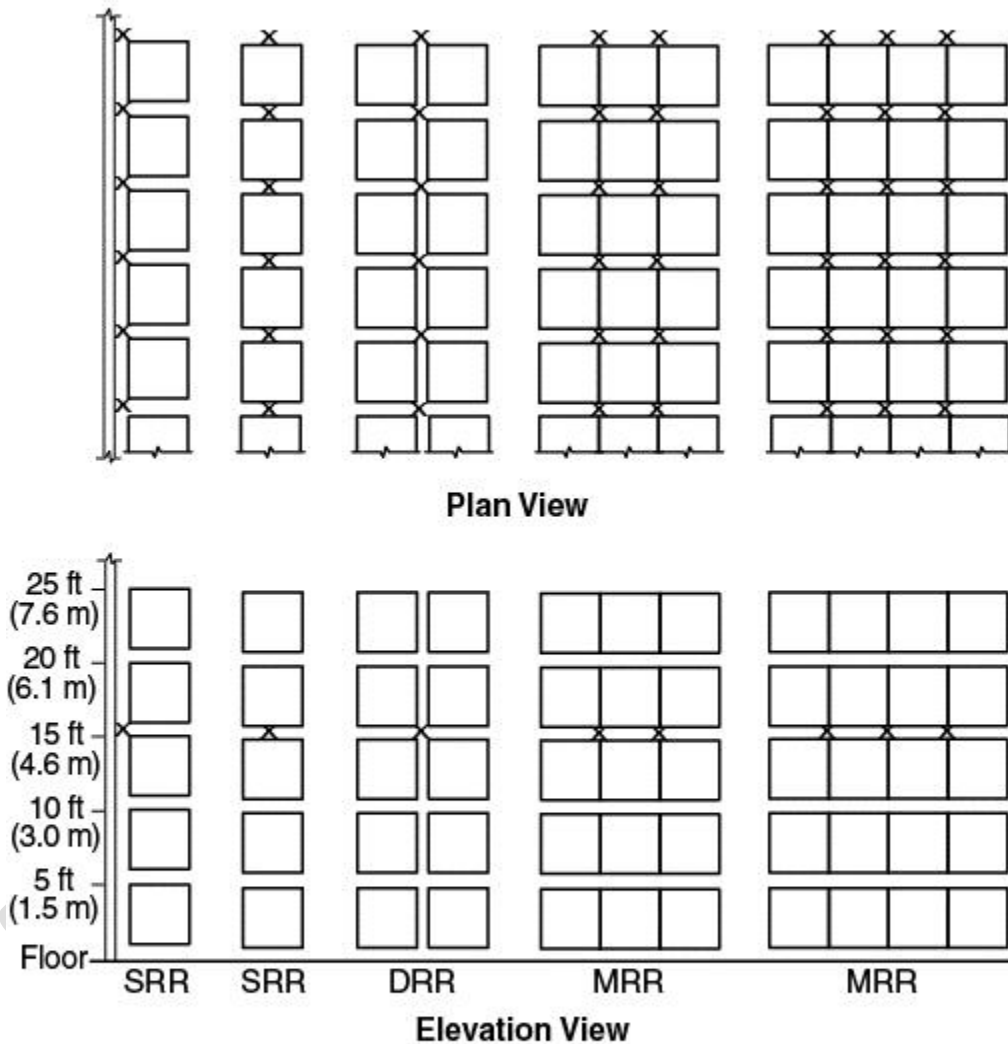
Note: Each square represents a storage cube measuring 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. to 10 ft (450 mm to 3.0 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.0 m) apart vertically.

Figure 25.9.3.3(i) In-Rack Sprinkler Arrangement, Exposed Nonexpanded Group A Plastic Commodities Up to 20 ft (6.1 m) in Height in Up to a 30 ft (9.1 m) High Building — Option 3.
Single-, double-, and multiple-row racks
0.30 gpm/ft² over 2000 ft² (12.2 mm/min over 196 m²)



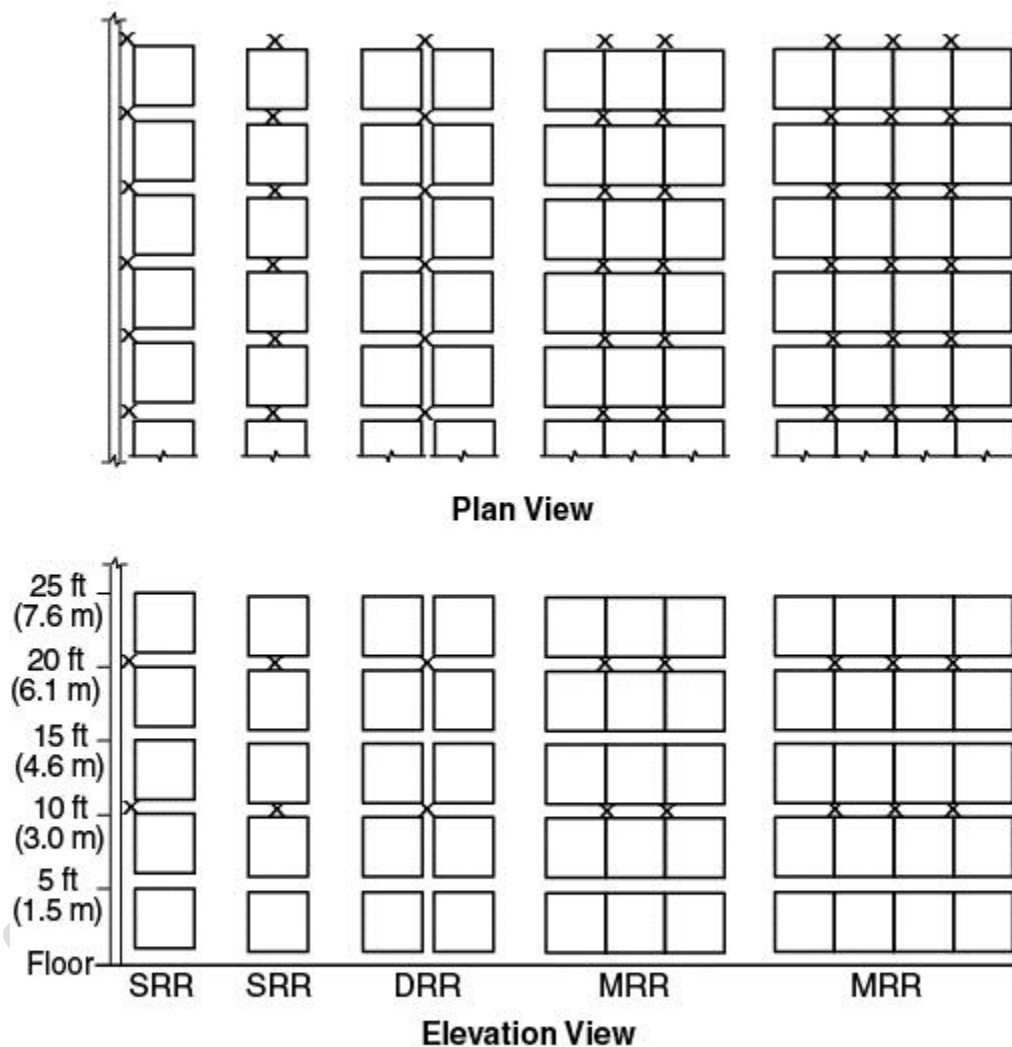
Note: Each square represents a storage cube measuring 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. to 10 ft (450 mm to 3.0 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.0 m) apart vertically.

Figure 25.9.3.3(j) In-Rack Sprinkler Arrangement, Exposed Nonexpanded Group A Plastic Commodities Up to 25 ft (7.6 m) in Height in Up to a 35 ft (10.7 m) High Building — Option 1.
Single-, double-, and multiple-row racks
0.80 gpm/ft² over 1500 ft² (32.6 mm/min over 138 m²)



Note: Each square represents a storage cube measuring 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. to 10 ft (450 mm to 3.0 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.0 m) apart vertically.

Figure 25.9.3.3(k) In-Rack Sprinkler Arrangement, Exposed Nonexpanded Group A Plastic Commodities Up to 25 ft (7.6 m) in Height in Up to a 35 ft (10.7 m) High Building — Option 2.
 Single-, double-, and multiple-row racks
 0.30 gpm/ft² over 2000 ft² (12.2 mm/min over 18 m²)



Note: Each square represents a storage cube measuring 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. to 10 ft (450 mm to 3.0 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.0 m) apart vertically.

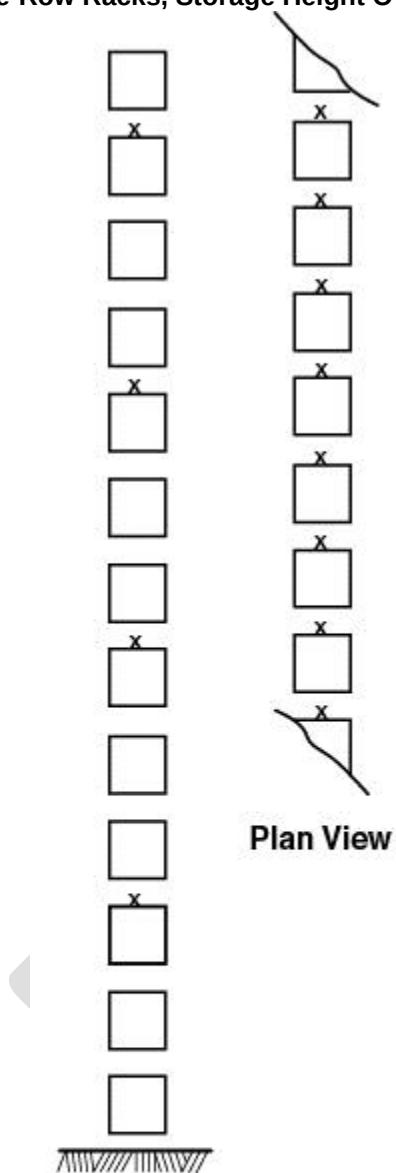
25.9.4 Rack Storage of Group A Commodities Over 25 ft (7.6 m) in Height.

25.9.4.1 Single-Row Racks.

25.9.4.1.1

Where single-row rack storage of cartoned Group A plastic commodities, expanded or nonexpanded, encapsulated or nonencapsulated, is over 25 ft (7.6 m) in height, in-rack sprinklers shall be arranged in accordance with one of the options in Figure 25.9.4.1.1(a) through Figure 25.9.4.1.1(d).

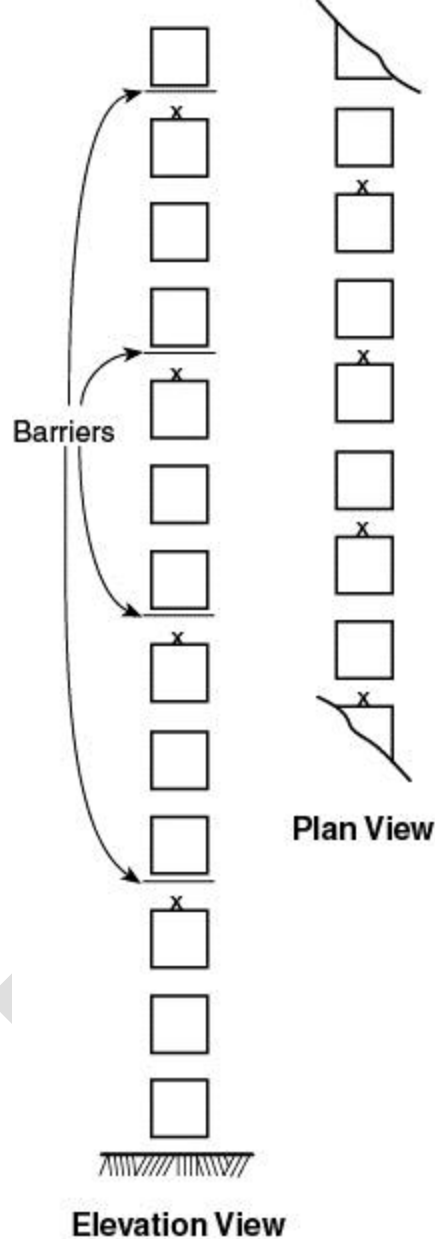
Figure 25.9.4.1.1(a) In-Rack Sprinkler Arrangement, Cartoned Group A Plastic Commodities, Single-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 1.



Elevation View

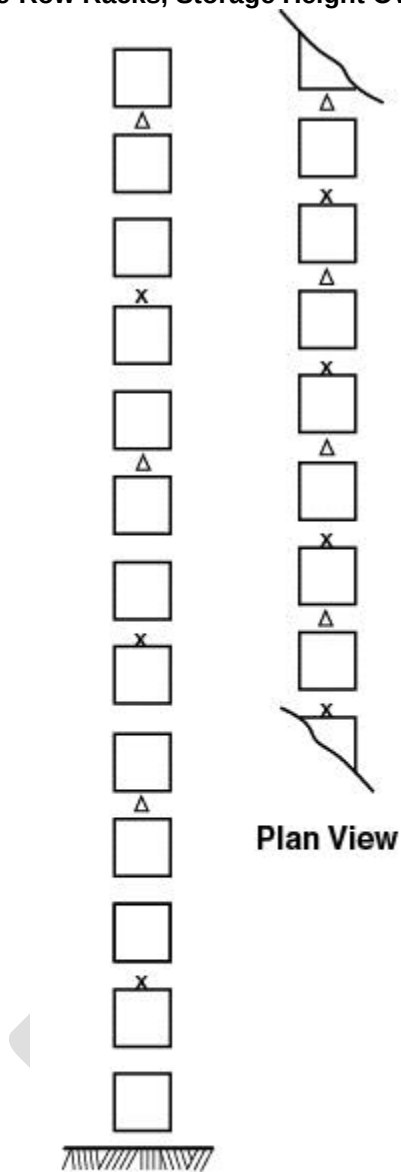
Note: Each square represents a storage cube measuring 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. (450 mm) up to 10 ft (3.0 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.0 m) apart vertically.

Figure 25.9.4.1.1(b) In-Rack Sprinkler Arrangement, Cartoned Group A Plastic Commodities, Single-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 2.



Note: Each square represents a storage cube measuring 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. (450 mm) up to 10 ft (3.0 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.0 m) apart vertically.

Figure 25.9.4.1.1(c) In-Rack Sprinkler Arrangement, Cartoned Group A Plastic Commodities, Single-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 3.



Elevation View

Note: Each square represents a storage cube measuring 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. (450 mm) up to 10 ft (3.0 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.0 m) apart vertically.

Figure 25.9.4.1.1(d) In-Rack Sprinkler Arrangement, Cartoned Group A Plastic Commodities, Single-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 4. [missing figure?]

25.9.4.1.2

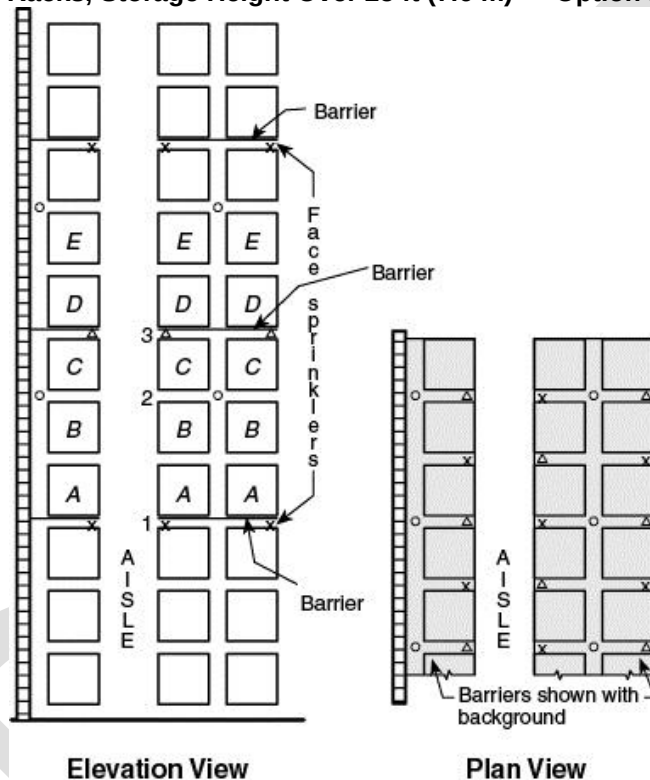
Where a single-row rack of cartoned Group A plastic commodities is located against a wall, the in-rack sprinkler arrangement shall be permitted to be in accordance with Figure 25.9.4.2(a) or Figure 25.9.4.2(b).

25.9.4.2 Double-Row Racks.

25.9.4.2.1

Where double-row rack storage of cartoned Group A plastic commodities, expanded or nonexpanded, encapsulated or nonencapsulated, is over 25 ft (7.6 m) in height, in-rack sprinklers shall be arranged in accordance with one of the options in Figure 25.3.5.2.1(a) through Figure 25.3.5.2.1(c).

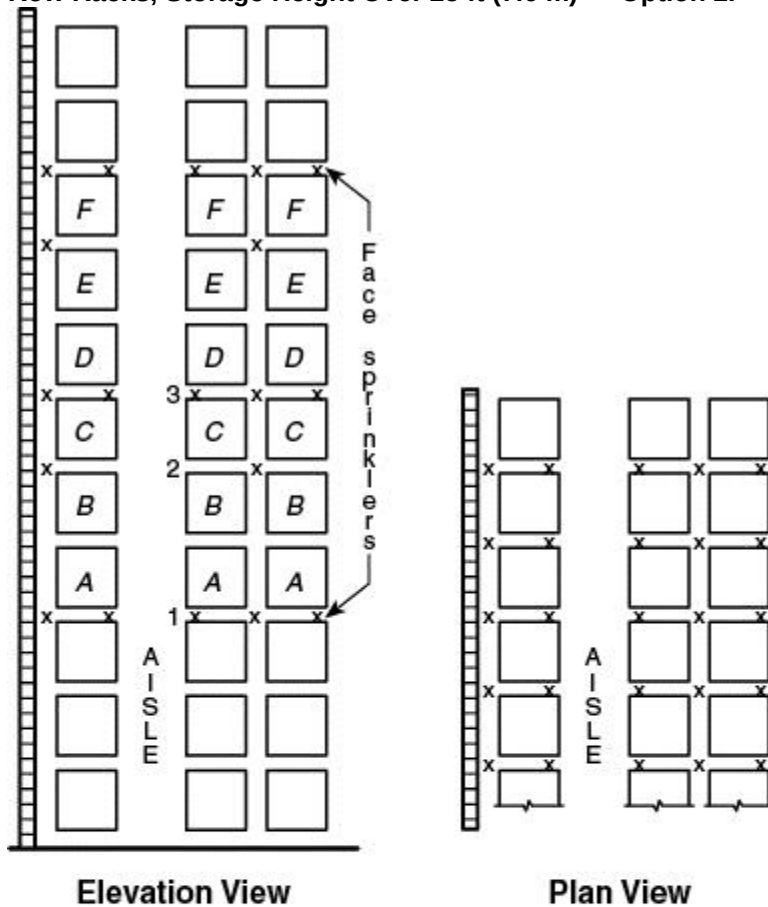
Figure 25.9.4.2.1(a) In-Rack Sprinkler Arrangement, Cartoned Group A Plastic Commodities, Double-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 1.



Notes:

1. Sprinklers and barriers labeled 1 shall be required where loads labeled A or B represent top of storage.
2. Sprinklers labeled 1 and 2 and barriers labeled 1 shall be required where loads labeled C represent top of storage.
3. Sprinklers and barriers labeled 1 and 3 shall be required where 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. Symbol Δ or x indicates face sprinklers on vertical or horizontal stagger.
6. Symbol o indicates longitudinal flue space sprinklers.
7. Each square represents a storage cube measuring 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. (450 mm) up to 10 ft (3.0 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.0 m) apart vertically.

Figure 25.9.4.2.1(b) In-Rack Sprinkler Arrangement, Cartoned Group A Plastic Commodities, Double-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 2.



Notes:

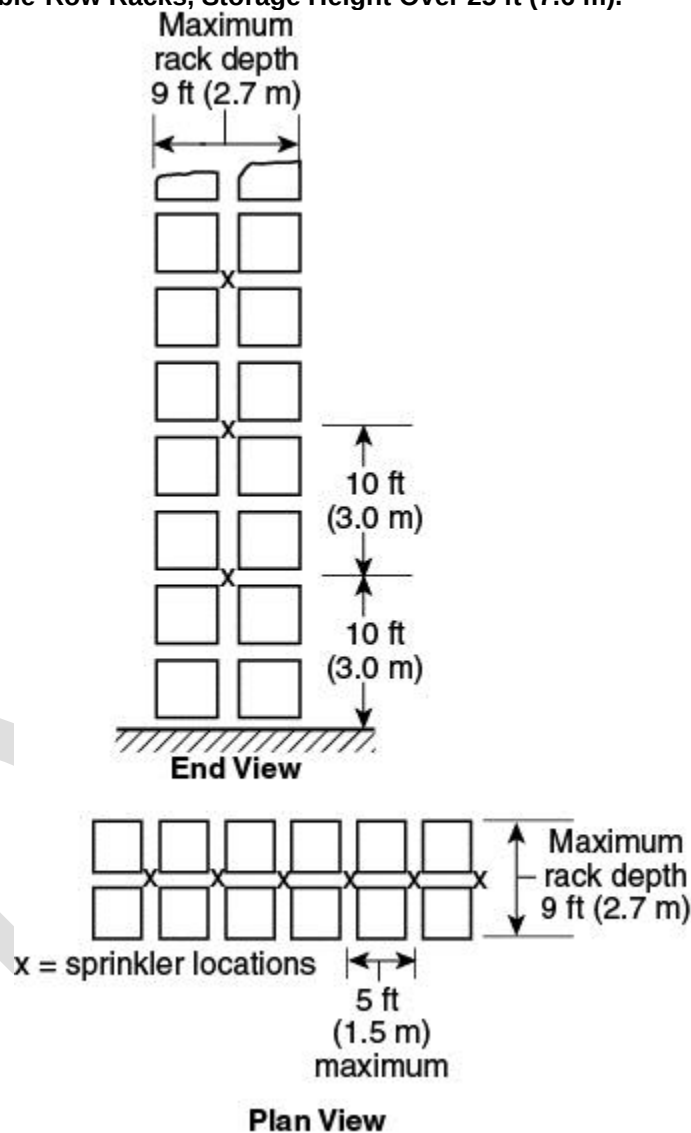
1. Sprinklers labeled 1 shall be required where loads labeled *A* or *B* represent top of storage.
2. Sprinklers labeled 1 and 2 shall be required where loads labeled *C* represent top of storage.
3. Sprinklers labeled 1 and 3 shall be required where loads labeled *D* or *E* represent top of storage.
4. For storage higher than loads labeled *F*, the cycle defined by Notes 2 and 3 is repeated.
5. Symbol *x* indicates face and in-rack sprinklers.
6. Each square represents a storage cube measuring 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. (450 mm) up to 10 ft (3.0 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.0 m) apart vertically.

Figure 25.9.4.2.1(c) In-Rack Sprinkler Arrangement, Cartoned Group A Plastic Commodities, Double-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 3. [missing figure?]

25.9.4.2.2*

Where double-row rack storage of exposed nonexpanded Group A plastic commodities, whether encapsulated or nonencapsulated, is over 25 ft (7.6 m) in height and has minimum 4 ft (1.2 m) wide aisles, in-rack sprinklers shall be arranged in accordance with Figure 25.9.4.2.2.

Figure 25.9.4.2.2 In-Rack Sprinkler Arrangement, Exposed Nonexpanded Group A Plastic Commodities, Double-Row Racks, Storage Height Over 25 ft (7.6 m).



25.9.4.2.3

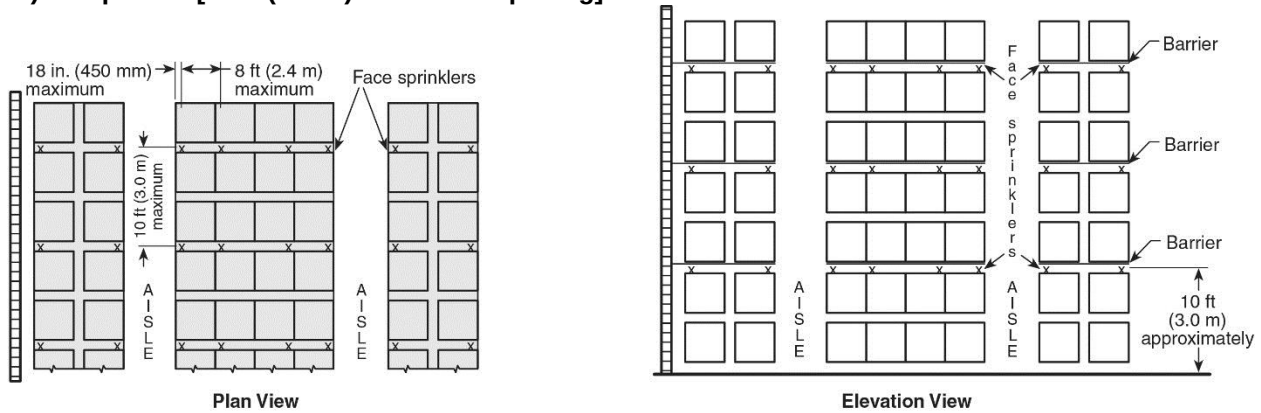
Protection of Group A plastic commodities that are exposed and nonexpanded, whether encapsulated or nonencapsulated racks and with a clearance to ceiling up to and including 10 ft (3.1 m), shall be permitted only using in-rack sprinkler arrangements that are specifically permitted to be used with exposed nonexpanded plastic commodities.

25.9.4.3 Multiple-Row Racks.

25.9.4.3.1

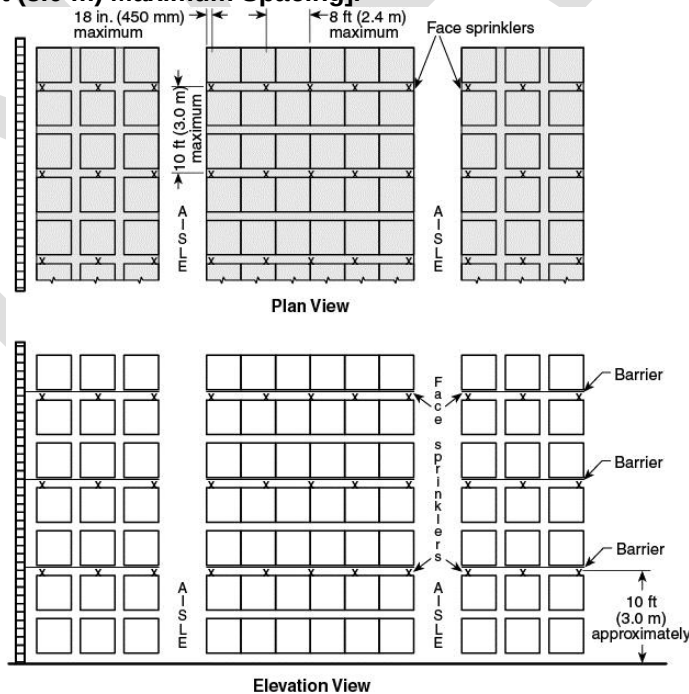
Where multiple-row rack storage of exposed nonexpanded Group A plastic commodities, encapsulated or nonencapsulated, or cartoned Group A plastic commodities, expanded or nonexpanded, encapsulated or nonencapsulated, is over 25 ft (7.6 m) in height, in-rack sprinklers shall be arranged in accordance with one of the options in Figure 25.9.4.3.1(a) through Figure 25.9.4.3.1(f).

Figure 25.9.4.3.1(a) In-Rack Sprinkler Arrangement, Cartoned Group A Plastic and Exposed Nonexpanded Group A Plastic Commodities, Multiple-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 1 [10 ft (3.0 m) Maximum Spacing].



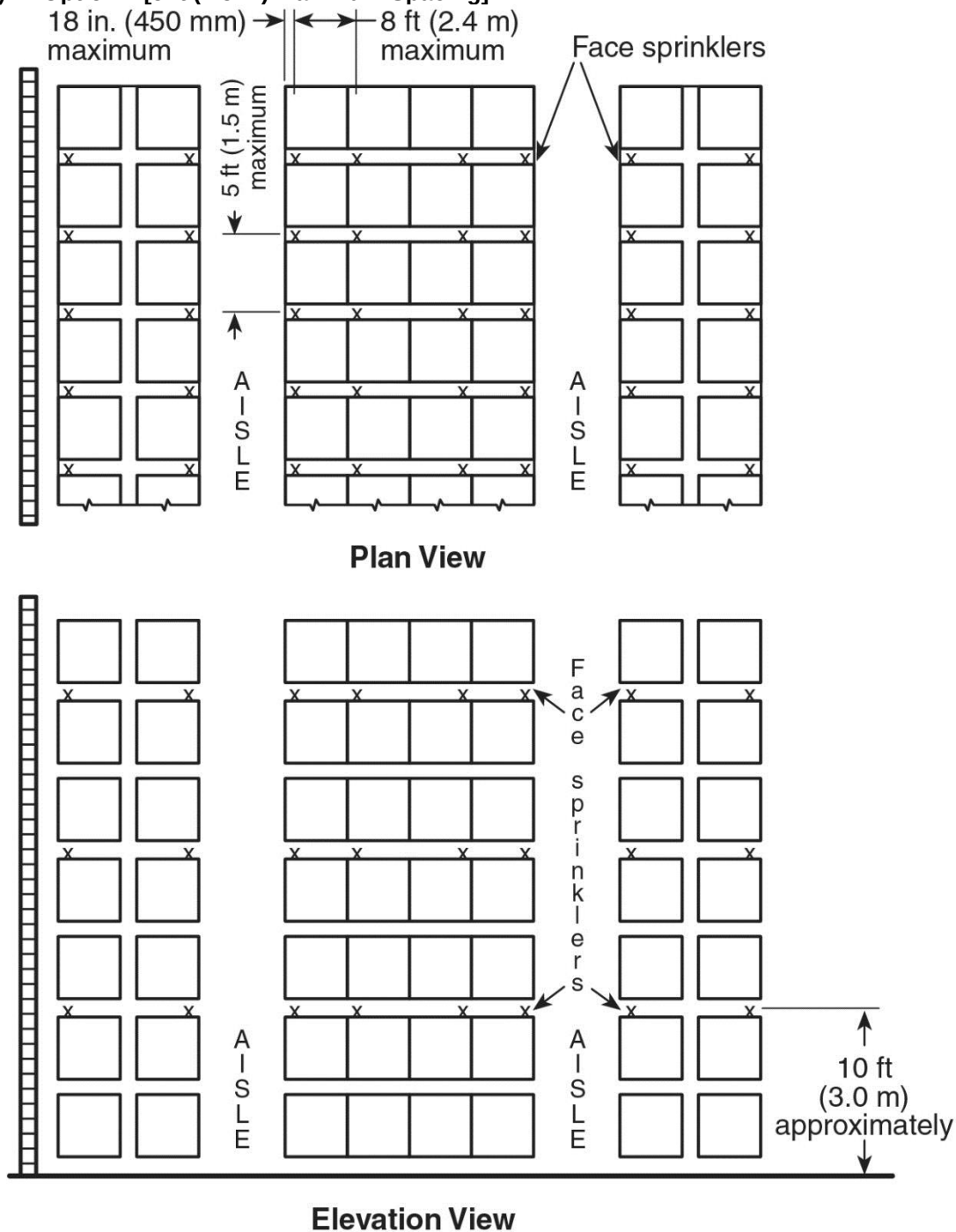
Note: Each square represents a storage cube measuring 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. (450 mm) up to 10 ft (3.0 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.0 m) apart vertically.

Figure 25.9.4.3.1(b) In-Rack Sprinkler Arrangement, Cartoned Group A Plastic and Exposed Nonexpanded Group A Plastic Commodities, Multiple-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 2 [10 ft (3.0 m) Maximum Spacing].



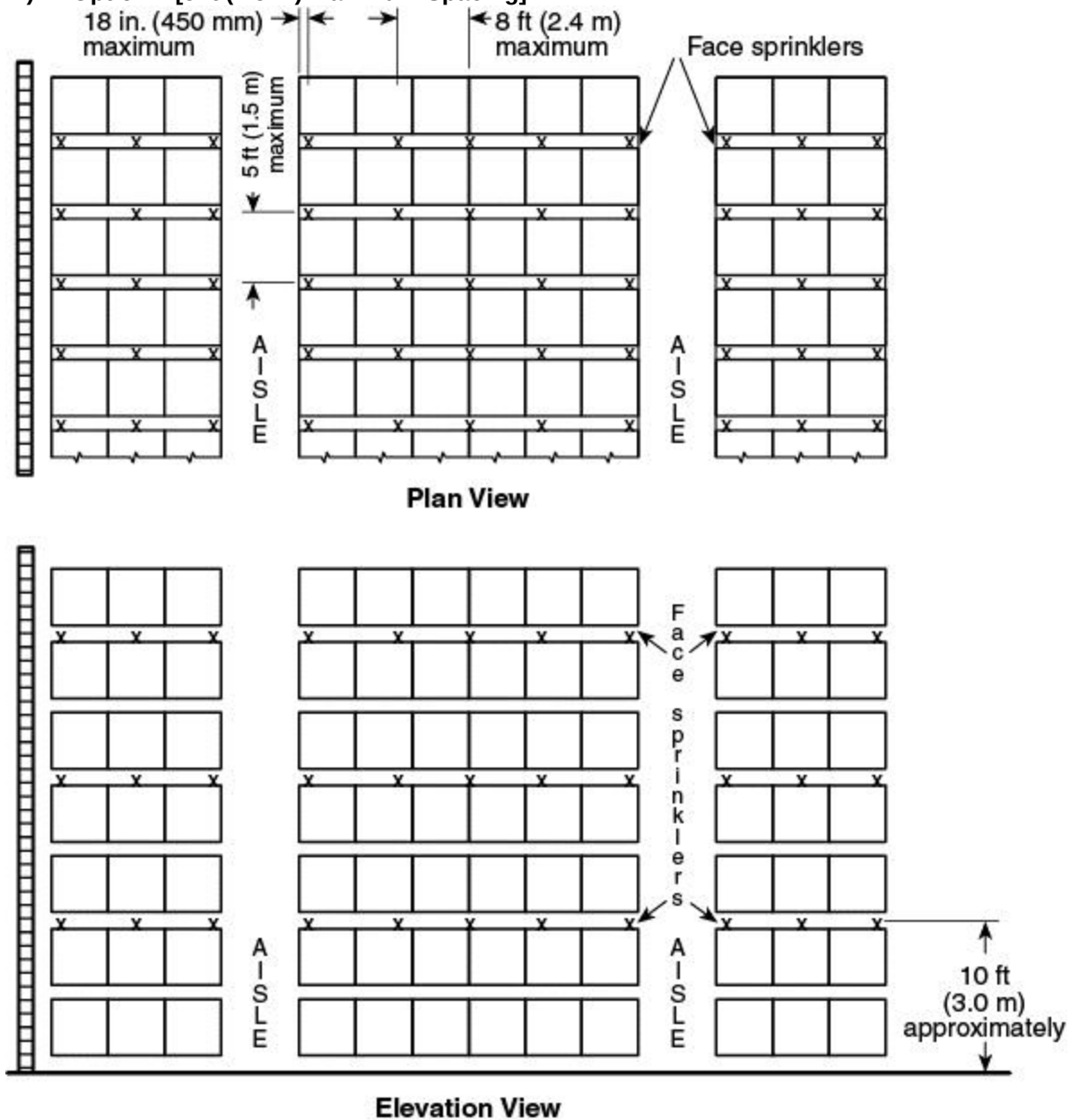
Note: Each square represents a storage cube measuring 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. (450 mm) up to 10 ft (3.0 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.0 m) apart vertically.

Figure 25.9.4.3.1(c) In-Rack Sprinkler Arrangement, Cartoned Group A Plastic and Exposed Nonexpanded Group A Plastic Commodities, Multiple-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 1 [5 ft (1.5 m) Maximum Spacing].



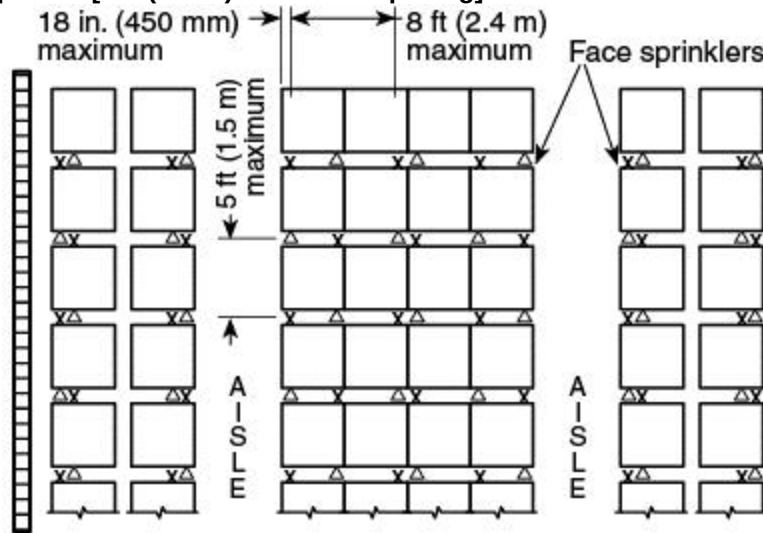
Note: Each square represents a storage cube measuring 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. (450 mm) up to 10 ft (3.0 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.0 m) apart vertically.

Figure 25.9.4.3.1(d) In-Rack Sprinkler Arrangement, Cartoned Group A Plastic and Exposed Nonexpanded Group A Plastic Commodities, Multiple-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 2 [5 ft (1.5 m) Maximum Spacing].

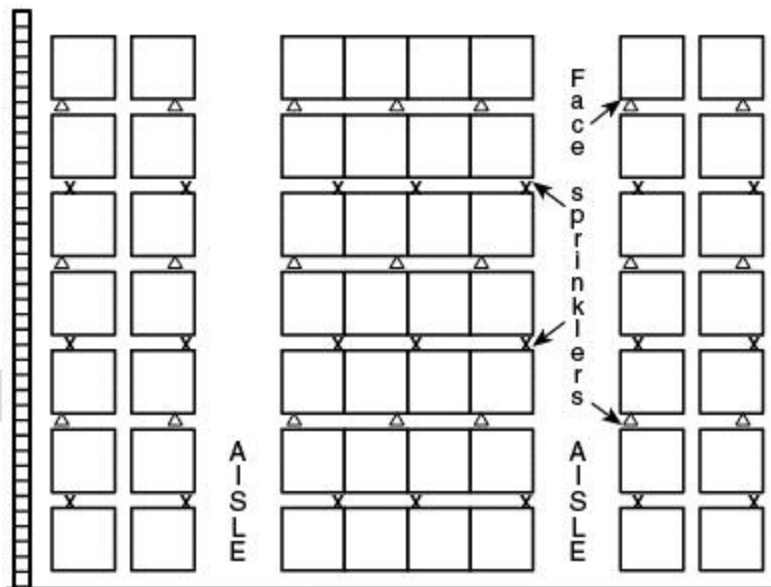


Note: Each square represents a storage cube measuring 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. (450 mm) up to 10 ft (3.0 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.0 m) apart vertically.

Figure 25.9.4.3.1(e) In-Rack Sprinkler Arrangement, Cartoned Group A Plastic and Exposed Nonexpanded Group A Plastic Commodities, Multiple-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 3 [5 ft (1.5 m) Maximum Spacing].



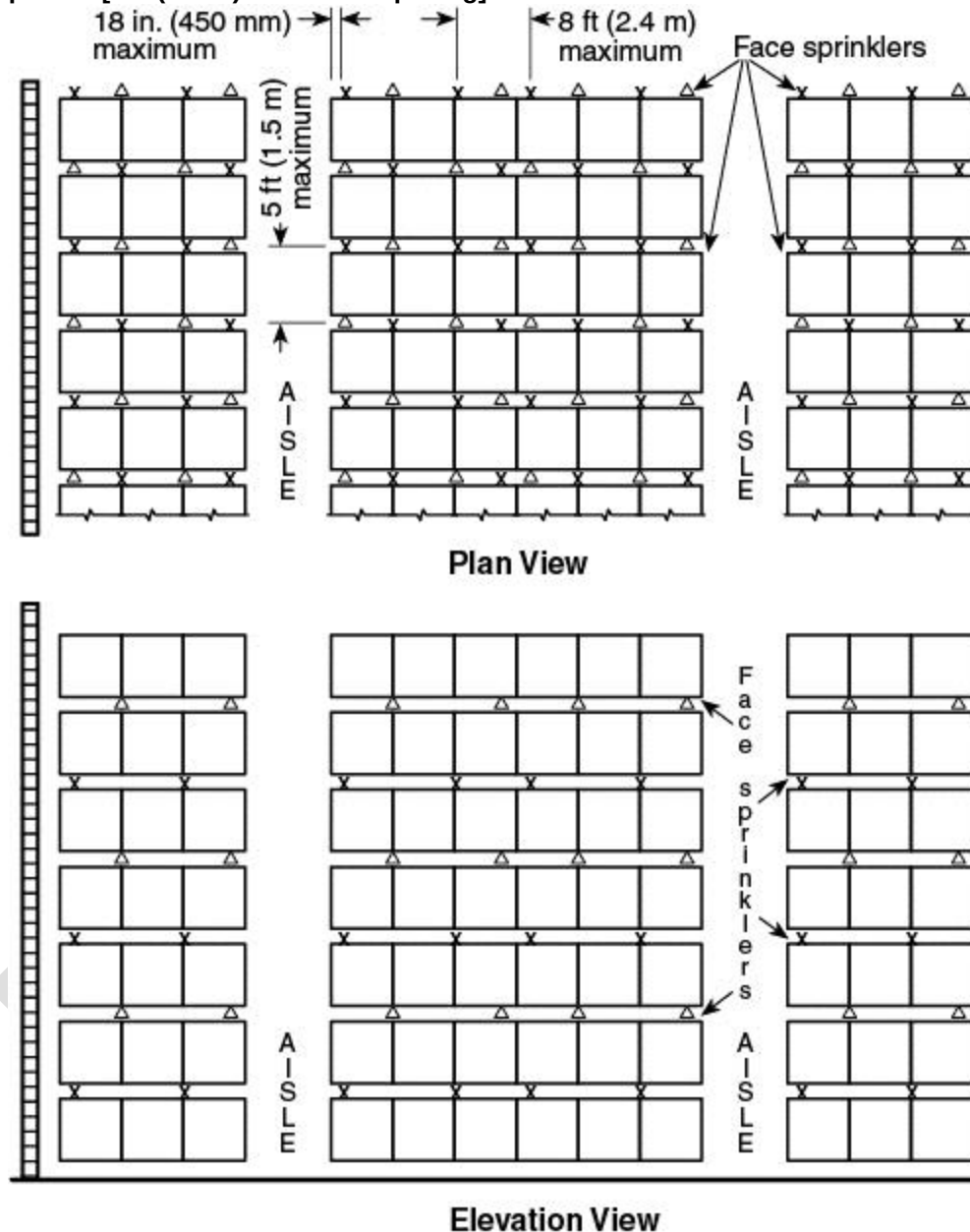
Plan View



Elevation View

Note: Each square represents a storage cube measuring 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. (450 mm) up to 10 ft (3.0 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.0 m) apart vertically.

Figure 25.9.4.3.1(f) In-Rack Sprinkler Arrangement, Cartoned Group A Plastic and Exposed Nonexpanded Group A Plastic Commodities, Multiple-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 4 [5 ft (1.5 m) Maximum Spacing].



Note: Each square represents a storage cube measuring 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. (450 mm) up to 10 ft (3.0 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.0 m) apart vertically.

25.9.5 In-Rack Sprinkler Arrangements Due to Excessive Clearance.

25.9.5.1

Where the clearance to ceiling for rack storage of Class 1 through Class IV commodities up to and including 25 ft (7.6 m) in height protected by CMDA ceiling-level sprinklers exceeds 20 ft (6.1 m) and the ceiling-level protection is not capable of providing the protection needed for the storage height that would result in a clearance to ceiling of 20 ft (6.1 m), one level of supplemental, quick-response in-rack sprinklers located directly below the top tier of storage and at every flue space intersection shall be installed.

25.9.5.2

Where the clearance to ceiling for rack storage of plastic commodities up to and including 25 ft (7.6 m) in height protected by CMDA ceiling-level sprinklers exceeds 10 ft (3.0 m), and the ceiling-level protection is not capable of providing the protection needed for the storage height that would result in a clearance to ceiling of 10 ft (3.0 m) one level of supplemental, quick-response in-rack sprinklers located directly below the top tier of storage and at every flue space intersection shall be installed.

25.9.5.3

Where the clearance to ceiling exceeds 10 ft (3.0 m) for rack storage over 25 ft (7.6 m) in height, and the ceiling-level protection is not capable of providing the protection needed for the storage height that would result in a clearance to ceiling of 10 ft (3.0 m) one level of supplemental, quick-response in-rack sprinklers located directly below the top tier of storage and at every flue space intersection shall be installed.

25.9.5.4

Where the supplemental in-rack sprinkler protection has been installed in accordance with this section, the ceiling-level sprinkler system design shall be based upon the storage height that results in an acceptable clearance to ceiling.

25.9.5.5

Where in-rack sprinklers are required for the actual storage height based on a theoretical acceptable clearance to ceiling, in-rack sprinklers shall be installed as indicated by that criteria and supplemented as outlined in this section.

25.9.6 Rack Storage of Rubber Tires Up to and Including 20 ft (6.1 m) in Height.

The in-rack arrangements for rack storage of rubber tires, either on-side or on-tread, up to and including 20 ft (6.1 m) in height shall be in accordance with the guidelines outlined in 25.4 through 25.7 as applicable.

25.10 In-Rack Sprinkler Arrangements in Combination with CMSA Sprinklers at Ceiling-Level.

25.10.1* Rack Storage of Class I Through Class IV and Group A Plastic Commodities.

The in-rack arrangements for rack storage of Class I through Class IV and Group A plastic commodities protected by CMSA sprinklers at ceiling level shall be in accordance with the guidelines outlined in Section 25.4 through 25.7 as applicable.

25.11 In-Rack Sprinkler Arrangements in Combination with ESFR Sprinklers at Ceiling-Level.

25.11.1 Rack Storage of Class I Through Class IV and Group A Plastic Commodities.

The in-rack arrangements for rack storage of Class I through Class IV and Group A plastic commodities protected by ESFR sprinklers at ceiling level shall be in accordance with the guidelines outlined in Section 25.4 through 25.7 as applicable.

25.12 Design Criteria for In-Rack Sprinklers in Combination with Ceiling-Level Sprinklers.

25.12.1 General.

25.12.1.1

In-rack sprinkler design criteria for Group A plastic commodities shall be permitted for the protection of the same storage height and configuration of Class I, II, III, and IV commodities.

25.12.1.2

Pipe sizing of an in-rack sprinkler system shall be permitted to be based on hydraulic calculations and not restricted by any pipe schedule.

25.12.1.3

Where in-rack sprinklers are being installed to protect a storage rack and, due to the length of the rack, fewer in-rack sprinklers will be installed than the number of in-rack sprinklers specified in the in-rack design, the in-rack sprinkler design shall be based on only those in-rack sprinklers installed within the protected rack.

25.12.1.4

Where in-rack sprinkler arrangements have been installed in accordance with Section 25.10, Section 25.11 or Section 25.12, the flow and pressure requirements of both the ceiling and in-rack sprinkler systems over the same protected area shall be hydraulically balanced together to the higher sprinkler system pressure requirement at their point of connection.

25.12.1.5

The minimum water supply requirements for a hydraulically designed occupancy hazard automatic in-rack sprinkler system shall be determined by adding the hose stream allowance from Table 20.12.2.6 to the water supply for ceiling-level sprinklers determined in Section 25.2, unless indicated otherwise.

25.12.2 Number of Operating In-Rack Sprinklers.

25.12.2.1 In-Rack Design Based on 4 In-Rack Sprinklers.

Where in-rack sprinklers have been installed to protect miscellaneous storage, the number of in-rack sprinklers to account for in the design shall be based on the simultaneous operation of the most hydraulically remote four in-rack sprinklers.

25.12.2.2 In-Rack Design Based on 6 In-Rack Sprinklers.

25.12.2.2.1

Where in-rack sprinklers have been installed on one level to protect the following commodities and storage arrangements, the number of in-rack sprinklers to account for in the design shall be based on the simultaneous operation of the most hydraulically remote six in-rack sprinklers:

- (1) Class I through Class III commodities stored in racks with solid shelves.
- (2) Class I through Class III commodities stored in racks protected by CMDA sprinklers at ceiling level.

25.12.2.3 In-Rack Design Based on 8 In-Rack Sprinklers.

25.12.2.3.1

Where in-rack sprinklers have been installed on one level to protect the following commodities and storage arrangements, the number of in-rack sprinklers to account for in the design shall be based on the simultaneous operation of the most hydraulically remote eight in-rack sprinklers:

- (1) Class IV and Group A plastic commodities stored in racks with solid shelves.
- (2) Class IV and Group A plastic commodities stored in racks protected by CMDA sprinklers at ceiling level.
- (3) Class I through Class IV commodities stored in racks protected by CMSA sprinklers at ceiling level.
- (4) Group A plastic commodities stored in racks up to and including 25 ft (7.6 m) in height protected by CMSA sprinklers at ceiling level.
- (5) Class I through Class IV commodities stored in racks protected by ESFR sprinklers at ceiling level.

25.12.2.4 In-Rack Design Based on 10 In-Rack Sprinklers.

25.12.2.4.1

Where in-rack sprinklers have been installed on more than one level to protect the following commodities and storage arrangements, the number of in-rack sprinklers to account for in the design shall be based on

the simultaneous operation of the most hydraulically remote ten in-rack sprinklers (five on each of the top two levels):

- (1) Class I through Class III commodities stored in racks with solid shelves.
- (2) Class I through Class III commodities stored in racks over 25 ft (7.6 m) in height protected by CMDA sprinklers at ceiling level.
- (3) Class IV commodities stored in racks up to and including 25 ft (7.6 m) in height protected by CMDA sprinklers at ceiling level.

25.12.2.5 In-Rack Design Based on 12 In-Rack Sprinklers.

Where in-rack sprinklers have been installed on one level to protect rack storage of rubber tires, the number of in-rack sprinklers to account for in the design shall be based on the simultaneous operation of the most hydraulically remote twelve in-rack sprinklers.

25.12.2.6 In-Rack Design Based on 14 In-Rack Sprinklers.

25.12.2.6.1

Where in-rack sprinklers have been installed on more than one level to protect the following commodities and storage arrangements, the number of in-rack sprinklers to account for in the design shall be based on the simultaneous operation of the most hydraulically remote fourteen in-rack sprinklers (seven on each of the top two levels):

- (1) Class IV and Group A plastic commodities stored in racks with solid shelves.
- (2) Class IV and Group A plastic commodities stored in racks protected by CMDA sprinklers at ceiling level.

25.12.3 In-Rack Sprinkler Flow/Pressure.

25.12.3.1 In-Rack Design Based on 15 psi (1.0 bar).

25.12.3.1.1

Where in-rack sprinklers have been installed to protect the following commodities and storage arrangements, the minimum allowable design pressure at the hydraulically most remote in-rack sprinkler shall be 15 psi (1.0 bar). (See Section C.19.)

- (1) Miscellaneous storage.
- (2) Class I through Class IV commodities stored in racks up to and including 25 ft (7.6 m) in height protected by CMDA sprinklers at ceiling level.
- (3) Class I through Class IV commodities stored in racks protected by CMSA sprinklers at ceiling level.
- (4) Group A plastic commodities stored in racks up to and including 25 ft (7.6 m) in height protected by CMDA sprinklers at ceiling level.
- (5) Group A plastic commodities stored in racks up to and including 25 ft (7.6 m) in height protected by CMSA sprinklers at ceiling level.

25.12.3.2 In-Rack Design Based on 30 psi (2.1 bar).

Where in-rack sprinklers have been installed to protect rack storage of rubber tires, the minimum allowable design pressure at the hydraulically most remote in-rack sprinkler shall 30 psi (2.1 bar).

25.12.3.3 In-Rack Design Based on 30 gpm (115 L/min).

25.12.3.3.1

Where in-rack sprinklers have been installed to protect rack storage of the following commodities and storage arrangements, the minimum allowable design pressure at the hydraulically most remote in-rack sprinkler shall be 30 gpm (115 L/min).

- (1) Class I through Class IV and Group A plastic commodities stored in racks with solid shelves.
- (2) Class I through Class IV and Group A plastic commodities stored in racks over 25 ft (7.6 m) in height protected by CMDA sprinklers at ceiling level.

25.12.3.4 In-Rack Design Based on 60 gpm (230 L/min).

Where in-rack sprinklers have been installed to protect rack storage protected by ESFR sprinklers at ceiling level, the minimum allowable design pressure at the hydraulically most remote in-rack sprinkler shall be 60 gpm (230 L/min).

Chapter 26 Special Occupancy Requirements

26.1 General.

26.1.1 Application.

26.1.1.1

In addition to the requirements of Chapter 8, Chapters 11 through 22, and Chapter 23, the following special occupancy requirements shall apply.

26.1.1.1.1

All provisions of design criteria in this standard, including design area increases and reductions, shall also apply to these special occupancy requirements.

26.1.1.2

Where the requirements of the reference standard differ from the requirements of this standard, the reference standard shall take precedence.

26.1.2 Definitions.

For terms not defined in Chapter 3, the definitions of the reference standard shall apply.

26.2 Flammable and Combustible Liquids.

26.2.1 Design Requirements.

Sprinkler system discharge criteria for the protection of flammable and combustible liquids shall comply with NFPA 30.

26.2.2 Installation Requirements. (Reserved)

26.3 Aerosol Products.

26.3.1 Design Requirements.

Sprinkler system discharge criteria for the protection of aerosol products shall comply with NFPA 30B.

26.3.2 Installation Requirements. (Reserved)

26.4 Spray Application Using Flammable or Combustible Materials.

26.4.1 Design Requirements.

26.4.1.1*

The automatic sprinkler system shall be a wet pipe system, a dry pipe system, a preaction system, or an open-head deluge system, whichever is most appropriate for the portion of the spray operation being protected. [33:9.4.1]

26.4.1.2

The automatic sprinkler system shall be designed for Extra Hazard (Group 2) occupancies as defined in NFPA 13.

Exception No. 1: For spray application of styrene cross-link thermoset resins, Section 17.3 of NFPA 33 shall apply.

Exception No. 2: Automatic sprinkler systems for powder coating operations shall be designed for Ordinary Hazard (Group 2), as defined in NFPA 13. [33:9.4.2]

26.4.1.3

The water supply shall be sufficient to supply all sprinklers likely to open in any one fire incident without depleting the available water for use in hose streams. [33:9.4.3]

26.4.1.4

Where sprinklers are installed to protect spray areas and mixing rooms only, water shall be permitted to be supplied from domestic water systems, provided the domestic supply can meet the design criteria of 26.4.1.2. [33:9.4.4]

26.4.1.5

The sprinkler system shall be controlled by a separate, listed indicating valve(s), operable from floor level. [33:9.4.5]

26.4.1.6

Automated liquid electrostatic spray application equipment that is unlisted shall be protected further by the following:

- (1) In addition to meeting the requirements in 9.8.1 of NFPA 33, the optical flame detection system shall also activate one of the following over each zone in which fire has been detected:
 - (a) An open head deluge system designed to discharge a minimum density of 24.4 l/min (0.6 gpm/ft²)
 - (b) A carbon dioxide extinguishing system
 - (c) A dry chemical extinguishing system
 - (d) A gaseous agent extinguishing system

[33:9.8.2(1)]

- (2) A wet pipe sprinkler system shall also be provided throughout the spray booth. This system shall meet all the applicable requirements of this standard for Extra Hazard (Group 2) occupancies.

[33:9.8.2(3)]

26.4.2 Installation Requirements.

26.4.2.1*

Sprinkler systems protecting stacks or ducts shall meet all of the following requirements:

- (1) Sprinklers shall be spaced no more than 3.7 m (12 ft) apart.
- (2) If exhaust ducts are manifolded, a sprinkler shall be located in the manifold at the junction of each exhaust duct with the manifold.
- (3) Sprinklers shall provide a minimum flow of 114 L/min (30 gpm) per head at a minimum of 1 bar (15 psi) pressure.
- (4) Sprinklers shall be ordinary temperature rated, unless required to be higher due to operating temperatures measured in the ducts, in which case the operating temperature shall be at least 28°C (50°F) above the inside temperature of the duct.

[33:9.4.6]

26.4.2.1.1

Stacks and exhaust ducts shall be provided with access openings for inspection and cleaning of sprinklers. [33:9.4.6.1]

26.4.2.1.2

Sprinkler systems protecting stacks and ducts that are subject to freezing shall be of a nonfreezing type or be a manually controlled open-head system. [33:9.4.6.2]

26.4.2.2

Sprinklers shall be protected against overspray residue, either by location or covering, so that they will operate quickly in event of fire. [33:9.4.7]

26.4.2.2.1

Sprinklers shall be permitted to be covered only by cellophane bags having a thickness of 0.08 mm (0.003 in.) or less or by thin paper bags. These coverings shall be replaced frequently so that heavy deposits of residue do not accumulate. [33:9.4.7.1]

26.4.2.2.2

Sprinklers that have been painted or coated by overspray or residues shall be replaced with new sprinklers. [33:9.4.7.2]

26.5 Solvent Extraction Plants. [NFPA 36]

26.5.1* Design Requirements.

26.5.2 Installation Requirements. (Reserved)

26.6 Installation and Use of Stationary Combustion Engines and Gas Turbines.

26.6.1* Design Requirements.

Automatic sprinkler systems shall be designed to provide for a density of 0.3 gpm/ft² (12.2 mm/min) over the most remote 2500 ft² (230 m²). [37:11.4.5.1]

26.6.2 Installation Requirements.

26.6.2.1

Sprinklers and spray nozzles shall be spaced at a 100 ft² (9 m²) maximum area of coverage per sprinkler or spray nozzle. [37:11.4.5.1.1]

26.6.2.2

Sprinkler and water spray system coverage shall be provided to all areas within the enclosure located within 20 ft (6 m) of the following:

- (1) The engine
- (2) The lubricating oil system
- (3) The fuel system

[37:11.4.5.1.2]

26.6.2.3

Sprinklers and water spray nozzles shall not be directed at engine components that are susceptible to thermal shock or deformation. [37:11.4.5.2]

26.7 Nitrate Film.

26.7.1 Design Requirements.

26.7.1.1

Every room, except projection booths and rewinding rooms, where nitrate film is stored or handled in quantities greater than 51 lb (23 kg), or 10 standard rolls, shall be protected by an automatic sprinkler system that is installed in accordance with the requirements for Group II extra hazard occupancies. [40:5.1.2]

26.7.1.2

Water supplies for automatic sprinklers shall be based on 20 gpm (1.26 L/sec) per sprinkler for 20 minutes for the total number of sprinklers in one vault plus 25 percent of the sprinklers in the communicating fire area. [40:5.2.2]

26.7.1.3* Vaults Other Than Extended Term Storage Vaults.

[40:6.3] (See Figure A.26.7.1.3.) Fire protection in vaults shall be provided by a deluge system with directional nozzles meeting the criteria in 26.7.1.4. [40:6.3.7]

26.7.1.4

For extended term storage vaults in accordance with Section 6.5.5 of NFPA 40, fire protection shall be provided by a deluge system with directional nozzles installed in accordance with NFPA 15 and meeting the criteria in 26.7.1.4.1 through 26.7.1.4.9. [40:6.5.6]

26.7.1.4.1

Sprinkler systems in existing extended term storage vaults that were in compliance with the provisions of this standard at the time of installation shall be permitted to be continued in use. [40:6.5.6.1]

26.7.1.4.2

High-velocity open head nozzles each capable of providing a discharge rate of 1.26 L/sec (20 gpm) at a gauge pressure of 345 kPa (50 psi) shall be installed. [40:6.5.6.2]

26.7.1.4.3

The design shall be based on a discharge density of 28 mm/min (0.68 gpm/ft²) over each face of storage racks. [40:6.5.6.3]

26.7.1.4.4*

The nozzles shall have a combined spray pattern capable of covering the face of the film storage racks. [40:6.5.6.4]

26.7.1.4.5

The nozzles shall be installed at the top of the storage shelf array, aimed at the opposite shelf array. [40:6.5.6.5]

26.7.1.4.6*

Nozzles shall be installed on opposite faces of the storage shelf array in a staggered pattern such that no nozzles are directly opposite one another. [40:6.5.6.6]

26.7.1.4.7

The water supply duration shall be a minimum of 20 minutes. [40:6.5.6.7]

26.7.1.4.8

The deluge system shall be activated by a signal from one of the following: [40:6.5.6.8]

- (1) An air sampling-type smoke detection system
- (2) A fixed temperature heat sensitive cable

26.7.1.4.9

Full water flow shall be discharged from the water spray nozzles within 10 seconds of reaching the set point actuation of the detection system [40:6.5.6.9.6]

26.7.2 Installation Requirements.

26.7.2.1

In areas or rooms where nitrate film is handled, the area that is protected per sprinkler head shall not exceed 64 ft² (6 m²) with sprinklers not being more than 8 ft (2.4 m) apart. [40:5.1.4]

26.7.2.2 Cabinet Protection.

[40:6.2.5]

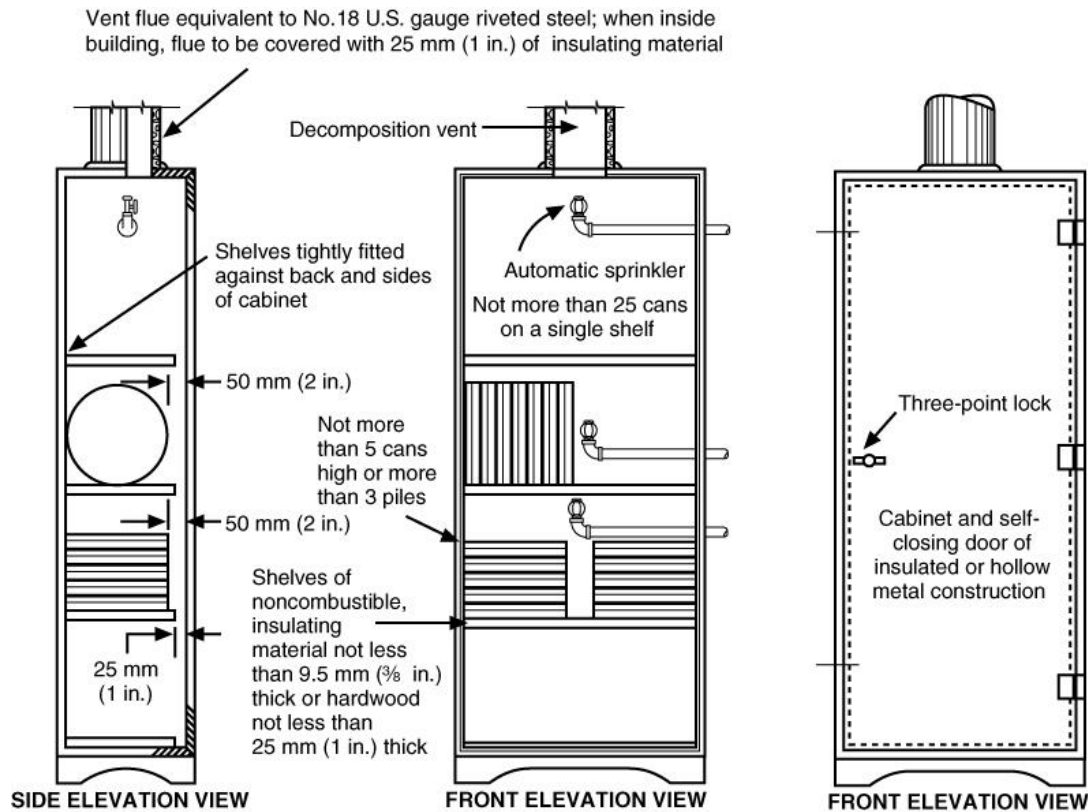
26.7.2.2.1

Cabinets having a capacity of more than 34 kg (75 lb), or 15 standard rolls, of film shall be provided with at least one automatic sprinkler head. [40:6.2.5.1]

26.7.2.2.2

Where cans are stored on more than one shelf, as shown in Figure 26.7.2.2.2 and as described in 6.2.6.2 or 6.2.6.3 of NFPA 40, one sprinkler shall be provided for each shelf. [40:6.2.5.2]

Figure 26.7.2.2.2 Standard Film Cabinet for Other Than Extended Term Storage Film. [40:Figure 6.2.1]



26.7.2.3 Motion Picture Film Laboratories.

In all cases, sprinklers shall be arranged so that not more than two machines are protected by any one sprinkler head. [40:9.2.5.2]

26.8 Laboratories Using Chemicals.

26.8.1 Design Requirements.

Automatic sprinkler system protection shall be required for all new laboratories in accordance with the following:

- (1) Automatic sprinkler system protection for Class A and Class B laboratories shall be in accordance with NFPA 13 for ordinary hazard (Group 2) occupancies.
- (2) Automatic sprinkler system protection for Class C and Class D laboratories shall be in accordance with NFPA 3 for ordinary hazard (Group 1) occupancies.

[45:6.1.1.1]

26.8.2 Installation Requirements.

Fire sprinklers in laboratory units shall be the quick response (QR) sprinkler type installed in accordance with NFPA 13. [45:6.1.1.2]

26.9 Oxygen-Fuel Gas Systems for Welding, Cutting, and Allied Processes.

26.9.1 Design Requirements.

26.9.1.1

Oxygen cylinders connected to one manifold shall be limited to a total gas capacity of 6500 ft³ (184 m³). [51:5.2.5]

26.9.1.1.1

Two such manifolds with connected cylinders shall be permitted to be located in the same room, provided the building is protected throughout with an approved automatic sprinkler system designed in accordance with this standard, furnishing a sprinkler discharge density of at least 0.25 gpm/ft² (10.2 mm/min) over a minimum operating area of at least 3000 ft² (279 m²) with sprinklers located not more than 20 ft (6.1 m) above the floor where the manifolds are located. [51:5.2.5.1]

26.9.1.2

For mobile acetylene trailer systems, a deluge sprinkler system shall be provided for MATS fire areas used as indoor and outdoor discharging stations. [51:10.5.8.1.1]

26.9.1.3

Deluge sprinkler systems shall provide a minimum density of 0.3 gpm/ft² (12.2 mm/min) over the MATS fire area being protected. [51:10.5.8.1.2]

26.9.1.4

The deluge system shall be identified and marked with a sign and shall be activated automatically by a fast-acting fire detection system and also by a manual actuator. [51:10.5.8.1.3]

26.9.1.5

The requirements of 26.9.1.2 shall not apply to existing indoor or outdoor facilities, equipment, structures, or installations where MATS are discharged that existed or were approved for construction or installation prior to the effective date of this standard, provided the MATS are protected with an automatic sprinkler system with a minimum design density of not less than 0.25 gpm/ft² (10.2 mm/min). [51:10.5.8.1.4.1]

26.9.2 Installation Requirements.

26.9.2.1

In buildings protected by an automatic sprinkler system and water supply designed in accordance with this standard for an Ordinary Hazard Group 2 or more hazardous occupancy, where the occupancy other than the cylinder storage is not more hazardous than ordinary hazard as defined in this standard, the distance between designated storage areas shall be permitted to be reduced to 15.2 m (50 ft). [51:4.3.4.1].

26.9.2.2

If the occupancy in such protected buildings between the designated storage areas is free of combustible material, the distance shall be permitted to be reduced to 25 ft (7.6 m). [51:4.3.4.2].

26.10 Acetylene Cylinder Charging Plants.

26.10.1 Design Requirements.

26.10.1.1

When sprinkler protection is provided, the area in which flammable compressed gases are stored or used shall be protected with a sprinkler system designed to be not less than that required by NFPA 13 for Extra Hazard Group 1 with a minimum design area of 2500 ft² (232.26 m²). [51A:11.2.1.2]

26.10.1.2

At mobile acetylene trailer systems (MATS) at mobile acetylene charging plants, a fire sprinkler system in accordance with this standard, Extra Hazard Group I shall be installed in the areas occupied by trailers in charging or discharging stations. [51A:11.2.1.3]

26.10.2 Installation Requirements. (Reserved)

26.11 Compressed Gases and Cryogenic Fluids Code.

26.11.1 Design Criteria.

26.11.1.1

When sprinkler protection is required, the area in which compressed gases or cryogenic fluids are stored or used shall be protected with a sprinkler system designed to be not less than that required by NFPA 13 for Ordinary Hazard Group 2. [55:6.10.2.1]

26.11.1.2

When sprinkler protection is required, the area in which the flammable or pyrophoric compressed gases or cryogenic fluids are stored or used shall be protected with a sprinkler system designed to be not less than that required by NFPA 13 for Extra Hazard Group 1. [55:6.10.2.2]

26.11.2 Installation Requirements. (Reserved)

26.12 Utility LP-Gas Plants.

26.12.1 Design Requirements.

26.12.1.1

The design of fire water supply and distribution systems, where used, shall provide for the simultaneous supply of those fixed fire protection systems involved in the maximum single incident expected in the plant, including monitor nozzles, at their design flow and pressure. [59:13.4.2]

26.12.1.2

An additional supply of 1000 gal/min (63 L/s) shall be available for hand hose streams for a period of not less than 2 hours. [59:13.4.2.1]

26.12.1.3

Manually actuated monitors shall be permitted to be used to augment hand hose streams. [59:13.4.2.2]

26.12.2 Installation Requirements. (Reserved)

26.13 Production, Storage, and Handling of Liquefied Natural Gas (LNG).

26.13.1 Design Requirements.

The fire water supply and distribution systems, if provided, shall simultaneously supply water to fixed fire protection systems, including monitor nozzles, at their design flow and pressure, involved in the maximum single incident expected in the plant plus an allowance of 1000 gpm (63 L/s) for hand hose streams for not less than 2 hours. [59A:12.5.2]

26.13.2 Installation Requirements. (Reserved)

26.14 Protection of Information Technology Equipment.

26.14.1 Design Requirements. (Reserved)

26.14.2 Installation Requirements.

26.14.2.1*

Information technology equipment rooms and information technology equipment areas located in a sprinklered building shall be provided with an automatic sprinkler system. [75:9.1.1]

26.14.2.2

Sprinkler systems protecting information technology equipment areas shall be valved separately from other sprinkler systems. [75:9.1.3]

26.14.2.3*

An automatic sprinkler system or a gaseous fire extinguishing system shall be provided for the protection of the area below a raised floor in an information technology equipment room or information technology equipment area when one or more of the following exist:

- (1) There is a critical need to protect data in the process, reduce equipment damage, and facilitate return to service.

(2) The area below the raised floor contains combustible material.

[75:9.1.1.2]

26.15 Standard on Incinerators, and Waste and Linen Handling Systems and Equipment.

26.15.1 Design Requirements. (Reserved)

26.15.2 Installation Requirements.

26.15.2.1

Automatic sprinklers shall be provided in incinerator rooms in accordance with this standard. [82:5.2.7.3]

26.15.2.2* Waste and Linen Chutes and Transport Systems.

[82:6]

26.15.2.2.1 Gravity Waste or Linen Chutes.

[82:6.2]

26.15.2.2.1.1

Lined metal chutes shall be protected internally by automatic sprinklers unless they are lined in accordance with 6.2.2.6.1 in NFPA 82. [82:6.2.2.6.2]

26.15.2.2.1.2

This protection requires that a sprinkler be installed at or above the top service opening of the chute. [82:6.2.6.1.2]

26.15.2.2.1.3 Chute Sprinkler Protection.

Automatic sprinklers installed in gravity chute service openings shall be recessed out of the chute area through which the material travels. [82:6.2.6.1.3]

26.15.2.2.1.4

In addition, a sprinkler shall be installed within the chute at alternate floor levels in buildings over two stories in height, with a mandatory sprinkler located at the lowest service level. [82:6.2.6.1.4]

26.15.2.2.1.5

Gravity chutes shall be protected internally by automatic sprinklers unless they are lined in accordance with 6.2.2.6.1 in NFPA 82. [82:6.2.6.1.1]

26.15.2.2.1.6 Chute Room Automatic Sprinklers.

Automatic sprinklers shall be installed in chute terminal rooms. [82:6.2.6.2.1]

26.15.2.2.2 Full Pneumatic Waste and Linen Conveying Systems.

[82:6.3]

26.15.2.2.2.1

Full pneumatic-type risers shall be protected internally by automatic sprinklers. [82:6.3.4.1]

26.15.2.2.2.2

A sprinkler shall be required at or above the top loading station and at alternate floor levels in buildings over two stories in height, with a mandatory sprinkler located at the lowest loading station. [82:6.3.4.2]

26.15.2.2.2.3

Sprinklers shall be recessed out of the station area through which the material travels. [82:6.3.4.3]

26.15.2.2.3 Gravity Pneumatic Trash or Linen Conveying Systems.

[82:6.4]

26.15.2.2.3.1 Chute Automatic Sprinklers.

Where material is to be stored at the bottom of the chute and above the riser discharge damper (above the transport tee), automatic sprinklers shall be installed below the last service door on the chute.

[82:6.4.2.3]

26.15.2.2.3.2

Automatic sprinklers shall be installed in chute discharge rooms. [82:6.4.2.4.3]

26.15.2.3 Other Waste Handling Systems. [82:7.4]

26.15.2.3.1

Automatic sprinklers shall be installed in rooms where waste handling systems and equipment are used to transport waste from interim storage areas to waste processing equipment, such as incinerators. [82:7.4.1]

26.15.2.3.2

In locations or rooms where waste handling systems and equipment are used for interim storage of waste only, the rooms shall be sprinklered in accordance with requirements specified in **26.15.2.4**. [82:7.4.2]

26.15.2.4 Waste Compactors. [82:8]

26.15.2.4.1

All chute-fed compactors shall have an automatic sprinkler with a minimum 13 mm ($\frac{1}{2}$ in.) orifice installed in the hopper of the compactor. [82:8.2.1]

26.15.2.4.2

Sprinklers shall be ordinary temperature-rated sprinklers. [82:8.2.1.1]

26.15.2.4.3

Sprinklers shall be supplied by a minimum of 1 in. (25 mm) ferrous piping or $\frac{3}{4}$ in. (19 mm) copper tubing line from the domestic cold water supply or by the building fire sprinkler system. [82:8.2.1.2]

26.15.2.4.4

Sprinkler water pipe shall be protected from freezing in outdoor installations. [82:8.2.1.3]

26.15.2.4.5

Hand-fed compactors located within a building and not operated in conjunction with a chute shall not require installation of an automatic sprinkler in the hopper. [82:8.2.2]

26.15.2.5

Waste and recyclables storage rooms shall be provided with automatic sprinklers in accordance with this standard. [82:9.3]

26.15.2.6

Rooms in which waste processing equipment is located shall be installed with automatic sprinklers. [82:10.4.1]

26.16 Standard for Ovens and Furnaces.

26.16.1 Design Requirements. (Reserved)

26.16.2 Installation Requirements.

26.16.2.1*

Where automatic sprinklers are provided, they shall be installed in accordance with NFPA 13, unless otherwise permitted by 26.16.2.2. [86:9.2.1]

26.16.2.2

Where sprinklers that protect only ovens are installed and connection to a reliable fire protection water supply is not feasible, a domestic water supply connection shall be permitted to supply these sprinklers subject to the approval of the authority having jurisdiction. [86:9.2.2]

26.16.2.3

Where sprinklers are selected for the protection of ovens, furnaces, or related equipment, the use of closed-head sprinkler systems shall be prohibited and only deluge sprinkler systems shall be used where the following conditions exist:

- (1) In equipment where temperatures can exceed 625°F (329°C)

(2) Where flash fire conditions can occur

[86:9.3.3]

26.16.2.4

Furnaces shall be located so as to minimize exposure to power equipment, process equipment, and sprinkler risers. [86:5.1.3.1]

26.16.2.5

Where water from a fixed protection system could come in contact with molten materials, such as molten salt or molten metal, shielding shall be provided to prevent water from contacting the molten material. [86:9.3.1]

26.16.2.6*

Galvanized pipe shall not be used in sprinkler or water spray systems in ovens, furnaces, or related equipment. [86:9.3.2]

26.17 Health Care Facilities Code, Class A Hyperbaric Chambers.

26.17.1 Design Requirements.

26.17.1.1

A fixed water deluge extinguishing system shall be installed in all chamber compartments that are designed for manned operations. [99:14.2.5.2]

26.17.1.2

In chambers that consist of more than one chamber compartment (lock), the design of the deluge system shall meet the requirements of 26.17.1.1 when the chamber compartments are at different depths (pressures). [99:14.2.5.2.1]

26.17.1.3

The deluge system in different compartments (locks) shall operate independently or simultaneously. [99:14.2.5.2.2]

26.17.1.4

Fixed deluge systems shall not be required in chamber compartments that are used strictly as personnel transfer compartments (locks) and for no other purposes. [99:14.2.5.2.3]

26.17.1.5*

Manual activation and deactivation deluge controls shall be located at the operator's console and in each chamber compartment (lock) containing a deluge system. [99:14.2.5.2.4]

26.17.1.6

Controls shall be designed to prevent unintended activation. [99:14.2.5.2.4.1]

26.17.1.7

Water shall be delivered from the fixed discharge nozzles as specified in **26.17.1.9** within 3 seconds of activation of any affiliated deluge control. [99:14.2.5.2.5]

26.17.1.8*

Average spray density at floor level shall be not less than 2 gpm/ft² (81.5 L/min/m²), with no floor area larger than 10.76 ft² (1 m²) receiving less than 1 gpm/ft² (40.75 L/min/m²). [99:14.2.5.2.6]

26.17.1.9

Water shall be available in the deluge system to maintain the flow specified in **26.17.1.8** simultaneously in each chamber compartment (lock) containing the deluge system for 1 minute. [99:14.2.5.2.7]

26.17.1.10

The limit on maximum extinguishment duration shall be governed by the chamber capacity (bilge capacity also, if so equipped) or its drainage system, or both. [99:14.2.5.2.7.1]

26.17.1.11

The deluge system shall have stored pressure to operate for at least 15 seconds without electrical branch power. [99:14.2.5.2.8]

26.17.2 Installation Requirements. (Reserved)

26.18 Fixed Guideway Transit and Passenger Rail Systems.

26.18.1 Design Requirements.

26.18.1.1

Other fire suppression systems, if approved, shall be permitted to be substituted for automatic sprinkler systems in the areas listed in 26.18.2.1. [130:5.7.3.4]

26.18.2 Installation Requirements.

26.18.2.1

An automatic sprinkler protection system shall be provided in areas of stations used for concessions, in storage areas, in trash rooms, and in the steel truss area of all escalators and other similar areas with combustible loadings, except trainways. [130:5.7.3.1]

26.18.2.2

Sprinkler protection shall be permitted to be omitted in areas of open stations remotely located from public spaces. [130:5.7.3.1.1]

26.18.2.3

Installation of sprinkler systems shall comply with NFPA 13 or applicable local codes as required. [130:5.7.3.2]

26.18.2.4

A sprinkler system waterflow alarm and supervisory signal service shall be installed. [130:5.7.3.3]

26.19 Motion Picture and Television Production Studio Soundstages, Approved Production Facilities, and Production Locations.

26.19.1 Design Requirements. (Reserved)

26.19.2 Installation Requirements.

26.19.2.1

The requirements of NFPA 13 prohibiting obstructions to sprinkler discharge shall not be applicable if approved mitigation is employed. [140:4.11.1.3.1]

26.19.2.2

The requirements of NFPA 13 prohibiting obstructions to sprinkler discharge shall not be applicable if the building sprinkler system meets the design criteria for Extra Hazard, Group 2. [140:4.11.1.3.2]

26.19.2.3

In any production location building protected by an existing automatic sprinkler system, where solid- or hard-ceiling sets or platforms are introduced and create an obstruction to sprinkler discharge, the provisions of 26.19.2.4 or 26.19.2.5 shall be met. [140:5.11.3]

26.19.2.4*

The requirements of NFPA 13 prohibiting obstructions to sprinkler discharge shall not be applicable if approved mitigation is employed. [140:5.11.4]

26.19.2.5*

The requirements of NFPA 13 prohibiting obstructions to sprinkler discharge shall not be applicable if the building sprinkler system meets the design criteria for Extra Hazard, Group 2. [140:5.11.5]

26.20 Animal Housing Facilities.

26.20.1 Design Requirements. (Reserved)

26.20.1.1 (Reserved)

26.20.2 Installation Requirements. (Reserved)

26.20.2.1

Quick-response sprinklers shall be utilized in animal housing facilities. [150:9.2.3]

26.21 Water Cooling Towers.

26.21.1 Design Requirements.

26.21.1.1 Types of Systems.

26.21.1.1.1*

Because the counterflow tower design lends itself to either closed- or open-head systems, the following systems shall be permitted to be used:

- (1) Wet-pipe
- (2) Dry-pipe
- (3) Preaction
- (4) Deluge

[214:5.2.2.1]

26.21.1.1.2*

The open-head deluge system shall be used in crossflow towers to maximize the water distribution and heat detection activation. [214:5.2.2.2]

26.21.1.2 Minimum Rate of Application.

[214:5.2.3]

26.21.1.2.1

Under the fan decks of counterflow towers, the rate of application of water shall be 0.5 gpm/ft² (20.4 mm/min), including fan opening. [214:5.2.3.1]

26.21.1.2.2

Under the fan decks of crossflow towers, the rate of application of water shall be 0.33 gpm/ft² (13.45 mm/min), including fan opening. [214:5.2.3.2]

26.21.1.2.3

Over the fill areas of crossflow towers, the rate of application of water shall be 0.5 gpm/ft² (20.4 mm/min). [214:5.2.3.3]

26.21.1.3 Extended Fan Decks.

On towers having extended fan decks that completely enclose the distribution basin, the discharge outlets protecting the fill area shall be located over the basin, under the extension of the fan deck. [214:5.2.4.3]

26.21.1.3.1

These discharge outlets shall be open directly spray nozzles or other approved spray devices arranged to discharge 0.35 gpm/ft² (14.26 mm/min) directly on the distribution basin and 0.15 gpm/ft² (6.11 mm/min) on the underside of the fan deck extension. [214:5.2.4.3.1]

26.21.1.3.2

On towers having extended fan decks that do not completely enclose the hot-water basin, outlets protecting the fill shall be located under the distribution basin in accordance with 5.2.4.2.2 of NFPA 214. [214:5.2.4.3.2]

26.21.1.4 Combustible Fan Decks.

For deluge systems using directional spray nozzles in the pendant position, provisions shall be made to protect the underside of a combustible fan deck at a minimum of 0.15 gpm/ft² (6.11 mm/min), which shall be included as part of the application rate specified in 5.2.3 of NFPA 214. [214:5.2.4.4]

26.21.1.5* Water Basin Covers.

On film-filled towers that have solid, hot-water basin covers over the complete basin, the discharge outlets protecting the fill area shall be permitted to be located under the basin covers. [214:5.2.4.5]

26.21.1.5.1

These discharge outlets shall be open directional spray nozzles or other approved devices arranged to discharge 0.50 gpm/ft² (20.4 mm/min) into the distribution basin horizontally, with some of the spray splashing up and on the underside of the water basin covers. [214:5.2.4.5.1]

26.21.1.6 Exterior Protection.

[214:5.2.10]

26.21.1.6.1

Where any combustible exterior surfaces of a tower, including the fan deck and distribution basins, are less than 100 ft (30.5 m) from significant concentrations of combustibles such as structures or piled material, the combustible exposed surfaces of the tower shall be protected by an automatic water spray system. [214:5.2.10.1]

26.21.1.6.2

Systems for exterior protection shall be designed with the same attention and care as interior systems. [214:5.2.10.2]

26.21.1.6.2.1

Pipe sizing shall be based on hydraulic calculations. [214:5.2.10.2.1]

26.21.1.6.2.2

Water supply and discharge rate shall be based on a minimum 0.15 gpm/ft² (6.11 mm/min) for all protected surfaces. [214:5.2.10.2.2]

26.21.1.7 Sprinkler System Water Supply.

26.21.1.7.1 Deluge Systems.

26.21.1.7.1.1*

Where all cells of a cooling tower are protected by a single deluge system, the water supply shall be adequate to supply all discharge outlets on that system. [214:5.6.1.1]

26.21.1.7.1.2

Where two or more deluge systems are used to protect a cooling tower and fire-resistant partitions are not provided between the deluge systems, the water supply shall be adequate to supply all discharge outlets in the two most hydraulically demanding adjacent systems. [214:5.6.1.2]

26.21.1.7.1.3*

Where two or more deluge systems are separated by fire-resistant partitions, the water supply shall be adequate to supply all discharge outlets in the single most hydraulically demanding system. [214:5.6.1.3]

26.21.1.7.2 Wet, Dry, and Preaction Systems.

26.21.1.7.2.1*

Where each cell of the cooling tower is separated by a fire-resistant partition, the water supply shall be adequate to supply all discharge outlets in the hydraulically most demanding single cell. [214:5.6.2.1]

26.21.1.7.2.2*

Where fire-resistant partitions are not provided between each cell of a cooling tower, the water supply shall be adequate to supply all discharge outlets in the two most hydraulically demanding adjoining cells. [214:5.6.2.2]

26.21.1.7.3 Hose Streams.

Water supplies shall be sufficient to include a minimum of 500 gpm (1892.5 L/min) for hose streams in addition to the sprinkler requirements. [214:5.6.3]

26.21.1.7.4 Duration.

A water supply adequate for at least a 2-hour duration shall be provided for the combination of the water supply specified in 5.6.1 or 5.6.2 of NFPA 214, plus the hose stream demand specified in 26.21.1.7.3. [214:5.6.4]

26.21.2 Installation Requirements.

26.21.2.1* Counterflow Towers.

[214:5.2.4.1]

26.21.2.1.1

The discharge outlets shall be located under the fan deck and fan opening. [214:5.2.4.1.1]

26.21.2.1.2

Except under the fan opening, all discharge outlets shall have deflector distances installed in accordance with Section 9.5 of NFPA 13. [214:5.2.4.1.2]

26.21.2.1.3

Closed-head discharge outlets for dry-pipe and preaction systems shall be installed in the upright position only. [214:5.2.4.1.3]

26.21.2.2* Crossflow Towers.

[214:5.2.4.2]

26.21.2.2.1

The discharge outlets protecting the plenum area shall be located under the fan deck and in the fan opening. [214:5.2.4.2.1]

26.21.2.2.2

Discharge outlets protecting the fill shall be located under the distribution basin on either the louver or drift eliminator side, discharging horizontally through the joist channels. [214:5.2.4.2.2]

26.21.2.2.3

Towers with an air travel dimension longer than the maximum allowable for the discharge device being used shall have discharge devices placed on both sides of the fill area in each joist channel. [214:5.2.4.2.3.1]

26.21.2.2.4

The pressure at each discharge device shall be adequate to provide protection for half of the length of the fill measured along the air travel. [214:5.2.4.2.3.2]

26.21.2.2.5

Where joist channels are wider than 2 ft (0.6 m), more than one discharge device shall be required per joist channel. [214:5.2.4.2.4.1]

26.21.2.2.6

If the discharge device being used is listed for the width of the joist channel being protected, one discharge device per joist channel shall be permitted to be used. [214:5.2.4.2.4.2]

26.21.2.3* Extended Fan Decks.

On towers having extended fan decks that completely enclose the distribution basin, the discharge outlets protecting the fill area shall be located over the basin, under the extension of the fan deck. [214:5.2.4.3]

26.21.2.4* Water Basin Covers.

On film-filled towers that have solid, hot-water basin covers over the complete basin, the discharge outlets protecting the fill area shall be permitted to be located under the basin covers. [214:5.2.4.5]

26.21.2.5 Valves.

[214:5.2.6]

26.21.2.5.1

Shutoff valves and automatically operated water control valves, if provided, shall be located as follows:

- (1) Outside the fire-exposed area
- (2) As close to the cooling tower as possible to minimize the amount of pipe to the discharge device
- (3) Where they will be accessible during a fire emergency

[214:5.2.6.1.2]

26.21.2.5.2 Manual Release Valve.

[214:5.2.6.2]

26.21.2.5.2.1

Remote manual release valves, where required, shall be conspicuously located and accessible during a fire emergency. [214:5.2.6.2.1]

26.21.2.5.2.2

Where remote manual release valves are not required, an inspector's test valve shall be provided for each pilot-head-operated system. [214:5.2.6.2.2]

26.21.2.6 Strainers.

Strainers shall be required for systems utilizing discharge devices with waterways of less than $\frac{3}{8}$ in. (9.5 mm) diameter. [214:5.2.7]

26.21.2.7 Heat Detectors.

Where deluge or preaction systems are used, heat detectors shall be installed and shall be selected from either of the types in 5.2.8.1 or 5.2.8.2 of NFPA 214. [214:5.2.8]

26.21.2.7.1

In mechanical-draft towers, pilot line detectors shall be located under the fan deck at the circumference of the fan opening and under the fan opening where necessary to comply with the spacing requirements in

26.21.2.7.1.1. (*For extended fan decks, see 5.2.8.2.3 in NFPA 214.*) [214:5.2.8.1.2.1(A)]

26.21.2.7.1.1

Pilot line detectors shall be spaced not more than 8 ft (2.4 m) apart in any direction including the fan opening. Temperature ratings shall be selected in accordance with operating conditions, but shall be no less than intermediate. [214:5.2.8.1.2.1(B)]

26.21.2.7.2

On towers having extended fan decks that completely enclose the distribution basin, electrical heat detectors shall be located under the fan deck extension in accordance with standard, indoor-spacing rules for the type detectors used in accordance with NFPA 72. [214:5.2.8.2.3]

26.21.2.7.2.1

Where the fan deck extension is 16 ft (4.9 m) or less and this dimension is the length of the joist channel, then only one row of detectors centered on and at right angles to the joist channels shall be required.

Spacing between detectors shall be in accordance with NFPA 72. [214:5.2.8.2.3.1]

26.21.2.7.2.2

On towers having extended fan decks that do not completely enclose the hot-water basin, electrical heat detectors shall not be required under the fan deck extension. [214:5.2.8.2.3.2]

26.21.2.7.3

Where electrical heat detectors are inaccessible during tower operation, an accessible test detector shall be provided for each detection zone. [214:5.2.8.3]

26.21.2.7.4

Electrical heat detector components exposed to corrosive vapors or liquids shall be protected by materials of construction or by protective coatings applied by the equipment manufacturer. [214:5.2.8.4]

26.21.2.8 Protection for Fan Drive Motor.

[214:5.2.9]

26.21.2.8.1

A sprinkler or spray nozzle shall be provided over each fan drive motor where the motor is located so that it is not within the protected area of the tower. [214:5.2.9.1]

26.21.2.8.2

Where a preaction or deluge system is used, the detection system shall be extended to cover the motor. [214:5.2.9.2]

26.21.2.8.3

Provision shall be made to interlock the fan motors with the fire protection system so that the cooling tower fan motors are stopped in the cell(s) for which the system is actuated. [214:5.2.9.3]

26.21.2.8.4

Where the continued operation of the fans is vital to the process, a manual override switch shall be permitted to be provided to reactivate the fan when it is determined that there is no fire. [214:5.2.9.4]

26.21.2.9 Corrosion Protection.

[214:5.3]

26.21.2.9.1

Piping, fittings, hangers, braces, and attachment hardware including fasteners shall be hot-dipped galvanized steel in accordance with ASTM A153A/153M, *Standard Specification for Zinc Coating (Hot Dip) on Iron and Steel Hardware*, or other materials having a superior corrosion resistance. [214:5.3.1]

26.21.2.9.1.1

Exposed pipe threads and bolts on fittings shall be protected against corrosion. [214:5.3.1.1]

26.21.2.9.1.2

All other components shall be corrosion resistant or protected against corrosion by a coating. [214:5.3.1.2]

26.21.2.9.2*

Wax-type coatings shall not be used on devices without fusible elements. [214:5.3.2]

26.21.2.9.3*

Special care shall be taken in the handling and installation of wax-coated or similar sprinklers to avoid damaging the coating. [214:5.3.3]

26.21.2.9.3.1

Corrosion-resistant coatings shall not be applied to the sprinklers by anyone other than the manufacturer of the sprinklers. [214:5.3.3.1]

26.21.2.9.3.2

In all cases, any damage to the protective coating occurring at the time of installation shall be repaired at once using only the coating of the manufacturer of the sprinkler in an approved manner, so that no part of the sprinkler will be exposed after the installation has been completed. [214:5.3.3.2]

26.22 Standard for the Construction and Fire Protection of Marine Terminals, Piers, and Wharves.

26.22.1 Design Requirements.

26.22.1.1*

Unless the requirements of 26.22.1.2 apply, automatic sprinkler systems shall be designed based upon the design criteria for the protection of Group A plastics. [307:5.4.2.1]

26.22.1.2

With the approval of the authority having jurisdiction, the requirements of 26.22.1.1 shall not apply to buildings used exclusively for the handling or storage of specific cargoes and commodities that are defined as commodity classes less than Group A plastics by this standard. [307:5.4.2.2]

26.22.1.3

Buildings consistent with 26.22.1.2 shall be protected in accordance with the design criteria for the applicable commodity as required by this standard. [307:5.4.2.3]

26.22.1.4

Buildings used for the storage of hazardous materials shall be protected in accordance with this standard and the applicable codes and standards for the type of hazardous material being stored. [307:5.4.2.4]

26.22.2 Installation Requirements.

26.22.2.1 Piers and Wharves with Combustible Substructure.

26.22.2.1.1

Where there is danger of damage to sprinkler equipment by floating objects, physical barriers shall be provided to exclude such objects. [307:4.3.3.1.2.2]

26.22.2.1.2

The installation requirements in 26.22.2.1.2.1, 26.22.2.1.2.1(A), and 26.22.2.1.2.1(B) are also required.

26.22.2.1.2.1* Upward Projecting Sprinklers.

Where narrow horizontal channels or spaces are caused by caps, stringers, ties, and other structural members and where the standard upright sprinkler does not project sufficient water upward to extinguish or control fires on the underside of the pier or wharf deck, a sprinkler that projects water upward to wet the overhead shall be used. [307:4.3.3.1.3.1]

(A)

Location, spacing, and deflector position shall be governed by the discharge pattern of the sprinkler and the structure being protected. [307:4.3.3.1.3.1(A)]

(B)

The following design and installation guides shall apply where pendent sprinklers in the upright position or old-style sprinklers are to be utilized:

- (1) The maximum coverage per sprinkler head shall be limited to 80 ft² (7.5 m²).
- (2) Where spacing or arrangement of stringers constitutes typical open-joist construction directly supporting the deck, sprinkler branch lines shall be installed between the bents at right angles to the stringers and shall meet the following requirements:
 - (a) Spacing between branch lines shall not exceed 10 ft (3 m).
 - (b) Sprinklers on branch lines shall be staggered and spaced not to exceed 8 ft (2.4 m) on center.
- (3) *Where crisscross construction is involved, closer spacing of sprinklers shall be permitted as necessary to provide wetting of the entire structure.
- (4) The deflectors of sprinklers on lines under stringers shall be located not less than 4 in. (100 mm) nor more than 10 in. (250 mm) below the bottom plane of the stringer, and not more than 18 in. (450 mm) below the underside of the pier or wharf deck.
- (5) *The sprinkler system shall be hydraulically designed in accordance with the requirements of this standard and shall meet the following requirements:
 - (a) Sprinkler orifice shall be ½ in. (12.7 mm) and shall discharge at a minimum pressure of 12.5 psi (85 kPa).
 - (b) Design area shall be based upon the largest area between firestops plus an additional area embracing at least two branch lines on opposite sides of the firestop.
 - (c) Minimum design area shall be not less than 5000 ft² (465 m²).
 - (6) The temperature rating of the sprinkler shall not exceed 165°F (74°C).
 - (7) The maximum area to be protected by any one system shall be limited to 25,000 ft² (2325 m²).

[307:4.3.3.1.3.1(B)]

26.23 Semiconductor Fabrication Facilities.

26.23.1 Design Requirements.

26.23.1.1*

Automatic sprinklers for cleanrooms or clean zones shall be installed in accordance with this standard and shall be hydraulically designed for a density of 0.20 gpm/ft² (8.15 L/min·m²) over a design area of 3000 ft² (278.8 m²). [318:4.1.2.1]

26.23.1.2

Automatic sprinkler protection shall be designed and installed in the plenum and interstitial space above cleanrooms in accordance with this standard, for a density of 0.20 gpm/ft² (8.15 L/min·m²) over a design area of 3000 ft² (278.8 m²). [318:4.1.2.5]

26.23.1.2.1*

Automatic sprinklers shall be permitted to be omitted if the construction and occupancy of these spaces are noncombustible. [318:4.1.2.5.1]

26.23.1.3*

Sprinklers installed in duct systems shall be hydraulically designed to provide 0.5 gpm (1.9 L/min) over an area derived by multiplying the distance between the sprinklers in a horizontal duct by the width of the duct. [318:4.1.2.6.2]

26.23.1.3.1*

Minimum discharge shall be 20 gpm (76 L/min) per sprinkler from the five hydraulically most remote sprinklers. [318:4.1.2.6.2.1]

26.23.2 Installation Requirements.

26.23.2.1*

Wet pipe automatic sprinkler protection shall be provided throughout facilities containing cleanrooms and clean zones. [318:4.1.1]

26.23.2.2*

Approved quick-response sprinklers shall be utilized for sprinkler installations within down-flow airstreams in cleanrooms and clean zones. [318:4.1.2.2]

26.23.2.3*

Sprinklers shall be spaced a maximum of 20 ft (6.1 m) apart horizontally and 12 ft (3.7 m) apart vertically. [318:4.1.2.6.2.2]

26.23.2.4

A separate indicating control valve shall be provided for sprinklers installed in ductwork. [318:4.1.2.6.3]

26.23.2.5

The sprinklers shall be accessible for periodic inspection and maintenance. [318:4.1.2.6.6]

26.24 Aircraft Hangars.

26.24.1 Design Requirements.

Sprinkler systems installed in aircraft hangars shall comply with NFPA 409.

26.24.2 Installation Requirements.

Sprinkler systems installed in aircraft hangars shall comply with NFPA 409.

26.25 Airport Terminal Buildings, Fueling Ramp Drainage, and Loading Walkways.

26.25.1 Design Requirements.

26.25.1.1

Passenger-handling areas shall be classified as Ordinary Hazard Group 1 Occupancy for the purpose of sprinkler system design. [415:4.5.1.3]

26.25.1.2*

Baggage, package, and mail-handling areas shall be classified as Ordinary Hazard Group 2 Occupancy for the purpose of sprinkler system design. [415:4.5.1.4]

26.25.1.3

Other areas of the airport terminal building shall be classified in accordance with Chapter 5 of this standard. [415:4.5.1.5]

26.25.1.4 Water Supply.

Water supply from public and private sources shall be adequate to supply maximum calculated sprinkler demand plus a minimum of 500 gpm (1893 L/min) for hose streams. The supply shall be available at the rate specified for a period of at least 1 hour. [415:4.5.5]

26.25.1.4.1

Main sizes shall be hydraulically calculated based on the total domestic and fire protection requirements. Main shall not be less than 8 in. (203 mm) in diameter except that laterals shall be permitted to be 6 in. (152 mm) in diameter if not over 200 ft (61 m) long. [415:4.5.5.1]

26.25.2 Installation Requirements. (Reserved)

26.26 Aircraft Engine Test Facilities.

26.26.1 Design Requirements.

26.26.1.1*

In engine test cells, the minimum design discharge density shall be 0.50 gpm/ft² (0.54 L/sec/m²) of protected area. [423:7.6.3]

26.26.1.2

In engine test cells, water supplies shall be capable of meeting the largest demand at the design rate plus hose stream demand for a period of 30 minutes. [423:7.6.4]

26.26.1.2.1

Hose stream demand shall be a minimum of 250 gpm (16 L/sec). [423:7.6.4.1]

26.26.1.2.2

The hydraulic calculation and the water supply shall be based on the assumption that all sprinklers in the test cell are operating simultaneously. [423:7.6.4.2]

26.26.2 Installation Requirements. (Reserved)

26.27 Advanced Light Water Reactor Electric Generating Plants.

26.27.1 Design Requirements.

26.27.1.1* Sprinkler System Water Supply.

The fire water supply shall be calculated on the basis of the largest expected flow rate for a period of 2 hours but shall not be less than 300,000 gal (1,135,500 L), and the following criteria also shall apply:

(1) The flow rate shall be based on 500 gpm (1892.5 L/min) for manual hose streams plus the largest design demand of any sprinkler or fixed water spray system as determined in accordance with this standard, with NFPA 15, or with NFPA 804.

(2) The fire water supply shall be capable of delivering the design demand specified in 26.27.1.1(1) with the hydraulically least demanding portion of fire main loop out of service.

[804:9.2.1]

26.27.1.2 Yard Mains.

The underground yard fire main loop shall be installed to furnish anticipated water requirements, and the following criteria also shall be met:

(1) The type of pipe and water treatment shall be design considerations, with tuberculation as one of the parameters.

(2) Means for inspecting and flushing the systems shall be provided.

[804:9.4.1]

26.27.1.3 Cable Spreading Room.

The cable spreading room shall have an automatic fixed water-based suppression system, and the following criteria also shall be met:

- (1) The location of sprinklers or spray nozzles shall protect cable tray arrangements to ensure water coverage for areas that could present exposure fire hazards to the cable raceways.
- (2) Automatic sprinkler systems shall be designed for a density of 0.30 gpm/ft² (12.2 L/min·m²) over the most remote 2500 ft² (232.2 m²).

[804:10.4.1.1]

26.27.1.4 Cable Tunnels.

[804:10.4.2]

26.27.1.4.1

Automatic sprinkler systems shall be designed for a density of 0.30 gpm/ft² (12.2 L/min·m²) for the most remote 100 linear ft (30.5 m) of cable tunnel up to the most remote 2500 ft² (232.2 m²). [804:10.4.2.2.2]

26.27.1.4.2

Deluge sprinkler systems or deluge spray systems shall meet the following criteria:

- (1) They shall be zoned to limit the area of protection to that which the drainage system can handle with any two adjacent systems actuated.
- (2) They shall be hydraulically designed with each zone calculated with the largest adjacent zone flowing.

[804:10.4.2.2.4]

26.27.1.5* Beneath Turbine Generator Operating Floor.

All areas beneath the turbine generator operating floor shall be protected by an automatic sprinkler or foam-water sprinkler system meeting the following criteria:

- (1) The sprinkler system beneath the turbine generator shall be designed around obstructions from structural members and piping.
- (2) The sprinkler system shall be designed with a minimum density of 0.30 gpm/ft² (12.2 L/min·m²) over a minimum application of 5000 ft² (464.5 m²).

[804:10.8.2.1]

26.27.1.6* Turbine Generator Bearings.

[804:10.8.3]

26.27.1.6.1

Lubricating oil lines above the turbine operating floor shall be protected with an automatic sprinkler system to a minimum density of 0.30 gpm/ft² (12.2 L/min·m²) that covers those areas subject to oil accumulation, including the area within the turbine lagging (skirt). [804:10.8.4]

26.27.1.6.2

Where shaft-driven ventilation systems are used, an automatic preaction sprinkler system providing a density of 0.30 gpm/ft² (12.2 L/min·m²) over the entire area shall be provided. [804:10.8.7(2)]

26.27.1.7 Standby Emergency Diesel Generators and Combustion Turbines.

The sprinkler and water spray protection systems shall be designed for a 0.25 gpm/ft² (10.19 L/min·m²) density over the entire area. [804:10.9.3(2)]

26.27.1.8 Fire Pump Room/House.

If sprinkler and water spray systems are provided for fire pump houses, they shall be designed for a minimum density of 0.25 gpm/ft² (10.19 L/min·m²) over the entire fire area. [804:10.22.2]

26.27.1.9 Auxiliary Boilers.

Sprinkler and water spray systems shall be designed for a minimum density of 0.25 gpm/ft² (10.19 L/min·m²) over the entire area. [804:10.24.3]

26.27.2 Installation Requirements.

26.27.2.1 Yard Mains, Hydrants, and Building Standpipes.

[804:9.4]

26.27.2.1.1

Approved visually indicating sectional control valves such as postindicator valves shall be provided to isolate portions of the main for maintenance or repair without simultaneously shutting off the supply to both primary and backup fire suppression systems. [804:9.4.2]

26.27.2.1.2*

Sectional control valves shall allow maintaining independence of the individual loop around each unit, and the following also shall apply:

- (1) For such installations, common water supplies shall also be permitted to be utilized.
- (2) For multiple-reactor sites with widely separated plants [approaching 1 mi (1.6 km) or more], separate yard fire main loops shall be used.

[804:9.4.4]

26.27.2.1.3

Sprinkler systems and manual hose station standpipes shall have connections to the plant underground water main so that a single active failure or a crack in a moderate-energy line can be isolated so as not to impair both the primary and the backup fire suppression systems unless otherwise permitted by the following:

- (1) Alternatively, headers fed from each end shall be permitted inside buildings to supply both sprinkler and standpipe systems, provided steel piping and fittings meeting the requirements of ASME B31.1, *Code for Power Piping*, are used for the headers (up to and including the first valve) supplying the sprinkler systems where such headers are part of the seismically analyzed hose standpipe system.
- (2) Where provided, such headers shall be considered an extension of the yard main system.
- (3) Each sprinkler and standpipe system shall be equipped with an outside screw and yoke (OS&Y) gate valve or other approved shutoff valve.

[804:9.4.7]

26.27.2.2 Cable Tunnels.

The location of sprinklers or spray nozzles shall protect cable tray arrangements and possible transient combustibles to ensure water coverage for areas that could present exposure fire hazards to the cable raceways. [804:10.4.2.2.3]

26.27.2.3 Deluge.

Deluge sprinkler systems or deluge spray systems shall meet the following criteria:

- (1) They shall be zoned to limit the area of protection to that which the drainage system can handle with any two adjacent systems actuated.
- (2) They shall be hydraulically designed with each zone calculated with the largest adjacent zone flowing.

[804:10.4.2.2.4]

26.27.2.4

Cable tunnels over 50 ft (15.2 m) long shall be provided with hose stations and portable fire extinguishers installed outside the tunnel. [804:10.4.2.4(3)]

26.28 Light Water Nuclear Power Plants.

26.28.1 Design Requirements.

A fire protection water supply of reliability, quantity, and duration shall be provided by one of the two following methods:

- (1) A fire protection water supply of not less than two separate 300,000 gal (1,135,500 L) supplies shall be provided.
- (2) The 2-hour fire flow rate for 2 hours shall be calculated, and the following criteria shall be met:

(a) The flow rate shall be based on 500 gpm (1892.5 L/min) for manual hose streams plus the largest design demand of any sprinkler or fixed water spray system(s) in the power block as determined in accordance with NFPA 13 or NFPA 15.

(b) The fire water supply shall be capable of delivering this design demand with the hydraulically least demanding portion of fire main loop out of service.

[805:5.5.1]

26.28.2 Installation Requirements.

26.28.2.1

Sprinkler systems and manual hose station standpipes shall be connected to the plant fire protection water main so that a single active failure or a crack to the water supply piping to these systems can be isolated so as not to impair both the primary and backup fire suppression systems. [805:5.5.12]

26.28.2.2

Each sprinkler and standpipe system shall be equipped with an outside screw and yoke (OS&Y) gate valve or other approved shutoff valve. [805:5.5.17]

26.29 Hydroelectric Generating Plants. [NFPA 851]

26.29.1 Design Requirements.

26.29.1.1 Hydraulic Control Systems.

Fixed fire protection for this equipment, where provided, should be as follows:

(1) Automatic wet pipe sprinkler systems utilizing a design density of 0.25 gpm/ft² (10.2 mm/min) for the entire hazard area.

(2) Automatic foam-water sprinkler systems providing a density of 0.16 gpm/ft² (6.5 mm/min).

[851:7.2.4]

26.29.1.2 Cable Concentrations.

Sprinkler or water spray systems should be designed for a density of 0.30 gpm/ft² (12.2 mm/min) over 2500 ft² (232 m²). This coverage is for area protection. Individual cable tray tier coverage could be required based on the fire risk evaluation. [851:7.5.3]

26.29.1.3 Cable Tunnels.

Where protection is required by the fire risk evaluation, cable tunnels should be protected by automatic water spray, automatic wet pipe sprinkler, or foam-water spray systems. Automatic sprinkler systems should be designed for a density of 0.30 gpm/ft² (12.2 mm/min) over 2500 ft² (232 m²) or the most remote 100 linear ft (30.5 m) of cable tunnel up to 2500 ft² (232 m²). [851:7.6.1]

26.29.1.4 Emergency Generators.

Emergency generators located within main plant structures should be protected by automatic sprinkler, water spray, foam-water sprinkler, compressed air foam, or gaseous-type extinguishing systems. Sprinkler and water spray protection systems should be designed for a 0.25 gpm/ft² (10.2 mm/min) density over the fire area. [851:7.11.2]

26.29.1.5 Air Compressors.

Automatic sprinkler protection designed for a density of 0.25 gpm/ft² (10.2 mm/min) over the postulated oil spill or compressed air foam should be considered for air compressors containing a large quantity of oil. [851:7.12]

26.29.1.6 Hydraulic Systems for Gate and Valve Operators.

Hydraulic control systems should use a listed fire-resistant fluid. Automatic sprinkler protection designed for a density of 0.25 gpm/ft² (10.2 mm/min) over the fire area or compressed air foam systems should be considered for hydraulic systems not using a listed fire-resistant fluid. [851:7.13]

26.29.1.7 Fire Pumps.

Rooms housing diesel-driven fire pumps should be protected by automatic sprinkler, water spray, foam-water sprinkler, or compressed air foam systems. If sprinkler and water spray protection systems are provided, they should be designed for a density of 0.25 gpm/ft² (10.2 mm/min) over the fire area. For automatic foam-water sprinkler systems, a density of 0.16 gpm/ft² (6.5 mm/min) should be provided. [851:7.14]

26.29.2 Installation Requirements.

26.29.2.1 Hydraulic Control Systems.

Fire extinguishing systems, where installed for lube oil systems employing combustible-type oil, should include protection for the reservoirs, pumps, and all oil lines, especially where unions exist on piping and beneath any shielded area where flowing oil can collect. Facilities not provided with curbs or drains should extend coverage for a distance of 20 ft (6 m) from the oil lines, when measured from the outermost oil line. [851:7.2.7]

26.30 Code for the Protection of Cultural Resource Properties — Museums, Libraries, and Places of Worship. [NFPA 909]

26.30.1 Design Requirements.

26.30.1.1*

Standard-response sprinklers shall be permitted for use in light-hazard areas. [909:9.12.13.1]

26.30.1.2*

Preaction and dry pipe systems shall be designed to minimize the risk of corrosion in accordance with the requirements of 26.30.2.1 through 22.30.2.5. [909:9.12.13.5]

26.30.1.3 System Design for Museums, Libraries, and Their Collections in Compact Storage.

26.30.1.3.1*

The design shall recognize the nature of the potential threat of a fire that originates in a compact mobile storage unit, where fuel loads are invariably large and fire growth is significantly different from that in other kinds of storage. [909:9.12.23.4.1.3]

26.30.1.3.2*

The automatic fire suppression system, the compact storage system, and the storage compartmentalization features shall be designed to limit fire damage in accordance with the facility's fire safety objectives. [909:9.12.23.4.1.4(A)]

26.30.1.3.3

Design calculations shall include the number and size of the storage modules, the separation provided between the modules end-to-end and back-to-back, and the type of material being stored. [909:9.12.23.4.1.4(B)]

26.30.1.3.4

Where the automatic fire suppression is provided by automatic fire sprinkler systems, the systems shall be wet pipe, single interlock pre-action, or single non-interlock pre-action systems. [909:9.12.23.4.1.4(C)]

26.30.1.3.5

Dry pipe or double-interlock pre-action systems shall not be installed in compact storage areas. [909:9.12.23.4.1.4(D)]

26.30.1.3.6

Where compact storage is installed in an existing storage area, the existing automatic fire detection and fire suppression systems shall be modified as required to accommodate the increased fire loading. [909:9.12.23.4.1.4(E)]

26.30.2 Installation Requirements.

26.30.2.1*

Branch lines shall be pitched at least $\frac{1}{2}$ in. per 10 ft (4 mm/m), and mains shall be pitched at least $\frac{1}{4}$ in. per 10 ft (2 mm/m). [909:9.12.13.3.1]

26.30.2.2*

Auxiliary drains shall be provided at all low points in accordance with NFPA 13 requirements for dry pipe systems and preaction systems subject to freezing. [909:9.12.13.3.2.1]

26.30.2.3*

Where steel pipe is used in dry pipe and preaction systems, the provisions of this standard shall be applied assuming water supplies and environmental conditions that contribute to unusual corrosive properties, and a plan shall be developed to address piping corrosion. [909:9.12.13.3.3]

26.31 National Electrical Code.

26.31.1 Design Requirements. (Reserved)

26.31.2 Installation Requirements.

26.31.2.1 Dedicated Electrical Space.

The space equal to the width and depth of the equipment and extending from the floor to a height of 6 ft (1.8 m) above the equipment or to the structural ceiling, whichever is lower, shall be dedicated to the electrical installation. No piping, ducts, leak protection apparatus, or other equipment foreign to the electrical installation shall be located in this zone.

Exception: Suspended ceilings with removable panels shall be permitted within the 1.8-m (6-ft) zone.

[

70:

110.26(E)(1)(a)]

26.31.2.2

The area above the dedicated space required by 26.31.2.1 shall be permitted to contain foreign systems, provided protection is installed to avoid damage to the electrical equipment from condensation, leaks, or breaks in such foreign systems. [70:110.26(E)(1)(b)]

26.31.2.3

Sprinkler protection shall be permitted for the dedicated space where the piping complies with this section. [70:110.26(E)(1)(c)]

26.32 Fire Protection of Telecommunication Facilities.

26.32.1 Design Requirements. (Reserved)

26.32.2 Installation Requirements.

26.32.2.1

All piping for dry pipe and pre-action sprinkler systems shall be installed with a pitch in accordance with NFPA 13 whether or not the piping is subjected to freezing conditions. [76:8.6.2.2.2]

26.33 Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids.

26.33.1 Design Requirements.

26.33.1.1

Any portion of an exhaust system utilizing combustible components or having the potential for combustible residue buildup on the inside, where the duct cross-sectional area is greater than or equal to 75 in.² (480 cm²), shall be provided with an automatic extinguishing system within the duct and at the duct intake, hood, enclosure, or canopy, or shall be constructed of material listed for use without sprinkler protection. [91:9.1]

26.33.1.2

When a sprinkler system is installed, means shall be provided to prevent water accumulation in the duct or flow of water back to a process subject that could be damaged by water. [91:9.2]

26.33.2 Installation Requirements. (Reserved)

26.34 Hypobaric Facilities.

26.34.1 Design Requirements.

26.34.1.1

A fire suppression system consisting of independently supplied and operating handline and fixed deluge-type water spray systems shall be installed. [99B:4.5.1.5]

26.34.1.2

Design of the fire suppression system shall be such that failure of components in either the handline or deluge system will not render the other system inoperative. [99B:4.5.1.6]

26.34.1.3

System design shall be such that activation of either the handline or the deluge system shall automatically cause the following:

- (1) Visual and audio alarm indicators shall be activated at the chamber operator's console.
- (2) All ungrounded electrical leads for power and lighting circuits contained inside the chamber shall be disconnected.
- (3) Emergency lighting and communication, where used, shall be activated.

[99B:4.5.1.7]

26.34.1.4

Intrinsically safe circuits, including sound-powered communications, shall be permitted to remain connected when either the handline or deluge system is activated. [99B:4.5.1.8]

26.34.1.5

Control circuitry and other electrical equipment involved in the fire detection and suppression system shall be powered from the critical branch of the emergency electrical system and connected to the uninterruptible power supply (UPS). [99B:4.5.1.11]

26.34.1.6

In chambers that consist of more than one compartment, the deluge system shall operate independently or simultaneously even if the compartments are at different pressures (altitudes). [99B:4.5.2.2]

26.34.1.7

Fixed deluge systems shall not be required in chamber compartments that are used strictly as personnel transfer compartments and for no other purpose. [99B:4.5.2.3]

26.34.1.8

Manual activation and deactivation deluge controls shall be located at the operator's console and in each chamber compartment containing a deluge system. [99B:4.5.2.4]

26.34.1.9

Controls shall be designed to prevent unintended activation. [99B:4.5.2.4.1]

26.34.1.10

Water shall be delivered from the fixed discharge nozzles of the deluge system within 3 seconds of activation of any affiliated deluge control. [99B:4.5.2.5]

26.34.1.11*

Total water demand shall be determined by multiplying the total chamber floor area by 7.5 gpm/ft² (305.6 L/min/m²). [99B:4.5.2.5.1]

26.34.1.12

The minimum operating pressure at the nozzle shall be 30 psi (206 ). [99B:4.5.2.5.2]

26.34.1.13

The water supply shall be constantly and fully charged. [99B:4.5.2.6]

26.34.1.14

The water supply pressure shall be constantly monitored and an interlock shall prevent chamber operation if water supply pressure has fallen 10 percent below normal operating charge pressure. [99B:4.5.2.7]

26.34.1.15

There shall be water in the deluge system to maintain the flow specified in 26.34.1.11 simultaneously in each chamber containing the deluge system for 1 minute. [99B:4.5.2.8]

26.34.1.16

The limit on maximum extinguishment duration shall be governed by the chamber capacity (bilge capacity also, if so equipped) and/or its drainage system. [99B:4.5.2.9]

26.34.1.17

The deluge system shall have stored pressure to operate for at least 15 seconds without electrical branch power. [99B:4.5.2.10]

26.34.2 Installation Requirements. (Reserved)

26.35 Coal Mines.

26.35.1 Design Requirements.

26.35.1.1 Underground Mining Operations.

26.35.1.1.1*

Fire sprinkler systems for underground mining operations shall be designed and installed in accordance with NFPA 120.

26.35.1.2 Coal Preparation Plants and Crusher Buildings.

26.35.1.2.1

When automatic sprinkler systems are to be supplied through the standpipe system, hydraulic calculations shall be used to ensure that the piping and the water supply meet the hose and automatic sprinkler demands simultaneously. [120:6.3.2.3.2]

26.35.1.3 Underground Conveyors.

26.35.1.3.1

The application rate shall not be less than 10.2  L/mm^2 (0.25 gpm/ft²) of the top surface of the top belt. [120:9.4.6.4]

26.35.1.3.2

The water supply shall be free of excessive sediment and corrosives and provide the required flow for not less than 10 minutes. A strainer with a flush-out connection and manual shutoff valve shall be provided. [120:9.4.6.6]

26.35.1.3.3

The system shall be interlocked to shut down the conveyor and provide an audible and a visual alarm. [120:9.4.6.8]

26.35.1.3.4

Fire suppression systems shall also comply with 26.35.1.1.1. [120:9.4.6.10]

26.35.1.3.5

Sprinkler systems shall meet the following requirements:

- (1) The sprinklers shall be installed in accordance with NFPA 13 as far as practical, and shall have components that have been listed.
- (2) The water supply shall be capable of supplying a constant flow of water with all heads functioning for a period of 10 minutes.
- (3) The sprinkler head activation temperature shall not be less than 65.6°C (150°F) or greater than 148.9°C (300°F).

[120:9.4.6.13]

26.35.2 Installation Requirements.

26.35.2.1 Underground Conveyors.

26.35.2.1.1

Deluge water spray systems, foam systems, closed-head sprinkler systems, or dry-chemical systems automatically actuated by rise in temperature shall be installed at main and secondary belt conveyor drives. [120:9.4.6.1]

26.35.2.1.2

Fire suppression systems shall extend to the drive areas of belt conveyors, including drive motor(s), reducer, head pulley, and belt storage unit (takeup) including any hydraulic power unit; its electrical controls; and the top and bottom of the first 15.2 m (50 ft) of belt from the drive on the downwind side. [120:9.4.6.2]

26.35.2.1.3

Piping for the deluge, foam, or closed-head sprinkler system shall be metal and listed for sprinkler applications. [120:9.4.6.3]

26.35.2.1.4

The discharge shall be directed at both the upper and the bottom surface of the top belt and the upper surface of the bottom belt. [120:9.4.6.5]

26.35.2.1.5

Maximum distance between nozzles on a branch line shall not exceed 2.4 m (8 ft). [120:9.4.6.7]

26.35.2.1.6

The components of the system shall be located so as to minimize the possibility of damage by roof fall or by the moving belt and its load. [120:9.4.6.9]

26.35.2.1.7

Deluge water spray systems shall meet the requirements of 26.35.2.1.7.1 through 26.35.2.1.7.5. [120:9.4.6.11]

26.35.2.1.7.1

The system shall be activated by heat detectors. [120:9.4.6.11.1]

26.35.2.1.7.2

Heat detectors shall be located at the belt drive, hydraulic takeup unit (unless fire-resistive fluid is used), discharge roller, and the roof above the conveyor. [120:9.4.6.11.1.1]

26.35.2.1.7.3

Heat detectors at the roof line should be spaced 2.4 m to 3.0 m (8 ft to 10 ft) apart along the entire length of the protected area of the belt. [120:9.4.6.11.1.2]

26.35.2.1.7.4

The nozzles shall be full cone, corrosion resistant, and provided with blow-off dust covers. [120:9.4.6.11.2]

26.35.2.1.7.5

A closed sprinkler head shall be used over the electrical controls. [120:9.4.6.11.3]

26.35.2.2 Mine Surface Buildings.

26.35.2.2.1

If sprinklers are installed, waterflow, valve tamper, and low building temperature alarms shall be provided. [120:8.6.1.2]

26.36 Metal/Nonmetal Mining and Metal Mineral Processing Facilities.

26.36.1 Design Requirements.

26.36.1.1 Water Supplies.

26.36.1.1.1

When automatic sprinkler systems are supplied through the hand hose line standpipe system, hydraulic calculations shall be used to ensure that the piping and water supply will supply the hose and automatic sprinkler demands simultaneously. [122:6.2.3]

26.36.1.1.2

Where a fire water supply [for a surface mineral processing plant] is required by the risk assessment, capacity and availability shall provide the water demand for fire-fighting purposes, including hose and sprinkler systems, for a minimum duration of 2 hours. [122:13.7.2]

26.36.1.2*

Where provided, automatic sprinkler systems installed for the protection of flammable liquid or diesel fuel storage areas shall be of the foam-water type. [122:11.3.1]

26.36.1.3 New Solvent Extraction (SX) Facilities.

26.36.1.3.1

Fixed fire suppression shall be provided for the following SX facility areas and equipment:

- (1) Buildings housing SX processes
- (2) Interior of all mixer-settler vessels/cells
- (3) Crud tanks that include treatment filters and centrifuges
- (4) Coalescers
- (5) Along launders and weirs outside of mixer-settler vessels
- (6) Inside pipe trenches carrying solvents
- (7) Inside organic solvent and diluent tanks
- (8) Inside dikes enclosing organic solvent storage tanks
- (9) Over organic solvent pumps
- (10) Over elevated pipe racks carrying organic solvents in plastic pipes
- (11) Other areas handling, processing, or exposed to flammable or combustible liquids

[122:13.19.1]

26.36.1.3.2*

Fire suppression for applications in 26.36.1.3.1 shall be water, foam, dry chemical, or water mist.

[122:13.19.1.1]

26.36.1.3.3*

Design of fire suppression systems in 26.36.1.3.1 shall be based on criteria set forth in NFPA 11, NFPA 15, NFPA 16, and NFPA 17. [122:13.19.1.2]

26.36.1.3.4*

Actuation of fire suppression systems in 26.36.1.3.1 shall be automatic. [122:13.19.1.3]

26.36.1.3.5

As exposure protection, automatic water-only deluge (open-head) sprinkler systems shall be provided between mixer-settler trains if spaced closer than 15.24 m (50 ft) from each other. [122:13.19.2]

26.36.1.3.6

As exposure protection, automatic water-only deluge sprinkler systems shall be provided around the exterior perimeter of organic solvent tanks if spaced closer than 15.24 m (50 ft) from each other. [122:13.19.3]

26.36.1.3.7

As exposure protection, automatic fire suppression shall be provided over other critical equipment (i.e., transformers) outside along important building walls [i.e., motor control center (MCC) rooms] that are within 15.24 m (50 ft) of a solvent fire area. [122:13.19.4]

26.36.1.3.8

Hydraulic design of automatic fire suppression systems in 26.36.1.3.1 shall include the simultaneous operation of all fire protection systems associated with a single (multi-cell) train. [122:13.19.5]

26.36.1.3.9

The total flow rate of foam application and water associated with the discharge of automatic fire extinguishing systems, fixed monitors, and hydrants shall determine the total volume of fire water required. [122:13.19.6]

26.36.2 Installation Requirements. (Reserved)

26.37 Hazardous Materials Code.

26.37.1 Design Requirements.

Sprinkler system discharge criteria for the protection of hazardous materials shall comply with NFPA 400.

26.37.1.1 Requirements for Occupancies Storing Quantities of Hazardous Materials Exceeding the Maximum Allowable Quantities per Control Area for High Hazard Contents.

The design of the sprinkler system shall be not less than ordinary hazard Group 2 in accordance with NFPA 13, except as follows:

- (1) Where different requirements are specified in Chapters 11 through 21 of NFPA 400
- (2) Where the materials or storage arrangement requires a higher level of sprinkler system protection in accordance with nationally recognized standards
- (3) Where approved alternative automatic fire extinguishing systems are permitted

[400:6.2.1.1.1]

26.37.1.2 General Requirements for Storage of Ammonium Nitrate Solids and Liquids.

Sprinkler systems shall be of the approved type and designed and installed in accordance with NFPA 13, and the following:

- (1) Ammonium nitrate in noncombustible or combustible containers (paper bags or noncombustible containers with removable combustible liners) shall be designated as a Class I commodity.
- (2) Where contained in plastic containers, ammonium nitrate shall be designated as a Class II commodity.
- (3) Where contained in fiber packs or noncombustible containers in combustible packaging, ammonium nitrate shall be designated as a Class III commodity.

[400:11.2.6.1.3]

26.37.1.3 General Requirements for Storage of Organic Peroxide Formulations.

6.37.1.3.1

Where required by other provisions of this code, automatic sprinklers and water spray systems shall be designed and installed according to the requirements of NFPA 13 and NFPA 15 and shall provide the following discharge densities:

- (1) Class I — 0.50 gpm/ft² (20.4 L/min/m²)

(2) Class II — 0.40 gpm/ft² (16.3 L/min/m²)

(3) Class III — 0.30 gpm/ft² (12.2 L/min/m²)

(4) Class IV — 0.25 gpm/ft² (10.2 L/min/m²)

[400:14.2.6.1]

26.37.1.3.2

The system shall be designed as follows:

(1) It shall provide the required density over a 3000 ft² (280 m²) area for areas protected by a wet pipe sprinkler system or 3900 ft² (360 m²) for areas protected by a dry pipe sprinkler system.

(2) The entire area of any building of less than 3000 ft² (280 m²) shall be used as the area of application.

[400:14.2.6.2]

26.37.1.3.3

Where required for detached storage buildings containing Class I organic peroxide formulations in quantities exceeding 2000 lb (907 kg), automatic sprinkler protection shall be open-head deluge-type, designed and installed in accordance with NFPA 13. [400:14.2.6.3]

26.37.1.4 Indoor Storage of Oxidizer Solids and Liquids.

26.37.1.4.1

Sprinkler protection for Class 2 oxidizers shall be designed in accordance with Table 26.37.1.4.1.

[400:15.3.2.3.4.1]

Table 26.37.1.4.1 Ceiling Sprinkler Protection for Class 2 Oxidizers in Palletized or Bulk and Rack Storage Areas

Type of Storage	Ceiling Sprinklers				Area of Application		In-Rack Sprinklers
	Storage Height		Density		ft²	m²	
	ft	m	gpm/ft²	L/min/m²			
Palletized or bulk	8	2.4	0.20	8	3750	348	
Palletized or bulk	12	3.7	0.35	14	3750	348	—
Rack	12	3.7	0.20	8	3750	348	One line above each level of storage, except the top level
Rack	16	4.9	0.30	12	2000	186	One line above each level of storage, except the top level

[400: Table 15.3.2.3.2.10(B)]

26.37.1.4.2

Ceiling sprinklers shall be high-temperature sprinklers. [400:15.3.2.3.4.2]

26.37.1.4.3 Storage Protection for Class 2 Oxidizers with In-Rack Sprinklers.

(A)

In-rack sprinklers shall be quick-response sprinklers with an ordinary-temperature rating and have a K-factor of not less than K = 8.0. [400:15.3.2.3.4.3(A)]

(B)

In-rack sprinklers shall be designed to provide 25 psi (172 kPa) for the six most hydraulically remote sprinklers on each level. [400:15.3.2.3.4.3(B)]

(C)

The in-rack sprinklers shall be 8 ft to 10 ft (2.4 m to 3.0 m) spacings in the longitudinal flue space at the intersection of the transverse flue spaces. [400:15.3.2.3.4.3(C)]

26.37.1.4.4 Sprinkler Criteria for Class 3 Oxidizers.

26.37.1.4.4.1 Class 3 Oxidizers Less than 2300 lb (1043 kg).

(A)

Sprinkler design criteria for buildings that require sprinkler protection and contain total quantities of Class 3 oxidizers less than 2300 lb (1043 kg) shall be in accordance with the requirements of 26.37.1.4.4.1(B). [400:15.3.2.4.13.1(A)]

(B)

Facilities that require sprinkler protection and contain total quantities of Class 3 oxidizers greater than 200 lb (91 kg), but less than 2300 lb (1043 kg), shall follow the sprinkler design criteria in Table 26.37.1.4.4.1(B). [400:15.3.2.4.13.1(B)]

Table 26.37.1.4.4.1(B) Sprinkler Protection of Class 3 Oxidizers Stored in Total Quantities Greater than 200 lb (91 kg) but Less than 2300 lb (1043 kg)

Storage Parameters	Shelf	Bulk or Pile	Bulk or Pile	Rack
Maximum storage height	6 ft (1.8 m)	5 ft (1.5 m)	10 ft (3 m)	10 ft (3 m)
Maximum ceiling height	25 ft (7.6 m)	25 ft (7.6 m)	25 ft (7.6 m)	NA
Aisles — pile separation	4 ft (1.2 m) min. clear aisles	4 ft (1.2 m) min. clear aisles	8 ft (2.4 m) min. clear aisles	8 ft (2.4 m) min. clear aisles
Ceiling design criteria	0.45 gpm/ft ² /2000 ft ²	0.35 gpm/ft ² /or 5000 ft ² or 0.6 gpm/2000 ft ²	0.65 gpm/ft ² /5000 ft ²	0.35 gpm/ft ² /or 5000 ft ² or 0.6 gpm/ft ² /2000 ft ²
In-rack sprinklers	NP	NP	NA	See 15.3.2.4.12.2.
Hose stream demand	500 gpm	500 gpm	500 gpm	500 gpm
Duration	120 minutes	120 minutes	120 minutes	120 minutes

For SI units, 1 gal = 3.79 L. NA: Not applicable. NP: Not permitted.

[400: Table 15.3.2.4.12.1(B)]

26.37.1.4.4.2 Storage Protection for Class 3 Oxidizers In-Rack Sprinkler Criteria.

(A)

Where required by Table 26.37.1.4.4.1(B), in-rack sprinkler protection shall be as follows:

- (1) In-rack sprinklers shall be installed above every level of oxidizer storage.
- (2) In-rack sprinklers shall be spaced at maximum 4 ft (1.2 m) intervals to provide one sprinkler in each flue space.
- (3) In-rack sprinklers shall be quick-response sprinklers with an ordinary-temperature rating and have a K-factor of not less than K = 8.0.
- (4) In-rack sprinklers shall be designed to provide 25 psi (172 kPa) for the six most hydraulically remote sprinklers on each level.

[400:15.3.2.4.13.3(A)]

26.37.1.4.4.3 Class 3 Oxidizers Greater than or Equal to 2300 lb (1043 kg).

The sprinkler protection shall be in accordance with Table 26.37.1.4.4.3. [400:15.3.2.4.13.4(B)]

Table 26.37.1.4.4.3 Sprinkler Protection of Class 3 Oxidizers Stored in Total Quantities of Greater than or Equal to 2300 lb (1043 kg)

Storage Parameters	Bulk or Pile	Rack
Maximum storage height	5 ft (1.5 m)	10 ft (3 m)
Maximum ceiling height	25 ft (7.6 m)	NP
Aisles — pile separation	8 ft (2.4 m) min. clear aisles	8 ft (2.4 m) min. clear aisles
Ceiling design criteria	0.35 gpm/ft ² /5000 ft ² (1.32 L/min/m ² /464.5 m ²)	Predominant for other commodities but not less than ordinary hazard Group II
In-rack sprinklers	NP	See 15.3.2.4.12.4
Hose stream demand	500 gpm (1893 L/min)	500 gpm (1893 L/min)
Duration	120 minutes	120 minutes

NP: Not permitted.

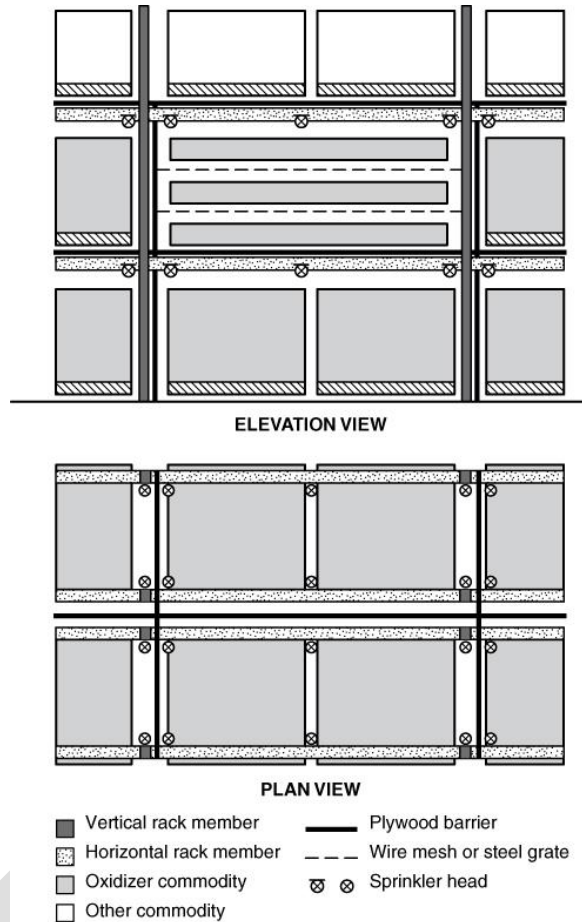
[400: Table 15.3.2.4.12.3(B)]

26.37.1.4.4.4 Special In-Rack Sprinkler Protection for Class 3 Oxidizers.

(A)

Where required by Table 26.37.1.4.4.3, special in-rack sprinkler protection shall be as shown in Figure 26.37.1.4.4.4(A). [400:15.3.2.4.13.5(A)]

Figure 26.37.1.4.4.4(A) Arrangement of Barriers and In-Rack Sprinklers for Special Fire Protection Provisions. [400: Figure 15.3.2.4.13.5(A)]



(B)
In-rack automatic sprinklers shall be provided under each horizontal barrier and arranged in accordance with 26.37.1.4.4.4(C) through 26.37.1.4.4.4(I). [400:15.3.2.4.13.5(K)]

(C)
For double-row racks, two lines of in-rack sprinklers shall be provided between the face of the rack and the longitudinal vertical barrier located in the center of the rack. [400:15.3.2.4.13.5(L)]

(D)
For single-row racks, two lines of in-rack sprinklers shall be provided between each rack face. [400:15.3.2.4.13.5(M)]

(E)
Three in-rack sprinklers shall be provided on each in-rack sprinkler line as follows:
(1) Two sprinklers on each line shall be spaced approximately 1½ in. (38.1 mm) from each transverse vertical barrier.

(2) One in-rack sprinkler on each in-rack sprinkler line shall be located approximately equidistant between the transverse vertical barriers.

[400:15.3.2.4.13.5(N)]

(F)
In-rack sprinklers shall be of the upright or pendent type, with the fusible element located no more than 6 in. (152.4 mm) from the horizontal barrier. [400:15.3.2.4.13.5(O)]

(G)
In-rack sprinklers shall be K = 8.0, quick-response, ordinary-temperature-rated sprinklers. [400:15.3.2.4.13.5(Q)]

(H)

The in-rack sprinkler system shall be designed to supply 6 sprinklers on each line, with a total of 12 sprinklers operating at gauge pressure of 25 psi (172 kPa). [400:15.3.2.4.13.5(R)]

(I)

The design of the in-rack sprinkler system shall be independent of, and shall not be required to be balanced with, ceiling sprinkler systems. [400:15.3.2.4.13.5(S)]

26.37.1.4.4.5 Sprinkler Criteria for Class 4 Oxidizers.

(A)

Sprinkler protection for Class 4 oxidizers shall be installed on a deluge sprinkler system to provide water density of 0.35 gpm/ft² (14.4 L/min/m²) over the entire storage area. [400:15.3.2.5.4.6(A)]

(B)

Sprinkler protection shall be installed in accordance with NFPA 13. [400:15.3.2.5.4.6(B)]

26.37.2 Installation Requirements. (Reserved)

Chapter 27 Systems Acceptance

27.1 Approval of Sprinkler Systems and Private Fire Service Mains.

The installing contractor shall do the following:

- (1) Notify the authority having jurisdiction and the property owner or the property owner's authorized representative of the time and date testing will be performed
- (2) Perform all required acceptance tests (see Section 27.2)
- (3) Complete and sign the appropriate contractor's material and test certificate(s) (see Figure 27.1)
- (4) Remove all caps and straps prior to placing the sprinkler system in service

Figure 27.1 Contractor's Material and Test Certificate for Aboveground Piping.

B.2.1.5 Future Upgrading of System Performance.

It is desirable in some cases to build into the system the capability to achieve a higher level of sprinkler performance than needed at present. If this is to be a consideration in conservatism, consideration needs to be given to maintaining sprinkler operating pressures on the lower side of the optimum operating range and/or designing for low pipeline velocities, particularly on feed and cross mains, to facilitate future reinforcement.

B.3 Effect of Clearance to Ceiling on Sprinkler Performance.

The problems with large clearances to ceiling were well recognized by the 1970s in terms of the effect both on delayed sprinkler activation and on the effect on droplet penetration through the fire plume. The work of Alpert (1972, 1975), Heskestad and Delichatsios (1979), and Beyler (1984) clearly identified the effect of clearance to ceiling on detection and activation of sprinklers. This was supplemented by the work of Heskestad and Smith (1976) in which the thermal responsiveness of sprinklers was studied and modeled. Similarly, the effect of the strong plumes resulting from large clearances to ceiling and highly challenging fires was recognized in the 1970s through the work of Yao and Kalelkar (1970), Yao (1976), and Yao (1980). This understanding was reflected in the development of large drop sprinklers in the 1970s [Yao (1997)]. The inability of $\frac{1}{2}$ in. and $\frac{17}{32}$ in. (12.7 mm and 13 mm) standard sprinklers to penetrate high-challenging fires was well understood and demonstrated in the 1970s [Yao (1976)]. The effect of excessive clearance to ceiling was also demonstrated in the testing summarized in Annex C.

This understanding of the role of clearance to ceiling on fire performance had a strong effect on the development of advanced sprinkler technologies.

References:

Alpert, R. (1972), "Calculation of Response Time of Ceiling-mounted Fire Detectors," *Fire Technology* 8, pp. 181–195.

Alpert, R. (1975), "Turbulent Ceiling Jet Induced by Large Scale Fire," *Combustion Science and Technology* 11, pp. 197–213.

Beyler, C.L. (1984), "A Design Method for Flaming Fire Detection," *Fire Technology* 20, No. 4, 1984, p. 5.

Heskestad, G., and Smith, H. (1976), "Investigation of a New Sprinkler Sensitivity Approval Test: The Plunge Test," FMRC Serial No. 22485, Factory Mutual Research Corporation, Norwood, MA, December 1976.

Heskestad, G., and Delichatsios, M. (1979), "The Initial Convective Flow in Fire," Seventeenth Symposium (International) on Combustion, The Combustion Institute, Pittsburgh, PA, pp. 1113–1123.

Yao, C., and Kalelkar, A. (1970), "Effect of Drop Size on Sprinkler Performance," *Fire Technology* 6, 1970.

Yao, C. (1976), "Development of Large-Drop Sprinklers," FMRC Serial 22476, RC76-T-18, Factory Mutual Research Corporation, Norwood, MA.

Yao, C. (1980), "Application of Sprinkler Technology," Engineering Applications of Fire Technology, National Bureau of Standards, Gaithersburg MD, and FMRC RC80-TP-34.

Yao, C. (1997), "Overview of Sprinkler Technology Research," Fire Safety Science-Proceedings of the Fifth International Symposium, Y. Hasemi (Ed.), International Association for Fire Safety Science, Boston, MA, pp. 93–110.

Annex C Explanation of Test Data and Procedures for Rack Storage

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

C.1

Annex C provides an explanation of the test data and procedures that led to the development of sprinkler system discharge criteria for rack storage applications. Numbers in brackets refer to paragraphs in the text.

C.2 [5.6]

A review of full-scale fire tests run on the standard commodity (double tri-wall carton with metal liner), of Hallmark products and 3M products (e.g., abrasives, pressure-sensitive tapes of plastic fiber, and paper), and of the considerable number of commodity tests conducted provides a guide for commodity classifications. Such guidance is not related to any other method of classification of materials; therefore, sound engineering judgment and analysis of the commodity and the packaging should be used when selecting a commodity classification.

C.3 [8.13.3.1]

Tests 71, 73, 81, 83, 91, 92, 95, and 100 in the 20 ft (6.1 m) high array involving a single level of in-rack sprinklers were conducted without heat or water shields. Results were satisfactory.

Test 115 was conducted with two levels of sprinklers in racks with shields. Test 116, identical to Test 115 but without water shields, produced a lack of control. Visual observation of lower level in-rack sprinklers that did not operate although they were in the fire area indicated a need for water shields.

Tests 115 and 116 were conducted to investigate the necessity for water shields where multiple levels of in-rack sprinklers are installed. Where water shields were not installed in Test 116, the fire jumped the aisle, and approximately 76 boxes were damaged. In Test 115 with water shields, the fire did not jump the aisle, and only 32 boxes were damaged. Water shields are, therefore, suggested wherever multiple levels of in-rack sprinklers are installed, except for installations with horizontal barriers or shelves that serve as water shields.

C.4 [8.17.1.7]

The time of operation of the first sprinkler varied from 52 seconds to 3 minutes and 55 seconds, with most tests under 3 minutes, except in Test 64 (Class III), where the first sprinkler operated in 7 minutes and 44 seconds. Fire detection more sensitive than waterflow is, therefore, considered necessary only in exceptional cases.

C.5 [8.17.5.1]

In most tests conducted, it was necessary to use small hose for mop-up operations. Small hose was not used in the high-expansion foam test.

Test 97 was conducted to evaluate the effect of dry pipe sprinkler operation. Test results were approximately the same as the base test with a wet pipe system. A study of NFPA records, however, indicates an increase in area of operation of 30 percent to be in order for dry pipe systems as compared with wet pipe systems.

C.6 [12.1.1]

Tests were conducted as a part of this program with eave line windows or louvers open to simulate smoke and heat venting. These tests opened 87.5 percent and 91 percent more sprinklers than did comparative tests without windows or louvers open. Venting tests that have been conducted in other programs were without the benefit of sprinkler protection and, as such, are not considered in this report, which covers only buildings protected by sprinklers. The design curves are based upon the absence of roof vents or draft curtains in the building. During mop-up operations, ventilating systems, where installed, should be capable of manual exhaust operations.

C.7 [12.12.1.3]

No tests were conducted with idle pallets in racks using standard spray sprinklers. However, tests were conducted using ESFR and large drop sprinklers. Such storage conceivably would introduce fire severity in excess of that contemplated by protection criteria for an individual commodity classification.

C.8 [12.8.6]

In all valid tests with double-row racks, sprinkler water supplies were shut off at approximately 60 minutes. In only one test did the last sprinkler operate in excess of 30 minutes after ignition; the last

sprinkler operated in excess of 25 minutes in three tests, with the majority of tests involving the last sprinkler operating within 20 minutes.

C.9 [16.1.1 and 17.1.1]

The discharge criteria of Section 12.3 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 × 250 ft (61 m × 76 m) [50,000 ft² (4650 m²) in area], of fire-resistive construction, and contains a volume of approximately 2.25 million ft³ (63,713 m³), the equivalent of a 100,000 ft² (9300 m²) building that is 22.5 ft (6.9 m) high. The test building has two primary heights beneath a single large ceiling. The east section is 30 ft (9.1 m) high, and the west section is 60 ft (18 m) high.

The test series for storage height of 20 ft (6.1 m) was conducted in the 30 ft (9.1 m) section with clearances from the top of storage to the ceiling nominally 10 ft (3.0 m).

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

The entire test series was fully instrumented with thermocouples attached to rack members, simulated building columns, bar joists, and the ceiling.

Racks were constructed of steel vertical and horizontal members designed for 4000 lb (1815 kg) loads. Vertical members were 8 ft (2.4 m) on center for conventional racks and 4 ft (1.2 m) on center for simulated automated racks. Racks were 3½ ft (1 m) wide with 6 in. (150 mm) longitudinal flue space for an overall width of 7½ ft (2.3 m). Simulated automated racks and slave pallets were used in the main central rack in the 4 ft (1.2 m) aisle tests. Conventional racks and conventional pallets were used in the main central rack in the 8 ft (2.4 m) aisle tests. The majority of the tests were conducted with 100 ft² (9.3 m²) sprinkler spacing.

The test configuration for storage heights of 15 ft (4.6 m), 20 ft (6.1 m), and 25 ft (7.6 m) covered an 1800 ft² (167.2 m²) floor area, including aisles between racks. Tests that were used in producing this standard limited fire damage to this area. The maximum water damage area anticipated in the standard is 6000 ft² (555 m²), the upper limit of the design curves.

The test data show that, as density is increased, both the extent of fire damage and sprinkler operation are reduced. The data also indicate that, with sprinklers installed in the racks, a reduction is gained in the area of fire damage and sprinkler operations (e.g., water damage).

Table C.9 illustrates these points. The information shown in the table is taken from the test series for storage height of 20 ft (6.1 m) using the standard commodity.

The fact that there is a reduction in both fire damage and area of water application as sprinkler densities are increased or where sprinklers are installed in racks should be considered carefully by those responsible for applying this standard to the rack storage situation.

In the test for storage height of 25 ft (7.6 m), a density of 0.55 gpm/ft² (22.4 mm/min) produced 42 percent, or 756 ft² (70 m²), fire damage in the test array and a sprinkler-wetted area of 1400 ft² (130 m²). Lesser densities would not be expected to achieve the same limited degree of control. Therefore, if the goal of smaller areas of fire damage is to be achieved, sprinklers in racks should be considered.

The test series for storage height over 25 ft (7.6 m) was conducted in the 60 ft (18 m) section of the test building with nominal clearances from the top of storage to the ceiling of either 30 ft (9.1 m) or 10 ft (3.0 m).

Doors at the lower and intermediate levels and ventilation louvers at the top of walls were kept closed during the fire tests, which minimized the effect of exterior wind conditions.

The purpose of the tests for storage height over 25 ft (7.6 m) was to accomplish the following:

- (1) Determine the arrangement of in-rack sprinklers that can be repeated as pile height increases and that provide control of the fire

(2) Determine other protective arrangements, such as high-expansion foam, that provide control of the fire

Control was considered to have been accomplished if the fire was unlikely to spread from the rack of origin to adjacent racks or spread beyond the length of the 25 ft (7.6 m) test rack. To aid in this judgment, control was considered to have been achieved if the fire failed to exhibit the following characteristics:

(1) Jump the 4 ft (1.2 m) aisles to adjoining racks

(2) Reach the end face of the end stacks (north or south ends) of the main rack

Control is defined as holding the fire in check through the extinguishing system until the commodities initially involved are consumed or until the fire is extinguished by the extinguishing system or manual aid.

The standard commodity as selected in the 20 ft (6.1 m) test series was used in the majority of tests for storage over 25 ft (7.6 m). Hallmark products and 3M products described in the 20 ft (6.1 m) test series report also were used as representative of Class III or Class IV commodities, or both, in several tests. The results of privately sponsored tests on Hallmark products and plastic encapsulated standard commodities also were made available to the committee.

A 25 ft (7.6 m) long test array was used for the majority of the tests for storage over 25 ft (7.6 m). The decision to use such an array was made because it was believed that a fire in racks over 25 ft (7.6 m) high that extended the full length of a 50 ft (15 m) long rack could not be considered controlled, particularly as storage heights increased.

One of the purposes of the tests was to determine arrangements of in-rack sprinklers that can be repeated as pile height increases and that provide control of the fire. The tests for storage height of 30 ft (9.1 m) explored the effect of such arrays. Many of these tests, however, produced appreciable fire spread in storage in tiers above the top level of protection within the racks. (In some cases, a total burnout of the top tiers of both the main rack and the target rack occurred.) In the case of the 30 ft (9.1 m) Hallmark Test 134 on the 60 ft (18 m) site, the material in the top tiers of storage burned vigorously, and the fire jumped the aisle above the fourth tier. The fire then burned downward into the south end of the fourth tier. In the test on the floor, a nominal 30 ft (9.1 m) clearance occurred between the top of storage and the ceiling sprinklers, whereas on the platform this clearance was reduced to nominal 10 ft (3.0 m). In most cases, the in-rack sprinklers were effective in controlling fire below the top level of protection within the racks. It has been assumed by the Test Planning Committee that, in an actual case with a clearance of 10 ft (3.0 m) or less above storage, ceiling sprinklers would be expected to control damage above the top level of protection within the racks. Tests have been planned to investigate lesser clearances.

Tests 114 and 128 explore the effect of changing the ignition point from the in-rack standard ignition point to a face ignition location. It should be noted, however, that both of these tests were conducted with 30 ft (9.1 m) clearance from the ceiling sprinklers to the top of storage and, as such, ceiling sprinklers had little effect on the fire in the top two tiers of storage. Firespread in the three lower tiers is essentially the same. A similar change in the firespread where the ignition point is changed was noted in Tests 126 and 127. Once again, 30 ft (9.1 m) clearance occurred between the top of storage and the ceiling sprinklers, and, as such, the ceiling sprinklers had little effect on the face fire. Comparisons of Tests 129, 130, and 131 in the test series for storage height of 50 ft (15 m) indicate little effect of point of ignition in the particular configuration tested.

Test 125, when compared with Test 133, indicates no significant difference in result between approved low-profile sprinklers and standard sprinklers in the racks.

Table C.9 Summary of Relationship Between Sprinkler Discharge Density and the Extent of Fire Damage and Sprinkler Operation

Density [gpm/ft ² (Lpm/m ²)]	Fire Damage in Test Array		Sprinkler Operation [165°F (74°C)] Area [ft ² (m ²)]
	%	ft ² (m ²)	
0.30 (12.2) (ceiling only)	22	395 (37)	4500–4800 (416–446)
0.375 (15.2) (ceiling only)	17	306 (24)	1800 (167)
0.45 (18.3) (ceiling only)	9	162 (15)	700 (65)
0.20 (8.1) (ceiling only)	28–36	504–648 (46–60)	13,100–14,000 (1211–1300)
0.20 (8.1) (sprinklers at ceiling and in racks)	8	144 (13)	4100 (380)
0.30 (12.2) (sprinklers at ceiling and in racks)	7	126 (12)	700 (65)

For SI units, 1 ft = 0.3048 m; °C = $\frac{5}{9}(\text{°F} - 32)$; 1 gpm/ft² = 40.746 mm/min.

C.10 [16.1.4 and 17.1.4]

Temperatures in the test column were maintained below 1000°F (538°C) with densities, of roof ceiling sprinklers only, of 0.375 gpm/ft² (15.3 mm/min) with 8 ft (2.4 m) aisles and 0.45 gpm/ft² (18.3 mm/min) with 4 ft (1.2 m) aisles using the standard commodity.

C.11 [16.1.6.1 and 17.1.5.1]

Test 98 with solid shelves 24 ft (7.3 m) long and 7½ ft (2.3 m) deep at each level produced total destruction of the commodity in the main rack and jumped the aisle. Density was 0.3 gpm/ft² (12.2 mm/min) from the ceiling sprinklers only. Test 108 with shelves 24 ft (7.3 m) long and 3½ ft (1.0 m) deep and with a 6 in. (150 mm) longitudinal flue space and one level of sprinklers in the rack resulted in damage to most of the commodity in the main rack but did not jump the aisle. Density from ceiling sprinklers was 0.375 gpm/ft² (15.3 mm/min), and rack sprinklers discharged at 15 psi (1.0 bar).

These tests did not yield sufficient information to develop a comprehensive protection standard for solid shelf racks. Items such as increased ceiling density, use of bulkheads, other configurations of sprinklers in racks, and limitation of shelf length and depth should be considered.

Where such rack installations exist or are contemplated, the damage potential should be considered, and sound engineering judgment should be used in designing the protection system.

Test 98, with solid shelving obstructing both the longitudinal and transverse flue space, produced unsatisfactory results and indicates a need for sprinklers at each level in such a rack structure.

Test 147 was conducted with ceiling sprinklers only. Density was 0.45 gpm/ft² (18.3 mm/min) with a sprinkler spacing of 100 ft² (9.3 m²). A total of 47 sprinklers opened, and 83 percent of the commodity was consumed. The fire jumped both aisles and spread to both ends of the main and target racks. The test was considered unsuccessful.

Test 148 was conducted with ceiling sprinklers and in-rack sprinklers. In-rack sprinklers were provided at each level (top of first, second, and third tiers) and were located in the longitudinal flue. They were directly above each other and 24 ft (7.3 m) on center or 22 ft (6.7 m) on each side of the ignition flue. Ceiling sprinkler discharge density was 0.375 gpm/ft² (15.3 mm/min). In-rack sprinkler discharge pressure was 30 psi (2.1 bar). A total of 46 ceiling sprinklers and three in-rack sprinklers opened, and 34 percent of the commodity was consumed. The fire consumed most of the material between the in-rack sprinklers and jumped both aisles.

C.12 [16.1.7 and 17.1.6]

Fire tests with open-top containers in the upper tier of storage and a portion of the third tier of storage produced an increase in sprinkler operation from 36 to 41 sprinklers and a more pronounced aisle jump and increase in firespread in the main array. The smooth underside of the containers closely approximates fire behavior of slave pallets.

C.13 [16.1.10 and 17.1.9]

Test 80 was conducted to determine the effect of closing back-to-back longitudinal 6 in. (150 mm) flue spaces 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 kept open.

Tests 145 and 146 were conducted to investigate the influence of longitudinal and transverse flue dimensions in double-row racks without solid shelves. Results were compared with Tests 65 and 66. Flue dimensions in Tests 65, 66, 145, and 146 were 6 in. (150 mm), 6 in. (150 mm), 3 in. (75 mm), and 12 in. (300 mm), respectively. All other conditions were the same.

In Tests 65 and 66, 45, and 48, sprinklers operated compared with 59 and 58 for Tests 145 and 146, respectively. Fire damage in Tests 145 and 146 was somewhat less than in Tests 65 and 66; 2100 ft³ (59 m³) and 1800 ft³ (51 m³) in Tests 145 and 146, respectively, versus 2300 ft³ (65 m³) and 2300 ft³ (65 m³) in Tests 65 and 66, respectively, of combustible material were consumed.

Test results indicate narrow flue spaces of about 3 in. (75 mm) allow reasonable passage of sprinkler water down through the racks.

Tests 96 and 107, on multiple-row racks, used 6 in. (150 mm) transverse flue spaces. The water demand recommended in the standard is limited to those cases with nominal 6 in. (150 mm) transverse flues in vertical alignment.

C.14 [16.2.1.3.1]

Tests 65 and 66, compared with Test 69, and Test 93, compared with Test 94, indicated a reduction in areas of application of 44.5 percent and 45.5 percent, respectively, with high temperature-rated sprinklers as compared with ordinary temperature-rated sprinklers. Other extensive Factory Mutual tests produced an average reduction of 40 percent. Design curves are based on this area reduction. In constructing the design curves, the high-temperature curves above 3600 ft² (335 m²) of application, therefore, represent 40 percent reductions in area of application of the ordinary temperature curves in the 6000 ft² to 10,000 ft² (555 m² to 930 m²) range.

Test 84 indicated the number of intermediate temperature-rated sprinklers operating is essentially the same as ordinary temperature-rated sprinklers.

C.15 [16.2.1.3.2.1]

Tests were not conducted with aisles wider than 8 ft (2.4 m) or narrower than 4 ft (1.2 m). It is, therefore, not possible to determine whether lower ceiling densities should be used for aisle widths greater than 8 ft (2.4 m) or if higher densities should be used for aisle widths less than 4 ft (1.2 m).

C.16 [16.2.1.4.2.3]

In one 20 ft (6.1 m) high test, sprinklers were buried in the flue space 1 ft (300 mm) above the bottom of the pallet load, and results were satisfactory. Coverage of aisles by in-rack sprinklers is, therefore, not necessary, and distribution across the tops of pallet loads at any level is not necessary for the occupancy classes tested.

C.17 [16.2.1.4.2.6]

In all tests with in-rack sprinklers, obstructions measuring 3 in. × 3 ft (75 mm × 900 mm) were introduced on each side of the sprinkler approximately 3 in. (75 mm) from the sprinkler to simulate rack structure member obstruction. This obstruction had no effect on sprinkler performance in the 20 ft (6.1 m) high tests.

Tests 103, 104, 105, and 109 in the 30 ft (9.1 m) high test with in-rack sprinklers obstructed by rack uprights produced unsatisfactory results. Tests 113, 114, 115, 117, 118, and 120 in the 30 ft (9.1 m) high test series with in-rack sprinklers located a minimum of 2 ft (600 mm) from rack uprights produced improved results.

C.18 [16.2.1.4.3]

In all except one case, using the standard commodity with one line of sprinklers installed in racks, only two sprinklers opened. In the one exception, two sprinklers opened in the main rack, and two sprinklers opened in the target rack.

C.19 [16.2.1.4.4, 16.3.2.7.10, 17.2.2.6.8]

Operating pressures were 15 psi (1.0 bar) on all tests of sprinklers in racks with storage 20 ft (6.1 m) high and 30 psi (2.1 bar) for storage 30 ft (9.1 m) and 50 ft (15 m) high.

Tests 112 and 124 were conducted to compare the effect of increasing sprinkler discharge pressure at in-rack sprinklers from 30 psi to 75 psi (2.1 bar to 5.2 bar). With the higher discharge pressure, the fire did not jump the aisle, and damage below the top level of protection within the racks was somewhat better controlled by the higher discharge pressure of the in-rack sprinklers. A pressure of 15 psi (1 bar) was maintained on in-rack sprinklers in the first 30 ft (9.1 m) high tests (Tests 103 and 104). Pressure on in-rack sprinklers in subsequent tests was 30 psi (2.1 bar), except in Test 124, where it was 75 psi (5.2 bar).

C.20 [16.2.4.1.1, 17.2.4.1.1]

A full-scale test program was conducted with various double-row rack storage arrangements of a cartoned Group A nonexpanded plastic commodity at the Factory Mutual Research Corporation (FMRC) test facility. The series of nine tests included several variations, one of which involved the use of the following four distinct shelving arrangements: slatted wood, solid wood, wire mesh, and no shelving. The results of the testing program, specifically Tests 1, 2, 3, and 5, clearly demonstrate the acceptable performance of sprinkler systems protecting storage configurations that involve the use of slatted shelving as described in 16.2.4.1.1 and 17.2.4.1.1. As a result of the test program, Factory Mutual has amended FM Loss Prevention Data Sheet 8-9 to allow slatted shelving to be protected in the same manner as an open rack arrangement.

Complete details of the test program are documented in the FMRC technical report FMRC J. I. 0X1R0.RR, "Large-Scale Fire Tests of Rack Storage Group A Plastics in Retail Operation Scenarios Protected by Extra Large Orifice (ELO) Sprinklers."

C.21 [17.1.2.1]

In the RSP rack storage test series as well as the stored plastics program palletized test series, compartmented 16 oz (1.1 bar) polystyrene jars were found to produce significantly higher protection requirements than the same commodity in a nested configuration. Polystyrene glasses and expanded polystyrene plates were comparable to the nested jars.

Different storage configurations within cartons or different products of the same basic plastic might, therefore, require reduced protection requirements.

In Test RSP-1 with nominal 15 ft (4.6 m) high storage with compartmented jars, a 0.6 gpm/ft² (24.4 mm/min) density, 8 ft (2.4 m) aisles, and a 10 ft (3.0 m) clearance to ceiling, 29 sprinklers opened. In Tests RSP-4 with polystyrene glasses, RSP-5 with expanded polystyrene plates, and RSP-16 with nested polystyrene jars all stored at nominal 15 ft (4.6 m) height, 10 ft (3.1 m) clearance to ceiling, 8 ft (2.4 m) aisles, and 0.6 gpm/ft² (24.4 mm/min) density, only four sprinklers opened.

However, Test RSP-11, with expanded polystyrene plates and 6 ft (1.8 m) aisles, demonstrated an increase in the number of operating sprinklers to 29. Test RSP-10 with expanded polystyrene plates, nominally 15 ft (4.6 m) high with a 10 ft (3.1 m) clearance and 8 ft (2.4 m) aisles, but protected only by 0.45 gpm/ft² (18.3 mm/min) density, opened 46 sprinklers and burned 100 percent of the plastic commodity.

At a nominal 20 ft (6.1 m) storage height with 8 ft (2.4 m) aisles, a 3 ft (900 mm) clearance to ceiling, and a 0.6 gpm/ft² (24.4 mm/min) density opened four sprinklers with polystyrene glasses in Test RSP-2 and 11 sprinklers with expanded polystyrene plates in Test RSP-6. In Test RSP-8, however, with the clearance to ceiling increased to 10 ft (3.1 m) and other variables held constant, 51 sprinklers opened, and 100 percent of the plastic commodity burned.

Test RSP-3, with polystyrene glasses at a nominal height of 25 ft (7.6 m) with a 3 ft (900 mm) clearance to ceiling, 8 ft (2.4 m) aisles, and 0.6 gpm/ft² (24.4 mm/min) ceiling sprinkler density in combination with one level of in-rack sprinklers, resulted in four ceiling sprinklers and two in-rack sprinklers operating. Test RSP-9, with the same configuration but with polystyrene plates, opened 12 ceiling sprinklers and three in-rack sprinklers.

No tests were conducted with compartmented polystyrene jars at storage heights in excess of a nominal 15 ft (4.6 m) as a part of this program.

C.22 [17.2.1.2]

The protection of Group A plastic by extra large orifice (ELO) sprinklers designed to provide 0.6 gpm/ft²/2000 ft² (24.4 mm/min/186 m²) or 0.45 gpm/ft²/2000 ft² (18.3 mm/min/186 m²) without the installation of in-rack sprinklers was developed from full-scale testing conducted with various double-row rack storage arrangements of a cartoned Group A nonexpanded plastic commodity at the Factory Mutual Research Corporation (FMRC) test facility. The results of this test program are documented in the FMRC technical report, FMRC J.I. 0X1R0.RR, "Large-Scale Fire Tests of Rack Stored Group A Plastics in Retail Operation Scenarios Protected by Extra Large Orifice (ELO) Sprinklers." The test program was initiated to address the fire protection issues presented by warehouse-type retail stores with regard to the display and storage of Group A plastic commodities including, but not limited to, acrylonitrile-butadiene-styrene copolymer (ABS) piping, polyvinyl chloride (PVC) hose and hose racks, tool boxes, polypropylene trash and storage containers, and patio furniture. Tests 1 and 2 of this series included protection of the Group A plastic commodity stored to 20 ft (6.1 m) under a 27 ft (8.2 m) ceiling by a design density of 0.6 gpm/ft² (24.4 mm/min), utilizing ELO sprinklers. The results of the testing program clearly demonstrate the acceptable performance of sprinkler systems that protect storage configurations involving Group A plastics up to 20 ft (6.1 m) in height under a 27 ft (8.2 m) ceiling where using ELO sprinklers to deliver a design density of 0.6 gpm/ft² (24.4 mm/min) and Group A plastics up to 14 ft (4.2 m) in height under a 22 ft (6.7 m) ceiling where using ELO sprinklers to deliver a design density of 0.45 gpm/ft² (18.3 mm/min). The tabulation of the pertinent tests shown in Table C.22 demonstrates acceptable performance.

Table C.22 Summary of Test Results for Plastic Commodities Using in. (15.9 mm) Orifice Sprinklers

Test Parameters	Date of Test						
	8/20/93	8/25/93	9/2/93	10/7/93	2/17/94	2/25/94	4/27/94
Type of shelving	Slatted wood	Slatted wood	Slatted wood	Slatted wood	Slatted wood	Slatted wood	Wire mesh
Other conditions/ inclusions	—	—	—	—	Draft curtains	Draft curtains	—
Storage height (ft-in.)	19-11	19-11	15-4	15-4	19-11	19-11	13-11
Number of tiers	6 ^a	6 ^a	5 ^b	5 ^b	6 ^a	6 ^b	3
Clearance to ceiling/sprinklers (ft-in.)	6-10/6-3	6-10/6-3	11-5/10-10	11-5/10-10	6-10/6-3	6-10/6-3	8-4/7-9
Longitudinal/ transverse flues (in.)	6/6 to 7½	6/6 to 7½	6/6 to 7	6/6 to 7½	6/6 to 7½	6/6 to 7½	6/3 ^c
Aisle width (ft)	7½	7½	7½	7½	7½	7½	7½
Ignition centered below (number of sprinklers)	2	2	1	1	2	2	1
Sprinkler orifice size (in.)	0.64	0.64	0.64	0.64	0.64	0.64	0.64
Sprinkler temperature rating (°F)	165	286	286	165	165	286	286
Sprinkler RTI (ft-sec) ^{1/2}	300	300	300	300	300	300	300
Sprinkler spacing (ft× ft)	8 × 10	8 × 10	8 × 10	8 × 10	8 × 10	8 × 10	10 × 10
Sprinkler identification	ELO-231	ELO-231	ELO-231	ELO-231	ELO-231	ELO-231	ELO-231
Constant water pressure (psi)	19	19	19	19	19	19	15.5

Test Parameters	Date of Test						
	8/20/93	8/25/93	9/2/93	10/7/93	2/17/94	2/25/94	4/27/94
Minimum density (gpm/ft ²)	0.6	0.6	0.6	0.6	0.6	0.6	0.45
Test Results							
First sprinkler operation (min:sec)	2:03	2:25	1:12	0:44	1:25	0:52	0:49
Last sprinkler operation (min:sec)	2:12	15:19	6:34	7:34	15:54	14:08	10:58
Total sprinklers opened	4	9	7	13	35	18	12
Total sprinkler discharge (gpm)	205	450	363	613	1651	945	600
Average discharge per sprinkler (gpm)	51	50	52	47	47	52	50
Peak/maximum 1-min average gas temperature (°F)	1107/566	1412/868	965/308	662/184	1575/883	1162/767	1464/895
Peak/maximum 1-min average steel temperature (°F)	185/172	197/196	233/232	146/145	226/225	255/254	502/500
Peak/maximum 1-min average plume velocity (ft/sec)	27/15	25/18	18/15 ^d	14/10 ^d	26/23	20/18 ^d	33/20
Peak/maximum 1-min heat flux (Btu/ft ² /sec)	0.6/0.5	2.0/1.9	2.8/2.5	1.1/0.8	1.0/0.9	4.8/3.0	1.6/1.4
Aisle jump, east/west target ignition (min:sec)	None	8:24/None	5:35/10:10	None	None	^e /8:18	^e /None
Equivalent number of pallet loads consumed	3	9	6	5	12	13	12
Test duration (min)	30	30	30	30	30	30	30
Results acceptable	Yes	Yes	Yes	Yes	No ^f	No ^g	Yes

For SI units, 1 ft = 0.305 m; 1 in. = 25.4 mm; °F = (1.8 × °C) + 32; °C = (°F - 32)/1.8; 1 psi = 0.069 bar; 1 gpm = 3.8 L/min; 1 ft/sec = 0.31 m/sec; 1 gpm/ft² = 40.746 mm/min.

^a Main (ignition) racks divided into five or six tiers; bottom tiers each approximately 2 ft (600 mm) high and upper tiers each about 5 ft (1.5 m) high; wood shelving below commodity at second through fifth tiers.

^b Main (ignition) racks divided into five or six tiers; bottom tiers each approximately 2 ft (600 mm) high and upper tiers each about 5 ft (1.5 m) high; wood shelving below commodity at second through fifth tiers; wire mesh shelving below commodity at sixth tier or below fifth (top) tier commodity.

^c Transverse flues spaced 8 ft (2.4 m) apart [versus 3½ ft (1.1 m) apart in all other tests].

^d Instrumentation located 5 ft (1.5 m) north of ignition.

^e Minor surface damage to cartons.

^f High water demand.

^g Excessive firespread; marginally high water demand.

C.23 [16.3.1.1]

The recommended use of ordinary temperature-rated sprinklers at ceiling for storage higher than 25 ft (7.6 m) was determined by the results of fire test data. A test with high temperature-rated sprinklers and 0.45 gpm/ft² (18.3 mm/min) density resulted in fire damage in the two top tiers just within acceptable limits, with three ceiling sprinklers operating. A test with 0.45 gpm/ft² (18.3 mm/min) density and ordinary temperature-rated sprinklers produced a dramatic reduction in fire damage with four ceiling sprinklers operating.

The four ordinary temperature-rated ceiling sprinklers operated before the first of the three high temperature-rated ceiling sprinklers. In both tests, two in-rack sprinklers at two levels operated at approximately the same time. The high temperature-rated sprinklers were at all times fighting a larger fire with less water than the ordinary temperature-rated ceiling sprinklers.

Tests 115 and 119 compare ceiling sprinkler density of 0.3 gpm/ft² (12.2 mm/min) with 0.45 gpm/ft² (18.3 mm/min). Damage patterns coupled with the number of boxes damaged in the main rack suggest that the increase in density produces improved control, particularly in the area above the top tier of in-rack sprinklers.

Tests 119 and 122 compare ceiling sprinkler temperature ratings of 286°F (141°C) and 165°F (74°C). A review of the number of boxes damaged and the firespread patterns indicates that the use of ordinary temperature-rated ceiling sprinklers on a rack configuration that incorporates in-rack sprinklers dramatically reduces the amount of firespread. Considering that in-rack sprinklers in the tests for storage over 25 ft (7.6 m) operated prior to ceiling sprinklers, it would seem that the installation of in-rack sprinklers converts an otherwise rapidly developing fire, from the standpoint of ceiling sprinklers, to a slower developing fire with a lower rate of heat release.

In the 20 ft (6.1 m) high test series, ceiling sprinklers operated before in-rack sprinklers. In the 30 ft (9.1 m) high series, ceiling sprinklers operated after in-rack sprinklers. The 50 ft (15 m) high test did not operate ceiling sprinklers. Ceiling sprinklers would, however, be needed if fire occurred in upper levels.

The results of these tests indicate the effect of in-rack sprinklers on storage higher than 25 ft (7.6 m). From the ceiling sprinkler operation standpoint, a fire with an expected high heat release rate was converted to a fire with a much lower heat release rate.

Since the fires developed slowly and opened sprinklers at two levels in the racks, only a few ceiling sprinklers were needed to establish control. Thus, the sprinkler operating area does not vary with height for storage over 25 ft (7.6 m) or for changes in sprinkler temperature rating and density.

All tests with sprinklers in racks were conducted using nominal ½ in. (15 mm) orifice size sprinklers of ordinary temperature.

C.24

[20.6] A series of fire tests were conducted by Spacesaver Corporation that indicated control was achieved with light hazard sprinkler spacing and design. The tests used quick-response, ordinary-temperature sprinklers on 15 ft × 15 ft (4.6 m × 4.6 m) spacing with an 8 ft (2.4 m) high compact storage unit located in the middle of the sprinkler array. Results indicated a classic definition of control, the fire was held in check within the compact storage module and the fire did not jump the aisle or ignite any of the target arrays.

C.25

[20.5] In July and August of 2007, a series of three large-scale fire tests were conducted at Southwest Research Institute to investigate the effectiveness of a specific ceiling and in-rack sprinkler protection scheme dedicated for the protection of paper files in 12 in. (300 mm) wide, and 16 in. (400 mm) and 10 in. (250 mm) high corrugated cardboard boxes (containers) maintained in multiple-row racks to a nominal height of 37 ft (11 m).

The storage rack for the main array in all three tests consisted of two 50 in. (1.3 m) deep racks placed back-to-back and separated by 1 in. (25 mm) gap. The storage rack for the target array in all three tests consisted of a single 50 in. (1.3 m) deep rack separated on both sides of the main array by a 30 in. (750 mm) wide aisle. Rack uprights were a nominal 3 in. (75 mm) wide. Rack bays were 120 in. (3.0 m) wide, 38 in. (950 mm) high, and equipped with perforated metal decking having a minimum of 50 percent

openings. Each storage bay was provided with 9 containers between uprights that was 3 containers deep and 3 containers high for a total of 81 containers per rack bay. Nominal 6 in. (150 mm) wide transverse flue spaces were provided at each rack upright. Both the main array and the target array were 4 bays long for an overall length of 41 ft 3 in. (12.6 m).

Open-grated (expanded) catwalks were provided in both storage aisles at the top of the third [9 ft 8 in. (2.9 m)], sixth [19 ft 2 in. (5.8 m)], and ninth [28 ft 8 in. (8.7 m)] tier levels.

The ceiling sprinkler system consisted of K-8.0 (115), 165°F (74°C) nominally rated, standard-response pendent automatic sprinklers installed on 10 ft × 10 ft (3.0 m × 3.0 m) spacing arranged to provide a constant 0.30 gpm/ft² (12.2 mm/min) density. A nominal 3 ft (900 mm) clearance was provided between the top of storage and the ceiling sprinklers.

The in-rack sprinkler system consisted of K-8.0 (115), 165°F (74°C) nominally rated, quick-response upright automatic sprinklers that were equipped with water shields and arranged to provide a constant 30 gpm (115 L/min) flow from each operating in-rack sprinkler. In-rack sprinklers were provided within the transverse flue spaces of the main array, 2 ft (600 mm) horizontally from the face of the rack, at the top of the third and ninth tier levels on one side of the main array and at the top of the sixth tier level on the other side of the main array. A minimum 6 in. (150 mm) vertical clearance was provided between the in-rack sprinkler and the top of storage within the storage rack.

The same type of sprinklers installed within the storage racks were also installed under each catwalk and designed to provide a constant 30 gpm (115 L/min) flow from each operating sprinkler. These sprinklers were centered within the aisles and installed 10 ft 3 in. (3.1 m) on line. They were arranged to be aligned with the adjacent transverse flue space when the flue space was not equipped with an in-rack sprinkler; they were positioned halfway between transverse flue spaces when the adjacent flue spaces were equipped with in-rack sprinklers.

In Test No. 1, ignition was at grade level, at the face of the rack and centered between rack uprights. The in-rack sprinklers within the transverse flue spaces nearest to the ignition location were at the top of the sixth tier level; the sprinkler under the catwalk at the top of the sixth tier level was located a horizontal distance of 15 in. (375 mm) away from the ignition location. The sprinkler under the catwalk at the top of the sixth tier level was the first sprinkler to operate at a time 2 minutes and 49 seconds after ignition. A total of 3 in-rack sprinklers and 1 catwalk sprinkler operated during this test; no ceiling-level sprinklers operated. The results of the test were considered acceptable.

In Test No. 2, ignition was at grade level at a rack upright, 2 ft (600 mm) horizontally from the rack face. The in-rack sprinkler within the transverse flue space of fire origin was at the top of the sixth tier level. The in-rack sprinkler directly over the ignition location was the first sprinkler to operate at a time 2 minutes and 9 seconds after ignition. A total of 2 in-rack sprinklers operated during this test; no ceiling-level sprinklers operated. The results of the test were considered acceptable.

In Test No. 3, ignition was at grade level, centered between rack uprights within the 2 in. (50 mm) gap. To allow vertical fire growth directly above the point of ignition, the gap was maintained open throughout the height of the storage rack. A total of 4 in-rack sprinklers and 1 sprinkler under a catwalk operated during the test; no ceiling-level sprinklers operated. The first in-rack sprinkler to operate was located at the top of the sixth tier level at a time 3 minutes and 1 second after ignition. The second in-rack sprinkler to operate was also at the top of the sixth tier level. The last 2 in-rack sprinklers to operate were both located at the top of the third tier level. The fifth and final sprinkler to operate was a sprinkler located under a catwalk at the top of the third tier level. The results of the test were considered acceptable.

All three tests were considered successful and confirmed that the ceiling and in-rack sprinkler protection scheme outlined in this standard for the protection of cartoned records storage maintained in multiple-row racks with catwalk access is acceptable.

C.26 [16.1.10.3, 16.1.11.1.2, 17.1.9.3, 17.1.10.1.2]

During full-scale fire tests, flue space width and alignment are typically set with care for test consistency and repeatability. Some full-scale fire tests and fire experience have shown sprinkler protection designed and installed in accordance with this standard are able to tolerate random variations in flue width and vertical flue alignment. For example, see Test 7 in the National Quick Response Sprinkler Research

Project: Large-Scale Fire Evaluation of Early Suppression Quick-Response (ESFR) Automatic Sprinklers (report available from the NFPA Research Foundation web site). For Test 7, transverse flue variations were substantial such that some flues at various tiers were completely closed (i.e., pallet loads placed immediately adjacent to each other), and the vertical alignment of one transverse flue was completely disrupted. The result was the operation of eight K14 (K200) ESFR sprinklers as well as minor aisle jump to both target racks. Reported damage was 2½ pallet loads in the main rack array and ¼ pallet load in the large racks. Findings such as Test 7 support the toleration of flue variations in the real world. However, ideally pallet loads should be positioned in racks with care to reduce the challenge faced by sprinklers should a fire occur.

Annex D Sprinkler System Information from the 2012 Edition of the Life Safety Code

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

D.1 Introduction.

This annex is provided as an aid to the user of NFPA 13 by identifying those portions of the 2012 edition of NFPA 101 that pertain to sprinkler system design and installation. It is not intended that this annex provide complete information regarding all aspects of fire protection addressed by NFPA 101. It is important to note that this information was copied from NFPA 101 but did not use NFPA's extract policy and is not intended to be a part of the requirements of NFPA 13.

D.1.1

The following sections cover situations where NFPA 101 provides different guidance on the design or installation of a fire sprinkler system from NFPA 13. In some cases, this different guidance is based on descriptions of unique situations handled by NFPA 101. In other cases, this different guidance stems from the different objective for NFPA 101, life safety of the occupant, rather than the property protection afforded by NFPA 13.

D.1.1.1 Features of Fire Protection.

D.1.1.1.1 Atriums.

Glass walls and inoperable windows shall be permitted in lieu of the fire barriers where all the following are met:

- (1) Automatic sprinklers are spaced along both sides of the glass wall and the inoperable windows at intervals not to exceed 6 ft (1830 mm).
- (2) The automatic sprinklers specified in 8.6.7(1)(c)(i) of NFPA 101 are located at a distance from the glass wall not to exceed 12 in. (305 mm) and arranged so that the entire surface of the glass is wet upon operation of the sprinklers.
- (3) The glass wall is of tempered, wired, or laminated glass held in place by a gasket system that allows the glass framing system to deflect without breaking (loading) the glass before the sprinklers operate.
- (4) The automatic sprinklers required by 8.6.7(1)(c)(i) of NFPA 101 are not required on the atrium side of the glass wall and the inoperable window where there is no walkway or other floor area on the atrium side above the main floor level. [101:8.6.7(1)(c)]

D.1.1.2 Special Structures and High-Rise Buildings.

D.1.1.2.1

High-rise buildings shall be protected throughout by an approved, supervised automatic sprinkler system in accordance with NFPA 101, Section 9.7. A sprinkler control valve and a waterflow device shall be provided for each floor. [101:11.8.3.1]

D.1.1.3 Lodging or Rooming Houses.

D.1.1.3.1

In buildings sprinklered in accordance with NFPA 13, closets that contain equipment such as washers, dryers, furnaces, or water heaters shall be sprinklered regardless of size. [101:26.3.6.3.5]

D.1.1.3.2

In existing lodging or rooming houses, sprinkler installations shall not be required in closets not exceeding 24 ft² (2.2 m²) and in bathrooms not exceeding 55 ft² (5.1 m²). [101:26.3.6.3.6]

D.1.1.4 New Hotels and Dormitories.

D.1.1.4.1

The provisions for draft stops and closely spaced sprinklers in NFPA 13 shall not be required for openings complying with NFPA 101, 8.6.9.1, where the opening is within the guest room or guest suite. [101:28.3.5.4]

D.1.1.4.2

Listed quick-response or listed residential sprinklers shall be used throughout guest rooms and guest room suites. [101:28.3.5.6]

D.1.1.5 Existing Hotels and Dormitories.

D.1.1.5.1

In guest rooms and in guest room suites, sprinkler installations shall not be required in closets not exceeding 24 ft² (2.2 m²) and in bathrooms not exceeding 55 ft² (5.1 m²). [101:29.3.5.5]

D.1.1.6 New Apartment Buildings.

D.1.1.6.1

In buildings sprinklered in accordance with NFPA 13, closets less than 12 ft² (1.1 m²) in area in individual dwelling units shall not be required to be sprinklered. Closets that contain equipment such as washers, dryers, furnaces, or water heaters shall be sprinklered regardless of size. [101:30.3.5.3]

D.1.1.6.2

Listed quick-response or listed residential sprinklers shall be used throughout all dwelling units. [101:30.3.5.5]

D.1.1.6.3

The draft stop and closely spaced sprinkler requirements of NFPA 13 shall not be required for convenience openings complying with NFPA 101, 8.6.9.1, where the convenience opening is within the dwelling unit. [101:30.3.5.4]

D.1.1.7 Existing Apartment Buildings.

D.1.1.7.1

In individual dwelling units, sprinkler installation shall not be required in closets not exceeding 24 ft² (2.2 m²) and in bathrooms not exceeding 55 ft² (5.1 m²). Closets that contain equipment such as washers, dryers, furnaces, or water heaters shall be sprinklered regardless of size. [101:31.3.5.3]

D.1.1.7.2

The draft stop and closely spaced sprinkler requirements of NFPA 13 shall not be required for convenience openings complying with NFPA 101, 8.6.9.1, where the convenience opening is within the dwelling unit. [101:31.3.5.4]

D.1.1.8 Existing Residential Board and Care Occupancies.

D.1.1.8.1

Standard response sprinklers shall be permitted for use in hazardous areas in accordance with NFPA 101, 33.2.3.2. [101:33.2.2.2.4]

D.1.1.8.2

Where an automatic sprinkler system is installed, for either total or partial building coverage, all of the following requirements shall be met:

- (1) The system shall be in accordance with NFPA 101, Section 9.7, and shall initiate the fire alarm system in accordance with 33.2.3.4.1, as modified by 33.2.3.5.3.1 through 33.2.3.5.3.6 of NFPA 101
- (2) The adequacy of the water supply shall be documented to the authority having jurisdiction.

[101:33.2.3.5.3]

D.1.1.8.2.1

In prompt evacuation capability facilities, all of the following shall apply:

- (1) An automatic sprinkler system in accordance with NFPA 13D shall be permitted.
- (2) Automatic sprinklers shall not be required in closets not exceeding 24 ft² (2.2 m²) and in bathrooms not exceeding 55 ft² (5.1 m²), provided that such spaces are finished with lath and plaster or materials providing a 15-minute thermal barrier.

[101:33.2.3.5.3.1]

D.1.1.8.2.2

In slow and impractical evacuation capability facilities, all of the following shall apply:

- (1) An automatic sprinkler system in accordance with NFPA 13D with a 30-minute water supply, shall be permitted.
- (2) All habitable areas and closets shall be sprinklered.
- (3) Automatic sprinklers shall not be required in bathrooms not exceeding 55 ft² (5.1 m²), provided that such spaces are finished with lath and plaster or materials providing a 15-minute thermal barrier.

[101:33.2.3.5.3.2]

D.1.1.8.2.3

In prompt and slow evacuation capability facilities, where an automatic sprinkler system is in accordance with NFPA 13, sprinklers shall not be required in closets not exceeding 24 ft² (2.2 m²) and in bathrooms not exceeding 55 ft² (5.1 m²), provided that such spaces are finished with lath and plaster or materials providing a 15-minute thermal barrier. [101:33.2.3.5.3.3]

D.1.1.8.2.4

In prompt and slow evacuation capability facilities in buildings four or fewer stories above grade plane, systems in accordance with NFPA 13R shall be permitted. [101:33.2.3.5.3.4]

D.1.1.8.2.5

In impractical evacuation capability facilities in buildings four or fewer stories above grade plane, systems in accordance with NFPA 13R shall be permitted. All habitable areas and closets shall be sprinklered. Automatic sprinklers shall not be required in bathrooms not exceeding 55 ft² (5.1 m²), provided that such spaces are finished with lath and plaster or materials providing a 15-minute thermal barrier.

[101:33.2.3.5.3.5]

D.1.1.8.2.6

Initiation of the fire alarm system shall not be required for existing installations in accordance with NFPA 101, 33.2.3.5.6. [101:33.2.3.5.3.6]

D.1.1.8.2.7

All impractical evacuation capability facilities shall be protected throughout by an approved, supervised automatic sprinkler system in accordance with NFPA 101, 33.2.3.5.3. [101:33.2.3.5.3.7]

D.1.1.9 New Mercantile Occupancies.

D.1.1.9.1 Protection of Vertical Openings.

Any vertical opening shall be protected in accordance with NFPA 101, Section 8.6, except under the following conditions:

- (1) In Class A or Class B mercantile occupancies protected throughout by an approved, supervised automatic sprinkler system in accordance with NFPA 101, 9.7.1.1(1), unprotected vertical openings shall be permitted at one of the following locations:
 - (a) Between any two floors

- (b) Among the street floor, the first adjacent floor below, and adjacent floor (or mezzanine) above
- (2) In Class C mercantile occupancies, unprotected openings shall be permitted between the street floor and the mezzanine.
- (3) The draft stop and closely spaced sprinkler requirements of NFPA 13 shall not be required for unenclosed vertical openings permitted in NFPA 101, 36.3.1(1) and (2).

[101:36.3.1]

D.1.1.9.2

Rooms housing building service equipment, janitor closets, and service elevators shall be permitted to open directly onto exit passageways, provided that the following criteria are met:

- (1) The required fire resistance rating between such rooms or areas and the exit passageway shall be maintained in accordance with NFPA 101, 7.1.3.2.
- (2) Such rooms or areas shall be protected by an approved, supervised automatic sprinkler system in accordance with NFPA 101, 9.7.1.1(1) but the exceptions in NFPA 13 allowing the omission of sprinklers from such rooms shall not be permitted.

[101:36.4.4.6.2]

D.1.1.10 Existing Mercantile Occupancies.

D.1.1.10.1 Protection of Vertical Openings.

Any vertical opening shall be protected in accordance with NFPA 101, Section 8.6, except under the following conditions:

- (1) In Class A or Class B mercantile occupancies protected throughout by an approved, supervised automatic sprinkler system in accordance with NFPA 101, 9.7.1.1(1), unprotected vertical openings shall be permitted at one of the following locations:
 - (a) Between any two floors
 - (b) Among the street floor, the first adjacent floor below, and adjacent floor (or mezzanine) above
- (2) In Class C mercantile occupancies, unprotected openings shall be permitted between the street floor and the mezzanine.
- (3) The draft stop and closely spaced sprinkler requirements of NFPA 13 shall not be required for unenclosed vertical openings permitted in NFPA 101, 37.3.1(1) and (2).

[101:37.3.1]

D.1.1.10.2

Rooms housing building service equipment, janitor closets, and service elevators shall be permitted to open directly onto exit passageways, provided that the following criteria are met:

- (1) The required fire resistance rating between such rooms or areas and the exit passageway shall be maintained in accordance with NFPA 101, 7.1.3.2.
- (2) Such rooms or areas shall be protected by an approved automatic sprinkler system in accordance with NFPA 101, 9.7.1.1(1) but the exceptions in NFPA 13 allowing the omission of sprinklers from such rooms shall not be permitted.

[101:37.4.4.6.2]

D.1.1.11 Industrial Occupancies.

D.1.1.11.1 Special Provisions — High-Rise Buildings.

The provisions of NFPA 101, 11.8.5.2.4(2) for jockey pumps and NFPA 101, 11.8.5.2.4(3) for air compressors serving dry-pipe and pre-action systems shall not apply to special-purpose industrial occupancies. [101:40.4.1]

D.2 Life Safety Code.

D.2.1 Features of Fire Protection.

D.2.1.1 Design Requirements. (Reserved)

D.2.1.2 Installation Requirements.

D.2.1.2.1 Atriums.

Glass walls and inoperable windows shall be permitted in lieu of the fire barriers where all the following are met:

- (1) Automatic sprinklers are spaced along both sides of the glass wall and the inoperable window at intervals not to exceed 6 ft (1830 mm).
- (2) The automatic sprinklers specified in NFPA 101, 8.6.7(1)(c)(i) are located at a distance from the glass wall not to exceed 12 in. (305 mm), and arranged so that the entire surface of the glass is wet upon operation of the sprinklers.
- (3) The glass wall is of tempered, wired, or laminated glass held in place by a gasket system that allows the glass framing system to deflect without breaking (loading) the glass before the sprinklers operate.
- (4) The automatic sprinklers required by NFPA 101, 8.6.7(1)(c)(i) are not required on the atrium side of the glass wall and the inoperable window where there is no walkway or other floor area on the atrium side above the main floor level. [101:8.6.7(1)(c)]

D.2.2 Special Structures and High-Rise Buildings.

D.2.2.1 Design Criteria.

D.2.2.1.1

High-rise buildings shall be protected throughout by an approved, supervised automatic sprinkler system in accordance with NFPA 101, Section 9.7. A sprinkler control valve and a waterflow device shall be provided for each floor. [101:11.8.3.1]

D.2.3 New Assembly Occupancies.

D.2.3.1 Design Criteria.

D.2.3.1.1 Protection of Vertical Openings.

Any vertical opening shall be enclosed or protected in accordance with Section 8.6 of NFPA 101, unless otherwise permitted by one of the following:

- (1) Stairs or ramps shall be permitted to be unenclosed between balconies or mezzanines and main assembly areas located below, provided that the balcony or mezzanine is open to the main assembly area.
- (2) Exit access stairs from lighting and access catwalks, galleries, and gridirons shall not be required to be enclosed.
- (3) Assembly occupancies protected by an approved, supervised automatic sprinkler system in accordance with Section 9.7 of NFPA 101 shall be permitted to have unprotected vertical openings between any two adjacent floors, provided that such openings are separated from unprotected vertical openings serving other floors by a barrier complying with 8.6.5 of NFPA 101.
- (4) Assembly occupancies protected by an approved, supervised automatic sprinkler system in accordance with Section 9.7 of NFPA 101 shall be permitted to have convenience stair openings in accordance with 8.6.9.2 of NFPA 101.

[101:12.3.1]

D.2.3.2 Installation Requirements. (Reserved)

D.2.4 Existing Assembly Occupancies.

D.2.4.1 Design Criteria.

D.2.4.1.1 Protection of Vertical Openings.

Any vertical opening shall be enclosed or protected in accordance with NFPA 101, Section 8.6, unless otherwise permitted by one of the following:

- (1) Stairs or ramps shall be permitted to be unenclosed between balconies or mezzanines and main assembly areas located below, provided that the balcony or mezzanine is open to the main assembly area.
- (2) Exit access stairs from lighting and access catwalks, galleries, and gridirons shall not be required to be enclosed.
- (3) Assembly occupancies protected by an approved, supervised automatic sprinkler system in accordance with NFPA 101, Section 9.7, shall be permitted to have unprotected vertical openings between any two adjacent floors, provided that such openings are separated from unprotected vertical openings serving other floors by a barrier complying with NFPA 101, 8.6.5.
- (4) Assembly occupancies protected by an approved, supervised automatic sprinkler system in accordance with NFPA 101, Section 9.7, shall be permitted to have convenience stair openings in accordance with NFPA 101, 8.6.9.2.

[101:13.3.1]

D.2.4.2 Installation Requirements. (Reserved)

D.2.5 New Educational Occupancies. (Reserved)

D.2.6 Existing Educational Occupancies. (Reserved)

D.2.7 New Day-Care Occupancies. (Reserved)

D.2.8 Existing Day-Care Occupancies. (Reserved)

D.2.9 New Health Care Occupancies. (Reserved)

D.2.10 Existing Health Care Occupancies. (Reserved)

D.2.11 New Ambulatory Health Care Occupancies. (Reserved)

D.2.12 Existing Ambulatory Health Care Occupancies. (Reserved)

D.2.13 New Detention and Correctional Occupancies. (Reserved)

D.2.14 Existing Detention and Correctional Occupancies. (Reserved)

D.2.15 One- and Two-Family Dwellings. (Reserved)

D.2.16 Lodging or Rooming Houses.

D.2.16.1 Design Requirements. (Reserved)

D.2.16.2 Installation Requirements.

D.2.16.2.1

In buildings sprinklered in accordance with NFPA 13, closets that contain equipment such as washers, dryers, furnaces, or water heaters shall be sprinklered, regardless of size. [101:26.3.6.3.5]

D.2.16.2.2

In existing lodging or rooming houses, sprinkler installations shall not be required in closets not exceeding 24 ft² (2.2 m²) and in bathrooms not exceeding 55 ft² (5.1 m²). [101:26.3.6.3.6]

D.2.17 New Hotels and Dormitories.

D.2.17.1 Design Requirements. (Reserved)

D.2.17.2 Installation Requirements.

D.2.17.2.1

The provisions for draft stops and closely spaced sprinklers in NFPA 13 shall not be required for openings complying with NFPA 101, 8.6.9.1, where the opening is within the guest room or guest suite. [101:28.3.5.4]

D.2.17.2.2

Listed quick-response or listed residential sprinklers shall be used throughout guest rooms and guest room suites. [101:28.3.5.6]

D.2.18 Existing Hotels and Dormitories.

D.2.18.1 Design Requirements. (Reserved)

D.2.18.2 Installation Requirements.

D.2.18.2.1

In guest rooms and in guest room suites, sprinkler installations shall not be required in closets not exceeding 24 ft² (2.2 m²) and in bathrooms not exceeding 55 ft² (5.1 m²). [101:29.3.5.5]

D.2.19 New Apartment Buildings.

D.2.19.1 Design Requirements. (Reserved)

D.2.19.2 Installation Requirements.

D.2.19.2.1

In buildings sprinklered in accordance with NFPA 13, closets less than 12 ft² (1.1 m²) in area in individual dwelling units shall not be required to be sprinklered. Closets that contain equipment such as washers, dryers, furnaces, or water heaters shall be sprinklered regardless of size. [101:30.3.5.3]

D.2.19.2.2

Listed quick-response or listed residential sprinklers shall be used throughout all dwelling units. [101:30.3.5.5]

D.2.19.2.3

The draft stop and closely spaced sprinkler requirements of NFPA 13 shall not be required for convenience openings complying with NFPA 101, 8.6.9.1, where the convenience opening is within the dwelling unit. [101:30.3.5.4]

D.2.20 Existing Apartment Buildings.

D.2.20.1 Design Requirements. (Reserved)

D.2.20.2 Installation Requirements.

D.2.20.2.1

In individual dwelling units, sprinkler installation shall not be required in closets not exceeding 24 ft² (2.2 m²) and in bathrooms not exceeding 55 ft² (5.1 m²). Closets that contain equipment such as washers, dryers, furnaces, or water heaters shall be sprinklered, regardless of size. [101:31.3.5.3]

D.2.20.2.2

The draft stop and closely spaced sprinkler requirements of NFPA 13 shall not be required for convenience openings complying with NFPA 101, 8.6.9.1, where the convenience opening is within the dwelling unit. [101:31.3.5.4]

D.2.21 New Residential Board and Care Occupancies. (Reserved)

D.2.22 Existing Residential Board and Care Occupancies.

D.2.22.1 Design Requirements. (Reserved)

D.2.22.2 Installation Requirements.

D.2.22.2.1

Standard-response sprinklers shall be permitted for use in hazardous areas in accordance with NFPA 101, 33.2.3.2. [101:33.2.2.2.4]

D.2.22.2.2

In prompt and slow evacuation facilities, where an automatic sprinkler system is in accordance with NFPA 13 sprinklers shall not be required in closets not exceeding 24 ft² (2.2 m²) and in bathrooms not exceeding 55 ft² (5.1 m²), provided that such spaces are finished with lath and plaster or materials providing a 15-minute thermal barrier. [101:33.2.3.5.3.3]

D.2.23 New Mercantile Occupancies.

D.2.23.1 Design Requirements. (Reserved)

D.2.23.2 Installation Requirements.

D.2.23.2.1 Protection of Vertical Openings.

Any vertical opening shall be protected in accordance with NFPA 101, Section 8.6, except under the following conditions:

(1) In Class A or Class B mercantile occupancies protected throughout by an approved, supervised automatic sprinkler system in accordance with NFPA 101, 9.7.1.1(1), unprotected vertical openings shall be permitted at one of the following locations:

(a) Between any two floors

(b) Among the street floor, the first adjacent floor below, and adjacent floor (or mezzanine) above

(2) In Class C mercantile occupancies, unprotected openings shall be permitted between the street floor and the mezzanine.

(3) The draft stop and closely spaced sprinkler requirements of NFPA 13 shall not be required for unenclosed vertical openings permitted in NFPA 101, 36.3.1(1) and (2).

[101:36.3.1]

D.2.23.2.2

Rooms housing building service equipment, janitor closets, and service elevators shall be permitted to open directly onto exit passageways, provided that the following criteria are met:

(1) The required fire resistance rating between such rooms or areas and the exit passageway shall be maintained in accordance with NFPA 101, 7.1.3.2.

(2) Such rooms or areas shall be protected by an approved, supervised automatic sprinkler system in accordance with NFPA 101, 9.7.1.1(1) but the exceptions in NFPA 13 allowing the omission of sprinklers from such rooms shall not be permitted.

[101:36.4.4.6.2]

D.2.24 Existing Mercantile Occupancies.

D.2.24.1 Design Requirements. (Reserved)

D.2.24.2 Installation Requirements.

D.2.24.2.1 Protection of Vertical Openings.

Any vertical opening shall be protected in accordance with NFPA 101, Section 8.6, except under the following conditions:

(1) In Class A or Class B mercantile occupancies protected throughout by an approved, supervised automatic sprinkler system in accordance with NFPA 101, 9.7.1.1(1), unprotected vertical openings shall be permitted at one of the following locations:

(a) Between any two floors

(b) Among the street floor, the first adjacent floor below, and adjacent floor (or mezzanine) above

(2) In Class C mercantile occupancies, unprotected openings shall be permitted between the street floor and the mezzanine.

(3) The draft stop and closely spaced sprinkler requirements of NFPA 13 shall not be required for unenclosed vertical openings permitted in NFPA 101, 37.3.1(1) and (2). [101:37.3.1]

D.2.24.2.2

Rooms housing building service equipment, janitor closets, and service elevators shall be permitted to open directly onto exit passageways, provided that the following criteria are met:

(1) The required fire resistance rating between such rooms or areas and the exit passageway shall be maintained in accordance with NFPA 101, 7.1.3.2.

(2) Such rooms or areas shall be protected by an approved, supervised automatic sprinkler system in accordance with NFPA 101, 9.7.1.1(1), but the exceptions in NFPA 13 allowing the omission of sprinklers from such rooms shall not be permitted. [101:37.4.4.6.2]

D.2.25 New Business Occupancies.

D.2.25.1 Design Requirements. (Reserved)

D.2.25.2 Installation Requirements. (Reserved)

D.2.26 Existing Business Occupancies.

D.2.26.1 Design Requirements. (Reserved)

D.2.26.2 Installation Requirements. (Reserved)

D.2.27 Industrial Occupancies. (Reserved)

D.2.27.1 Design Criteria.

D.2.27.1.1 Special Provisions — High-Rise Buildings.

The provisions of NFPA 101, 11.8.5.2.4(2), for jockey pumps and NFPA 101, 11.8.5.2.4(3), for air compressors serving dry-pipe and pre-action systems shall not apply to special-purpose industrial occupancies. [101:40.4.1]

D.2.28 Storage Occupancies. (Reserved)

Dimensions Found in NFPA 13-2016

Length					
.003"	.08 mm	7.5"	190 mm	26"	650 mm
.0315"	.8 mm	8"	200 mm	27.6"	690 mm
1/32"	0.8 mm	8.5"	215 mm	28"	700 mm
1/16"	1.6 mm	9"	225 mm	29"	725 mm
3/32"	2 mm	9.25"	230 mm	30"	750 mm
1/8"	3 mm	9.5"	240 mm	30.5"	765 mm
3/16"	5 mm	10"	250 mm	31"	775 mm
¼"	6 mm	11"	275 mm	32"	800 mm
5/16"	8 mm	11.5"	290 mm	33"	825 mm
3/8"	10 mm	12"	300 mm	35"	875 mm
½"	13 mm	12.25"	305 mm	35.4"	885 mm
17/32"	13 mm	12.5"	315 mm	36"	900 mm
9/16"	14 mm	12.75"	320 mm	37"	925 mm
5/8"	16 mm	14"	350 mm	38"	950 mm
¾"	19 mm	15"	375 mm	40"	1000 mm
7/8"	22 mm	15.5"	390 mm	42"	1050 mm
1"	25 mm	16"	400 mm	44"	1100 mm
1.5"	40 mm	16.25"	410 mm	47"	1175 mm
1.75"	45 mm	16.5"	415 mm	48"	1200 mm
2"	50 mm	17"	425 mm	54"	1350 mm
2.5"	65 mm	17.5"	440 mm	55"	1375 mm
2.75"	70 mm	18"	450 mm	57"	1425 mm
3"	75 mm	19"	475 mm	58"	1450 mm
3.5"	90 mm	20"	500 mm	66"	1650 mm
4"	100 mm	21"	525 mm	68"	1700 mm
4.5"	115 mm	22"	550 mm	72"	1800 mm
5"	125 mm	22.5"	565 mm	76"	1900 mm
5.5"	140 mm	23"	575 mm	78"	1950 mm
5.75"	145 mm	24"	600 mm	96"	2400 mm
6"	150 mm	25"	625 mm	102"	2550 mm
7"	175 mm	25.5"	640 mm	120"	3000 mm
				148"	3700 mm

Dimensions Found in NFPA 13-2016

Length					
3.5ft	1.1 m	10'-10"	3.3 m	22'-6"	6.9 m
3'-8"	1.1 m	11'-0"	3.4 m	24ft	7.3 m
4ft	1.2 m	11'-3"	3.4 m	25ft	7.6 m
4'-2"	1.3 m	11'-5"	3.5 m	25'-3"	7.7 m
4.5ft	1.4 m	11'-6"	3.5 m	26ft	7.9 m
4'-7"	1.4 m	11'-6 11/16"	3.5 m	27ft	8.2 m
4'-9"	1.4 m	11'-8"	3.6 m	28ft	8.5 m
5ft	1.5 m	12ft	3.7 m	28'-8"	8.7 m
5'-2"	1.6 m	12'-4"	3.8 m	29'-8"	9 m
5.5ft	1.7 m	13ft	4.0 m	30ft	9.1 m
5'-8"	1.7 m	13'-6"	4.1 m	32ft	10 m
5'-9 5/16"	1.8 m	13'-7 1/2"	4.2 m	33ft	10 m
6ft	1.8 m	13'-11"	4.2 m	35ft	11 m
6'-3"	1.9 m	14ft	4.3 m	36ft	11 m
6'-4"	1.9 m	14'-6"	4.4 m	40ft	12 m
6.5ft	2 m	15ft	4.6 m	41'-3"	13 m
6'-10"	2.1 m	15'-4"	4.7 m	45ft	14 m
7ft	2.1 m	16ft	4.9 m	50ft	15 m
7.5ft	2.3 m	16'-6"	5.0 m	51'-6"	16 m
7'-7"	2.3 m	16'-8"	5.1 m	55ft	17 m
7'-9"	2.4 m	17ft	5.2 m	60ft	18 m
8ft	2.4 m	18ft	5.5 m	65ft	20 m
8'-2"	2.5 m	18'-6"	5.6 m	70ft	21 m
8'-4"	2.5 m	19'-2"	5.8 m	75ft	23 m
8'-7 7/8"	2.6 m	19'-10"	6 m	76ft	23 m
9ft	2.7 m	19'-11"	6.1 m	80ft	24 m
9'-5"	2.9 m	20ft	6.1 m	100ft	30 m
9'-6"	2.9 m	20'-8"	6.3 m	200ft	61 m
10ft	3 m	21'-6"	6.6 m	250ft	76 m
10.5ft	3.2 m	21'-10"	6.7 m	300ft	91 m
10'-9"	3.3 m	22 ft	6.7 m	400ft	120 m

Dimensions Found in NFPA 13-2016

Area					
3.5 ft2	0.3 m2	256 ft2	24 m2	2,700 ft2	250 m2
6 ft2	0.6 m2	300 ft2	28 m2	2,734 ft2	255 m2
10 ft2	0.9 m2	306 ft2	28 m2	2,800 ft2	260 m2
12 ft2	1.1 m2	324 ft2	30 m2	3,000 ft2	280 m2
16 ft2	1.5 m2	395 ft2	37 m2	3,250 ft2	300 m2
18 ft2	1.7m2	400 ft2	37 m2	3,300 ft2	305 m2
20 ft2	1.9m2	450 ft2	42 m2	3,450 ft2	320 m2
24 ft2	2.2m2	504 ft2	47 m2	3,500 ft2	325 m2
25 ft2	2.3 m2	585 ft2	54 m2	3,600 ft2	335 m2
32 ft2	3.0 m2	600 ft2	56 m2	3,750 ft2	350 m2
50 ft2	4.6 m2	648 ft2	60 m2	3,900 ft2	360 m2
55 ft2	5.1 m2	700 ft2	65 m2	4,000 ft2	370 m2
64 ft2	5.9 m2	756 ft2	70 m2	4,100 ft2	380 m2
70 ft2	6.5 m2	768 ft2	71 m2	4,500 ft2	420 m2
80 ft2	7.4 m2	800 ft2	74 m2	4,800 ft2	445 m2
90 ft2	8.4 m2	1,000 ft2	93 m2	5,000 ft2	465 m2
100 ft2	9 m2	1,200ft2	112 m2	6,000 ft2	555 m2
110 ft2	10 m2	1,300 ft2	120 m2	6,400 ft2	595 m2
120 ft2	11 m2	1,365 ft2	125 m2	8,000 ft2	740 m2
124 ft2	12 m2	1,400 ft2	130 m2	8,800 ft2	820 m2
130 ft2	12 m2	1,500 ft2	140 m2	10,000 ft2	930 m2
144 ft2	13 m2	1,700 ft2	160 m2	13,100 ft2	1 215 m2
150 ft2	14 m2	1,800 ft2	165 m2	25,000 ft2	2 320 m2
168 ft2	16 m2	1,950 ft2	180 m2	40,000 ft2	3 720 m2
175 ft2	16 m2	2,000 ft2	185 m2	50,000 ft2	4 650 m2
196 ft2	18 m2	2,300 ft2	215 m2	52,000 ft2	4 830 m2
200 ft2	18 m2	2,500 ft2	230m2	100,000 ft2	9 230 m2
225 ft2	20 m2	2,535 ft2	235 m2		
250 ft2	23 m2	2,600 ft2	240 m2		

Dimensions Found in NFPA 13-2016

Volume			
1.76 cuin	28 ml	160 ft3	4.5 m3
15.5 ft3	0.5 m3	400 ft3	11 m3
17.4 ft3	0.5 m3	1,000 ft3	28 m3
17.6 ft3	0.5 m3	1,800 ft3	51 m3
20.7 ft3	0.6 m3	2,100 ft3	59 m3
21.1 ft3	0.6 m3	2,300 ft3	65 m3
22 ft3	0.6 m3	6,500 ft3	184 m3
100 ft3	2.8 m3	2.25M ft3	63,720 m3

Capacity	
16 oz.	0.5 l
32 oz.	1 l
1 gal	4 l
5 gal	20 l
40 gal	150 l
100 gal	380 l
150 gal	570 l
250 gal	950 l
500 gal	1900 l
750 gal	2850 l
300,000 gal	1,135,500 l

Drill Size	
3/32"	2,3 mm
1/8"	3,2 mm
3/8"	10 mm

Density of Cotton Bales	
22.0 lb/ft ³	350 kg/m ³
22.7 lb/ft ³	365 kg/m ³
24.2 lb/ft ³	390 kg/m ³
28.4 lb/ft ³	455 kg/m ³
28.7 lb/ft ³	460 kg/m ³
32.2 lb/ft ³	515 kg/m ³

Dimensions Found in NFPA 13-2016

Flow					
30 gpm	115 lpm	300 gpm	1150 lpm	1000 gpm	3800 lpm
15 gpm	57 lpm	400 gpm	1500 lpm	1500 gpm	5700 lpm
20 gpm	75 lpm	500 gpm	1900 lpm	1992 gpm	7540 lpm
50 gpm	190 lpm	600 gpm	2250 lpm	1993 gpm	7543 lpm
60 gpm	230 lpm	700 gpm	2650 lpm	2156 gpm	8160 lpm
100 gpm	380 lpm	750 gpm	2850 lpm	2575 gpm	9750 lpm
102.8 gpm	390 lpm	800 gpm	3050 lpm	4907 gpm	18,572 lpm
200 gpm	760 lpm	850 gpm	3200 lpm		
215.8 gpm	815 lpm	900 gpm	3400 lpm		
250 gpm	950 lpm				

Pressure			
5 psi	0.3 bar	75	5.2 bar
7	0.5 bar	90	6.2 bar
10	0.7 bar	100	6.9 bar
11	.8 bar	150	10 bar
15	1.0 bar	165	11 bar
20	1.4 bar	175	12 bar
22	15 bar	189	13 bar
25	1.7 bar	200	14 bar
30	2.1 bar	259	17 bar
35	2.4 bar	300	21 bar
50	3.4 bar	400	28 bar
63	4.3 bar		

Gauge	
12	2.8 mm
14	1.98 mm
16	1.57 mm
22	.78 mm
24	.63mm

Dimensions Found in NFPA 13-2016

Weight			
6 lb	2.7 kg	350 lb	160 kg
10 lb	4.5 kg	440 lb	200 kg
20 lb	9.1 kg	520 lb	235 kg
40 lb	18 kg	750 lb	340 kg
61 lb	27 kg	787 lb	355 kg
91 lb	41 kg	1200 lb	544 kg
131 lb	59 kg	1634 lb	740 kg
200 lb	91 kg	2000 lb	907 kg
250 lb	115 kg	2300 lb	1043 kg
		4000 lb	1815 kg

Velocity	
30 mph	49 km/h

Dimensions Found in NFPA 13-2016

Discharge Density			
gpm/ft2	mm/min	gpm/ft2	mm/min
.005	.2	.425	17.3
.05	2.04	.426	17.4
.1	4.1	.44	17.9
.15	6.1	.45	18.3
.16	6.5	.46	18.7
.17	7.0	.49	20
.18	7.3	.5	20.4
.19	7.7	.55	22.4
.2	8.2	.56	22.8
.21	8.6	.57	23.2
.225	9.2	.6	24.5
.24	9.8	.61	24.9
.25	10.2	.65	26.5
.26	10.6	.68	27.7
.28	11.4	.7	28.5
.29	11.8	.74	30.2
.3	12.2	.75	30.6
.31	12.6	.77	31.4
.32	13.0	.8	32.6
.33	13.4	.85	34.6
.34	13.9	.9	36.7
.35	14.3	.92	37.5
.37	15.1	.96	39.1
.375	15.3	1.1	44.8
.39	15.9	1.2	48.9
.4	16.3	6.0	245
.42	17.1	7.5	306

**Second Revision No. 369-NFPA 13-2017 [Section No. 3.3.8.2]****3.3.8.2** Closed Array (Rolled Paper).

A vertical storage arrangement in which the distances between columns in both directions are short [not more than 2 in. (50 mm) in one direction and 1 in. (25 mm) in the other].

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Thu Jun 29 12:46:28 EDT 2017

Committee Statement

Committee Statement: Editorial.

Response Message:

**Second Revision No. 370-NFPA 13-2017 [Sections 3.3.8.4, 3.3.8.5]****3.3.8.4** Open Array (Rolled Paper).

A vertical storage arrangement in which the distance between columns in both directions is lengthy (all vertical arrays other than closed or standard).

3.3.8.5* Standard Array (Rolled Paper).

A vertical storage arrangement in which the distance between columns in one direction is short [1 in. (25 mm) or less] and is in excess of 2 in. (50 mm) in the other direction.

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submission Date: Thu Jun 29 12:47:55 EDT 2017

Committee Statement

Committee Statement: Editorial.

Response Message:

**Second Revision No. 371-NFPA 13-2017 [Section No. 3.3.33]**

3.3.32 Closed Array (Rolled Paper).

See 3.3.8.2.

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Thu Jun 29 12:49:20 EDT 2017

Committee Statement

Committee Statement: Editorial.

Response Message:

**Second Revision No. 372-NFPA 13-2017 [Section No. 3.3.39]****3.3.34** Column (Rolled Paper) .

A single vertical stack of rolls.

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Thu Jun 29 12:50:43 EDT 2017

Committee Statement

Committee Statement: Editorial.

Response Message:

**Second Revision No. 373-NFPA 13-2017 [Section No. 3.3.50]****3.3.49** Core (Rolled Paper) .

The central tube around which paper is wound to form a roll.

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Thu Jun 29 12:52:04 EDT 2017

Committee Statement

Committee Statement: Editorial.

Response Message:

**Second Revision No. 333-NFPA 13-2017 [Sections 3.3.70, 3.3.71]**

3.3.70 Extra Hazard (Group 1) (EH1) .

See 3.3.135.1.

3.3.71 Extra Hazard (Group 2) (EH2) .

See 3.3.135.2.

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Wed Jun 28 17:27:24 EDT 2017

Committee Statement

Committee Statement: Editorial.

Response Message:

**Second Revision No. 368-NFPA 13-2017 [Section No. 3.3.128]****3.3.128 Multiple-Row Racks.**

Racks greater than 12 ft (~~300 mm~~ 3.7 m) in depth or single- or double-row racks separated by aisles less than 3.5 ft (1.1 m) wide having an overall width greater than 12 ft (~~300 mm~~ 3.7 m).

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Thu Jun 29 12:44:39 EDT 2017

Committee Statement

Committee Statement: Editorial.

Response Message:

**Second Revision No. 334-NFPA 13-2017 [Sections 3.3.135.1, 3.3.135.2]****3.3.135.1** Extra Hazard (Group 1) (EH1) .

Extra hazard (Group 1) ~~occupancies shall be defined as occupancies~~ Occupancies or portions of other occupancies where the quantity and combustibility of contents are very high and dust, lint, or other materials are present, introducing the probability of rapidly developing fires with high rates of heat release but with little or no combustible or flammable liquids.

3.3.135.2 Extra Hazard (Group 2) (EH2) .

Extra hazard (Group 2) ~~occupancies shall be defined as occupancies~~ Occupancies or portions of other occupancies with moderate to substantial amounts of flammable or combustible liquids or occupancies where shielding of combustibles is extensive.

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Wed Jun 28 17:31:30 EDT 2017

Committee Statement

Committee Statement: Editorial.

Response Message:

**Second Revision No. 335-NFPA 13-2017 [Sections 3.3.135.4, 3.3.135.5]****3.3.135.4 Ordinary Hazard (Group 1) (OH1) .**

~~Ordinary hazard (Group 1) occupancies shall be defined as occupancies~~ Occupancies or portions of other occupancies where the quantity and combustibility of the contents does not exceed the amount of miscellaneous storage of Class 2, 3, 4, plastics, tires, and roll paper provided in ~~Table 13.2.1~~ Table 4.3.1.7.1 .

3.3.135.5 Ordinary Hazard (Group 2) (OH2) .

~~Ordinary hazard (Group 2) occupancies shall be defined as occupancies~~ Occupancies or portions of other occupancies where the quantity and combustibility of contents are moderate to high, stockpiles of contents with moderate rates of heat release do not exceed 12 ft (3.66 m), and stockpiles of contents with high rates of heat release do not exceed 8 ft (2.4 m).

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Wed Jun 28 17:33:45 EDT 2017

Committee Statement

Committee Statement: Editorial.

Response Message:

**Second Revision No. 374-NFPA 13-2017 [Section No. 3.3.140]**

3.3.140 Open Array (Rolled Paper).

See 3.3.8.4.

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Thu Jun 29 12:53:19 EDT 2017

Committee Statement

Committee Statement: Editorial.

Response Message:

**Second Revision No. 336-NFPA 13-2017 [Sections 3.3.144, 3.3.145]**

3.3.144 Ordinary Hazard (Group 1) (OH1) .

See 3.3.135.4.

3.3.145 Ordinary Hazard (Group 2) (OH2) .

See 3.3.135.5.

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Wed Jun 28 17:38:49 EDT 2017

Committee Statement

Committee Statement: Editorial.

Response Message:

**Second Revision No. 375-NFPA 13-2017 [Section No. 3.3.208]**

3.3.209 Standard Array (Rolled Paper).

See 3.3.8.5.

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Thu Jun 29 12:54:39 EDT 2017

Committee Statement

Committee Statement: Editorial.

Response Message:

**Second Revision No. 376-NFPA 13-2017 [Section No. 3.3.220]****3.3.220*** Tiered Storage (Baled Cotton) .

An arrangement in which bales are stored directly on the floor, two or more bales high.

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Thu Jun 29 12:55:47 EDT 2017

Committee Statement

Committee Statement: Editorial.

Response Message:

**Second Revision No. 367-NFPA 13-2017 [Section No. 4.2]****4.2* Owner's Certificate.**

The owner(s) of a building or structure where the fire sprinkler system is going to be installed or their authorized agent shall provide the sprinkler system installer with the following information prior to the layout and detailing of the fire sprinkler system [see *Figure A.4.6(b)* *Figure A.27.1(b)*]:

- (1) Intended use of the building including the materials within the building and the maximum height of any storage
- (2) A preliminary plan of the building or structure along with the design concepts necessary to perform the layout and detail for the fire sprinkler system
- (3) Water supply information as identified in 5.2.2.2.1
- (4)* Any special knowledge of the water supply, including known environmental conditions that might be responsible for corrosion, including microbiologically influenced corrosion (MIC)

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Thu Jun 29 08:39:04 EDT 2017

Committee Statement

Committee Statement: This information is required prior to the design of the system.

Response Message:

**Second Revision No. 302-NFPA 13-2017 [Sections 4.3.1.5.1, 4.3.1.5.2]****4.3.1.5.1**

For storage of Class I through Class IV commodities 12 ft (3.7 m) or less in height that ~~does~~ do not meet the definition of *Miscellaneous Storage* that is on solid shelf racks, in-rack sprinklers shall be provided in accordance with ~~46.4.6~~ 25.6.1 , and ceiling sprinkler protection shall be provided in accordance with ~~Chapter 13~~ this chapter for the applicable occupancy hazard criteria .

4.3.1.5.2

For storage of Group A ~~Plastics~~ plastic commodities 5 ft (1.5 m) or less in height that ~~does~~ do not meet the definition of *Miscellaneous Storage* that is on solid shelf racks, in-rack sprinklers shall be provided in accordance with ~~47.4.5~~ 25.6.1 , and ceiling sprinkler protection shall be provided in accordance with ~~Chapter 13~~ this chapter for the applicable occupancy hazard criteria .

Supplemental Information

<u>File Name</u>	<u>Description</u> <u>Approved</u>
SSD_SR-302_4.3.1.5.1_2_leg_changes.docx	For staff use.

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Wed Jun 28 10:40:41 EDT 2017

Committee Statement

Committee Statement: In the First Draft Report the references are from the 2016 edition of the NFPA 13. These matters need to be revised to match the new chapter structure for the standard.

Response Message:

Public Comment No. 310-NFPA 13-2017 [Sections 4.3.1.5.1, 4.3.1.5.2]



Second Revision No. 387-NFPA 13-2017 [New Section after 4.3.1.6.2]

4.3.1.7 Protection Criteria for Miscellaneous and Low-Piled Storage.

4.3.1.7.1

The protection criteria for miscellaneous and low-piled storage protected by ceiling sprinklers only shall be selected from Table 4.3.1.7.1 and Figure 19.3.3.1.1 in accordance with the density/area method of 19.3.3.2.

Table 4.3.1.7.1 Discharge Criteria for Miscellaneous Storage Up to 12 ft (3.7 m) in Height

Commodity	Type of Storage	Storage Height		Maximum Ceiling Height		Design Curve Figure 19.3.3.1.1	Note	Inside Hose		Total Combined Inside and Outside Hose		
		ft	m	ft	m			gpm	L/min	gpm	L/min	
Class I to Class IV												
Class I	Solid-piled, palletized, bin box, shelf, single-, double-, multiple-row rack, and back-to-back shelf storage	≤12	≤3.7	=	=	OH1	-	0, 50, 100	0, 190, 380	250	950	
Class II		≤10	≤3.0	=	=	OH1	-	0, 50, 100	0, 190, 380	250	950	
Class II		>10 to ≤12	>3.0 to ≤3.7	=	=	OH2	-	0, 50, 100	0, 190, 380	250	950	
Class III		≤12	≤3.7	=	=	OH2	-	0, 50, 100	0, 190, 380	250	950	
Class IV		≤10	≤3.0	=	=	OH2	-	0, 50, 100	0, 190, 380	250	950	
Class IV	Palletized, bin box, shelf, and solid-piled	>10 to ≤12	>3.0 to ≤3.7	32	10	OH2	-	0, 50, 100	0, 190, 380	250	950	
	Single-, double-, multiple-row rack and back-to-back shelf storage	>10 to ≤12	>3.0 to ≤3.7	32	10	EH1	-	0, 50, 100	0, 190, 380	500	1900	
	Singles, double-, multiple-row rack	>10 to ≤12	>3.0 to ≤3.7	32	10	See Chapter 25	+1 level of in-rack	0, 50, 100	0, 190, 380	250	950	
Group A Plastic Storage												
Cartoned	Nonexpanded and expanded	Solid-piled, palletized, bin box, shelf, single-, double-, multiple-row rack, and back-to-back shelf storage	≤5	≤1.5	=	=	OH2	-	0, 50, 100	0, 190, 380	250	950
			>5 to ≤10	>1.5 to ≤3.0	15	4.6	EH1	-	0, 50, 100	0, 190, 380	500	1900
			>5 to ≤10	>1.5 to ≤3.0	20	6.1	EH2	-	0, 50, 100	0, 190, 380	500	1900
			>10 to ≤12	>3.0 to ≤3.7	17	5.2	EH2	-	0, 50, 100	0, 190, 380	500	1900

<u>Commodity</u>	<u>Type of Storage</u>	<u>Storage Height</u>		<u>Maximum Ceiling Height</u>		<u>Design Curve Figure</u> 19.3.3.1.1	<u>Note</u>	<u>Inside Hose</u>		<u>Total Combined Inside and Outside Hose</u>	
		<u>ft</u>	<u>m</u>	<u>ft</u>	<u>m</u>			<u>gpm</u>	<u>L/min</u>	<u>gpm</u>	<u>L/min</u>
<u>Exposed</u>	<u>Solid-piled, palletized, bin box, shelf, and back-to-back shelf storage</u>	<u>>10</u> <u>to</u> <u>≤12</u>	<u>>3.0</u> <u>to</u> <u>≤3.7</u>	<u>32</u>	<u>10</u>	<u>EH2</u>	-	<u>0</u> <u>50</u> <u>100</u>	<u>0</u> <u>190</u> <u>380</u>	<u>500</u>	<u>1900</u>
	<u>Single-, double-, multiple-row rack</u>	<u>>10</u> <u>to</u> <u>≤12</u>	<u>>3.0</u> <u>to</u> <u>≤3.7</u>	<u>32</u>	<u>10</u>	<u>See Chapter 25</u>	<u>+ 1 level of in-rack</u>	<u>0</u> <u>50</u> <u>100</u>	<u>0</u> <u>190</u> <u>380</u>	<u>250</u>	<u>950</u>
	<u>Solid-piled, palletized, bin box, shelf, single-, double-, multiple-row rack, and back-to-back shelf storage</u>	<u>≤5</u>	<u>≤1.5</u>	<u>=</u>	<u>=</u>	<u>OH2</u>	-	<u>0</u> <u>50</u> <u>100</u>	<u>0</u> <u>190</u> <u>380</u>	<u>250</u>	<u>950</u>
	<u>Nonexpanded and expanded</u> <u>Solid-piled, palletized, bin box, shelf, and back-to-back shelf storage</u>	<u>>5</u> <u>to</u> <u>≤8</u>	<u>>1.5</u> <u>to</u> <u>≤2.4</u>	<u>28</u>	<u>8.5</u>	<u>EH2</u>	-	<u>0</u> <u>50</u> <u>100</u>	<u>0</u> <u>190</u> <u>380</u>	<u>500</u>	<u>1900</u>
	<u>Solid-piled, palletized, bin box, shelf, single-, double-, multiple-row rack, and back-to-back shelf storage</u>	<u>>5</u> <u>to</u> <u>≤10</u>	<u>>1.5</u> <u>to</u> <u>≤3.0</u>	<u>15</u>	<u>4.6</u>	<u>EH2</u>	-	<u>0</u> <u>50</u> <u>100</u>	<u>0</u> <u>190</u> <u>380</u>	<u>500</u>	<u>1900</u>
	<u>Nonexpanded</u> <u>Solid-piled, palletized, bin box, shelf, single-, double-, multiple-row rack, and back-to-back shelf storage</u>	<u>>5</u> <u>to</u> <u>≤10</u>	<u>>1.5</u> <u>to</u> <u>≤3.0</u>	<u>20</u>	<u>6.1</u>	<u>EH2</u>	-	<u>0</u> <u>50</u> <u>100</u>	<u>0</u> <u>190</u> <u>380</u>	<u>500</u>	<u>1900</u>
	<u>Expanded</u> <u>Single-, double-, multiple-row rack</u>	<u>>5</u> <u>to</u> <u>≤10</u>	<u>>1.5</u> <u>to</u> <u>≤3.0</u>	<u>20</u>	<u>6.1</u>	<u>See Chapter 25</u>	<u>+1 level of in-rack</u>	<u>0</u> <u>50</u> <u>100</u>	<u>0</u> <u>190</u> <u>380</u>	<u>250</u>	<u>950</u>
	<u>Nonexpanded and expanded</u> <u>Solid-piled, palletized, bin box, shelf, and back-to-back shelf storage</u>	<u>>10</u> <u>to</u> <u>≤12</u>	<u>>3.0</u> <u>to</u> <u>≤3.7</u>	<u>17</u>	<u>5.2</u>	<u>EH2</u>	-	<u>0</u> <u>50</u> <u>100</u>	<u>0</u> <u>190</u> <u>380</u>	<u>500</u>	<u>1900</u>

Commodity	Type of Storage	Storage Height		Maximum Ceiling Height		Design Curve Figure 19.3.3.1.1	Note	Inside Hose		Total Combined Inside and Outside Hose		
		ft	m	ft	m			gpm	L/min	gpm	L/min	
		>10 to ≤12	>3.0 to ≤3.7	17	5.2			EH2	-	0, 50, 100	0, 190, 380	500
Tires	Single-, double-, multiple-row rack	>10 to ≤12	>3.0 to ≤3.7	32	10	See Chapter 25.	+1 level of in-rack	0, 50, 100	0, 190, 380	250	950	
	Tire Storage											
	On floor, on side	>5 to ≤12	>1.5 to ≤3.7	32	10	EH1	-	0, 50, 100	0, 190, 380	500	1900	
	On floor, on tread, or on side	≤5	≤1.5	=	=	OH2	-	0, 50, 100	0, 190, 380	250	950	
	Single-, double-, or multiple-row racks on tread or on side	≤5	≤1.5	=	=	OH2	-	0, 50, 100	0, 190, 380	250	950	
	Single-row rack, portable, on tread or on side	>5 to ≤12	>1.5 to ≤3.7	32	10	EH1	-	0, 50, 100	0, 190, 380	500	1900	
	Single-row rack, fixed, on tread or on side	>5 to ≤12	>1.5 to ≤3.7	32	10	EH1	-	0, 50, 100	0, 190, 380	500	950	
		>5 to ≤12	>1.5 to ≤3.7	32	10	See Chapter 25.	+1 level of in-rack	0, 50, 100	0, 190, 380	250	950	
	Rolled Paper Storage											
	Heavyweight and mediumweight	On end	≤10	≤3.0	30	9.1	OH2	-	0, 50, 100	0, 190, 380	250	950
	Tissue and lightweight	On end	≤10	≤3.0	30	9.1	EH1	-	0, 50, 100	0, 190, 380	250	950

4.3.1.7.1.1

The protection criteria for rack storage of miscellaneous and low-piled storage with in-rack sprinklers shall be in accordance with 25.2.2 .

4.3.1.7.2

Except as provided in 4.3.1.6.1 , the maximum design area for miscellaneous and low-piled storage shall not exceed 3000 ft ² (279 m ²).

Supplemental Information

<u>File Name</u>	<u>Description</u>	<u>Approved</u>

New_Table_4.3.1.7.1.docx

Table 4.3.1.7.1. For staff use.

Submitter Information Verification

Submitter Full Name: AUT-SSD**Organization:** [Not Specified]**Street Address:****City:****State:****Zip:****Submittal Date:** Thu Jul 13 15:26:26 EDT 2017

Committee Statement

Committee Statement: Former Table 13.2.1 has been added back into the 2019 edition as Table 4.3.1.7.1 in order to make it easier for the end user to find ceiling only criteria for miscellaneous and low-piled storage applications. For in-rack information the user must go to Chapter 25.

Response Message:

[Public Comment No. 174-NFPA 13-2017 \[New Section after A.19.3.2.6\]](#)

[Public Comment No. 313-NFPA 13-2017 \[Section No. 20.1.1\]](#)

**Second Revision No. 388-NFPA 13-2017 [Section No. 4.3.3]****4.3.3* Ordinary Hazard (Group 1).**

The following shall be protected with ~~ordinary hazard group 1~~ OH1 occupancy criteria in this standard:

- (1) Spaces with moderate quantity and low combustibility of contents
- (2) Stockpiles of contents with low combustibility that do not exceed 8 ft (2.4 m)

~~Miscellaneous storage or storage facilities of solid-piled, palletized, bin box, shelf, rack, and back-to-back shelf storage of Class I commodities not exceeding 12 ft (3.7 m)~~

~~Miscellaneous storage or storage facilities of solid-piled, palletized, bin box, shelf, rack, and back-to-back shelf storage of Class II commodities not exceeding 10 ft (3.0 m)~~

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Fri Jul 14 08:15:19 EDT 2017

Committee Statement

Committee Statement: The list items have been deleted because they are redundant to what is in Table 4.3.1.7.1.

Response Message:



Second Revision No. 303-NFPA 13-2017 [Section No. 4.3.4]

4.3.4* Ordinary Hazard (Group 2).

The following shall be protected with ordinary hazard group 2 OH2 occupancy criteria in this standard:

(1) Spaces with moderate to high quantity and combustibility of contents

(2) Stockpiles of contents with moderate to high combustibility that do not exceed 12 ft (3.7 m)

~~Miscellaneous or low-piled storage of solid-piled, palletized, bin box, shelf, rack, and back-to-back shelf storage of Class II commodities more than 10 ft (3.0 m) and not exceeding 12 ft (3.7 m)~~

~~Miscellaneous or low-piled storage of solid-piled, palletized, bin box, shelf, rack, and back-to-back shelf storage of Class III commodities not exceeding 12 ft (3.7 m)~~

~~Miscellaneous or low-piled storage of solid-piled, palletized, bin box, shelf, rack, and back-to-back shelf storage of Class IV commodities not exceeding 10 ft (3.0 m)~~

~~Miscellaneous or low-piled storage of solid-piled, palletized, bin box, and shelf storage of Class IV commodities more than 10 ft (3.0 m) and not exceeding 12 ft (3.7 m) and a maximum ceiling height of 32 ft (9.8 m)~~

~~Miscellaneous or low-piled storage of solid-piled, palletized, bin box, shelf, rack, and back-to-back shelf storage of Group A commodities not exceeding 5 ft (1.5 m)~~

~~Miscellaneous storage of rack storage of Group A commodities more than 10 ft (3.0 m) and not exceeding 12 ft (3.7 m) and a maximum ceiling height of 32 ft (9.8 m) with the use of 1 level of in-rack sprinklers~~

~~Miscellaneous storage of rack storage of exposed expanded Group A commodities more than 5 ft (1.5 m) and not exceeding 10 ft (3.0 m) and a maximum ceiling height of 20 ft (5.1 m) with the use of 1 level of in-rack sprinklers~~

~~Miscellaneous tire storage stored on floor or in rack either on tread or on side not exceeding 5 ft (1.5 m)~~

~~Miscellaneous tire storage stored on a fixed single-row rack either on tread or on side more than 5 ft (1.5 m) and not exceeding 12 ft (3.7 m) and a maximum ceiling height of 32 ft (9.8 m) with the use of 1 level of in-rack sprinklers~~

~~Miscellaneous store of medium weight and heavyweight rolled paper stored on end not exceeding 10 ft (3.0 m) and a maximum ceiling height of 30 ft (9.1 m)~~

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Wed Jun 28 10:44:29 EDT 2017

Committee Statement

Committee Statement: The list items have been deleted because they are redundant to what is in Table 4.3.1.7.1.

Response Message:

[Public Comment No. 275-NFPA 13-2017 \[Section No. 4.3.4\]](#)



Second Revision No. 389-NFPA 13-2017 [Sections 4.3.5, 4.3.6]

4.3.5* Extra Hazard (Group 1) (EH1).

The following shall be protected with extra-hazard-group-1 EH1 occupancy criteria in this standard:

- (1) Spaces with very high quantity and combustibility of contents
- (2) Spaces where dust, lint, or other materials are present, introducing the probability of rapidly developing fires

~~Miscellaneous or low-piled storage of rack and back-to-back shelf storage of Class IV commodities more than 10 ft (3.0 m) and not exceeding 12 ft (3.7 m) and a maximum ceiling height of 32 ft (9.8 m)~~

~~Miscellaneous or low-piled storage of solid-piled, palletized, bin box, shelf, rack, and back-to-back shelf storage of cartoned Group A commodities more than 5 ft (1.5 m) and not exceeding 10 ft (3.0 m) and a maximum ceiling height of 15 ft (4.6 m)~~

~~Miscellaneous tire storage stored on floor on side or in single-row rack (portable and fixed) either on tread or on side more than 5 ft (1.5 m) and not exceeding 12 ft (3.7 m) and a maximum ceiling height of 32 ft (9.8 m)~~

~~Miscellaneous storage of tissue and lightweight rolled paper stored on end not exceeding 10 ft (3.0 m) and a maximum ceiling height of 30 ft (9.1 m)~~

Global SR-531

4.3.6* Extra Hazard (Group 2) (EH2).

The following shall be protected with extra-hazard-group-2 EH2 occupancy criteria in this standard:

- (1) Spaces with very high quantity and combustibility of contents
- (2) Spaces with substantial amounts of combustible or flammable liquids
- (3) Spaces where shielding of combustibles is extensive

~~Miscellaneous or low-piled storage of solid-piled, palletized, bin box, shelf, rack, and back-to-back shelf storage of cartoned Group A commodities more than 5 ft (1.5 m) and not exceeding 10 ft (3.0 m) and a maximum ceiling height of 20 ft (6.1 m)~~

~~Miscellaneous or low-piled storage of solid-piled, palletized, bin box, shelf, rack, and back-to-back shelf storage of cartoned Group A commodities more than 10 ft (3.0 m) and not exceeding~~

~~Miscellaneous or low-piled storage of solid-piled, palletized, bin box, shelf, and back-to-back shelf storage of cartoned Group A commodities more than 10 ft (3.0 m) and not exceeding 12 ft (3.7 m) and a maximum ceiling height of 32 ft (9.8 m)~~

~~Miscellaneous or low-piled storage of solid-piled, palletized, bin box, shelf, and back-to-back shelf storage of exposed Group A commodities more than 5 ft (1.5 m) and not exceeding 8 ft (2.4 m) and a maximum ceiling height of 28 ft (8.5 m)~~

~~Miscellaneous storage of solid-piled, palletized, bin box, shelf, rack, and back-to-back shelf storage of exposed Group A commodities more than 5 ft (1.5 m) and not exceeding 10 ft (3.0 m) and a maximum ceiling height of 15 ft (4.6 m)~~

~~Miscellaneous storage of solid-piled, palletized, bin box, shelf, rack, and back-to-back shelf storage of exposed unexpanded Group A commodities more than 5 ft (1.5 m) and not exceeding 10 ft (3.0 m) and a maximum ceiling height of 20 ft (6.1 m)~~

~~Miscellaneous storage of solid-piled, palletized, bin box, shelf, and back-to-back shelf storage of exposed Group A commodities more than 10 ft (3.0 m) and not exceeding 12 ft (3.7 m) and a maximum ceiling height of 17 ft (5.2 m)~~

~~Miscellaneous storage of rack storage of exposed Group A commodities more than 10 ft (3.0 m) and not exceeding 12 ft (3.7 m) and a maximum ceiling height of 17 ft (5.2 m)~~

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]
Street Address:
City:
State:
Zip:
Submittal Date: Fri Jul 14 08:18:04 EDT 2017

Committee Statement

Committee Statement: The list items have been deleted because they are redundant to what is in Table 4.3.1.7.1.
Response Message:

**Second Revision No. 384-NFPA 13-2017 [Section No. 4.5.2]****4.5.2**

The floor area occupied by mezzanines shall ~~not be included in the area limits of 4.5.1~~ comply with 4.5.2.1 , 4.5.2.2 , or 4.5.2.3 .

4.5.2.1

In a building with only one sprinkler system, the floor area occupied by mezzanines shall not be included in the area limits of 4.5.1 .

4.5.2.2

In a building with more than one sprinkler system, if a mezzanine is located entirely within the same sprinkler system boundary as the sprinklers protecting the ceiling above, the floor area occupied by mezzanine(s) shall not be included in the area limits of 4.5.1 .

4.5.2.3

In a building with more than one sprinkler system, if any portion of the mezzanine floor area that is located outside the system boundary of the riser supplying the sprinklers under the mezzanine, the area of the mezzanine of the system boundary shall be added to the system area from which it is supplied, and the total system area shall meet the limits of 4.5.1 .

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Thu Jul 13 11:48:47 EDT 2017

Committee Statement

Committee Statement: Without the acceptance of this proposal in a large multi-system building it is possible to have a single riser supplying a system of up to 52,000 sqft and also supply a mezzanine of unlimited size. It is not the intent to allow a single system riser to control an unlimited area.

This was submitted as a public proposal and resolved stating that this is addressed in the annex. This issue is not addressed in the annex. For example a single riser in a 1,000,000 sqft building may supply a 52,000 sqft roof system and also a 300,000 sqft mezzanine. I don't believe that it is the intend of the section to allow 352,000 sqft to be supplied by a single riser.

Response Message:

Public Comment No. 122-NFPA 13-2017 [Section No. 4.5.2]

**Second Revision No. 385-NFPA 13-2017 [Section No. 4.5.4]****4.5.4**

The area protected by a single in-rack system includes all of the floor area occupied by the racks, including aisles, regardless of the number of levels of in-rack sprinklers.

4.5.4.2

~~The area protected by a single in-rack system shall include all of the floor area occupied by the racks, including aisles, regardless of the number of levels of in-rack sprinklers.~~

4.5.4.2.1

~~Multiple buildings attached by canopies, covered breezeways, common roofs, or a common wall(s) shall be permitted to be supplied by a single fire sprinkler riser.~~

4.5.4.1

Multiple buildings attached by canopies, covered breezeways, common roofs, or a common wall(s) shall be permitted to be supplied by a single fire sprinkler riser.

4.5.5

The maximum system size shall comply with 4.5.1.

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Thu Jul 13 11:59:57 EDT 2017

Committee Statement

Committee Statement: In the First Draft Report, the text of 4.5.4 and 4.5.4.1 is duplicated in 4.5.4.2 and 4.5.4.2.1. The redundant text should be deleted. Renumber remainder of Chapter accordingly.

Response Message:

[Public Comment No. 230-NFPA 13-2017 \[Section No. 4.5.4\]](#)

**Second Revision No. 364-NFPA 13-2017 [Section No. 4.6]****27.1* Working Plans.****27.1.1***

Working plans shall be submitted for approval to the authority having jurisdiction before any equipment is installed or remodeled.

27.1.1.1

Working plan submittals shall include the following:

- (1) Working plans of the system(s), per 27.1.3
- (2) Hydraulic calculations where systems are required to be calculated
- (3) Data sheets for the system components where required by the AHJ authority having jurisdiction
- (4)* Signed owner's certificate

27.1.1.2

Submittals shall be permitted to be in electronic format when approved by the authority having jurisdiction.

27.1.1.3

A copy of the approved plans shall be given to the owner or owner's representative.

27.1.2

Deviation from approved plans shall require permission of the authority having jurisdiction.

27.1.3

Working plans shall be drawn to an indicated scale, on sheets of uniform size, with a plan of each floor, and shall show those items from the following list that pertain to the design of the system:

- (1) Name of owner and occupant.
- (2) Location, including street address.
- (3) Point of compass.
- (4) Full height cross section or schematic diagram, including structural member information if required for clarity and including ceiling construction and method of protection for nonmetallic piping.
- (5) Ceiling/roof heights and slopes not shown in the full height cross section.
- (6) Location of partitions.
- (7) Location of fire walls.
- (8) Occupancy class of each area or room.
- (9) Location and size of concealed spaces, closets, attics, and bathrooms.
- (10) Any small enclosures in which no sprinklers are to be installed.
- (11) Size of city main in street and whether dead end or circulating; if dead end, direction and distance to nearest circulating main; and city main test results and system elevation relative to test hydrant.
- (12) Other sources of water supply, with pressure or elevation.
- (13) Make, type, model, and nominal K-factor of sprinklers, including sprinkler identification number.
- (14) Temperature rating and location of high-temperature sprinklers.
- (15) Total area protected by each system on each floor.
- (16) Number of sprinklers on each riser per floor.
- (17) Total number of sprinklers on each dry pipe system, preaction system, combined dry pipe–preaction system, or deluge system.
- (18) Approximate capacity in gallons of each dry pipe system.
- (19) Pipe type and schedule of wall thickness.
- (20) Nominal pipe size and cutting lengths of pipe (or center-to-center dimensions). Where typical branch lines prevail, it shall be necessary to size only one typical line.
- (21) Location and size of riser nipples.
- (22) Type of fittings and joints and location of all welds and bends. The contractor shall specify on drawing any sections to be shop welded and the type of fittings or formations to be used.
- (23) Type and locations of hangers, sleeves, braces, and methods of securing sprinklers when applicable.
- (24) All control valves, check valves, drain pipes, and test connections.
- (25) Size Make , location type , and valve and piping arrangement for model, and size of backflow prevention assembly, and means to forward flow test at system demand.
- (26) Make, type, model, and size of alarm or dry pipe valve.
- (27) Make, type, model, and size of preaction or deluge valve.
- (28) Kind and location of alarm bells.
- (29) Size and location of standpipe risers, hose outlets, hand hose, monitor nozzles, and related equipment.
- (30) Private fire service main sizes, lengths, locations, weights, materials, point of connection to city main; the sizes, types and locations of valves, valve indicators, regulators, meters, and valve pits; and the depth that the top of the pipe is laid below grade.
- (31) Piping provisions for flushing.
- (32) Where the equipment is to be installed as an addition to an existing system, enough of the existing system indicated on the plans to make all conditions clear.
- (33) For hydraulically designed systems, the information on the hydraulic data nameplate.

- (34) A graphic representation of the scale used on all plans.
- (35) Name, address, and phone number(s) of contractor.
- (36) Hydraulic reference points shown on the plan that correspond with comparable reference points on the hydraulic calculation sheets.
- (37) The minimum rate of water application (density or flow or discharge pressure), the design area of water application, in-rack sprinkler demand, and the water required for hose streams both inside and outside.
- (38) The total quantity of water and the pressure required noted at a common reference point for each system.
- (39) Relative elevations of sprinklers, junction points, and supply or reference points.
- (40) If room design method is used, all unprotected wall openings throughout the floor protected.
- (41) Calculation of loads for sizing and details of sway bracing.
- (42) Zones of influence used in calculations for seismic bracing indicated on plans.
- (43) The setting for pressure-reducing valves.
~~Information about backflow preventers (manufacturer, size, type).~~
- (44) Information about listed antifreeze solution used (type and amount).
- (45) Size and location of hydrants showing size and number of outlets and if outlets are to be equipped with independent gate valves. Whether hose houses and equipment are to be provided, and by whom, shall be indicated. Static and residual hydrants that were used in flow tests shall be shown.
~~Utility plans and/or plumbing plans necessary to show connection from water supply to fire sprinkler system.~~
- (46) Size, location, and piping arrangement of fire department connections.
~~Ceiling/roof heights and slopes not shown in the full height cross section.~~
- (47) Edition year of NFPA 13 to which the sprinkler system is designed.

27.1.4

A signed copy of the owner's certificate and the working plan submittal shall include the manufacturer's installation instructions for any specially listed equipment, including descriptions, applications, and limitations for any sprinklers, devices, piping, or fittings.

27.1.5* Working Plans for Automatic Sprinkler Systems with Non-Fire Protection Connections.

27.1.5.1

Special symbols shall be used and explained for auxiliary piping, pumps, heat exchangers, valves, strainers, and the like, clearly distinguishing these devices and piping runs from those of the sprinkler system.

27.1.5.2

Model number, type, and manufacturer's name shall be identified for each piece of auxiliary equipment.

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Wed Jun 28 22:40:04 EDT 2017

Committee Statement

Committee Statement: The details regarding working plans are far too specific to be in a "General Requirements" chapter. They require the knowledge of many pieces of information that have not been determined by the user when they get to Chapter 4. This forces the user to circle back to Chapter 4 after reading other chapters in the book.

The rules for plans should not be separated from the rules for hydraulic calculation. Those rules were proposed for a different chapter, and I will be proposing to bring them together in the new Chapter 27. The rules for information that needs to be provided on working plans cannot be separated from hydraulic calculations. Just look at how much information in the proposed section 4.6 needs to come from the hydraulic calculations. They should be together in a chapter after the design approaches have been determined by the user.

Some of the revisions made to this section are redundant and according to my notes they were not accepted by the TC at the 1st Draft Meeting:

- The new Item 25 was edited to call for the details of the backflow preventer and provide better clarity. As written in the First Draft Report, it implies that every system requires a forward flow test connection, whereas it is only called for when there is a backflow preventer installed.
- Item 44 should be deleted, because with the new Item 25 it became redundant.
- Item 47 should be deleted, because the information is already called for in Item 30. Also, by referring to utility and plumbing plans, it suggests that the underground water service is not part of the sprinkler system.
- Item 49 should be deleted, because the information is already called for in the new Item 5.

Response Message:

[Public Comment No. 67-NFPA 13-2017 \[Section No. 4.6\]](#)

[Public Comment No. 131-NFPA 13-2017 \[Section No. 4.6.3\]](#)

[Public Comment No. 320-NFPA 13-2017 \[Section No. 4.6.3\]](#)

**Second Revision No. 305-NFPA 13-2017 [Section No. 5.1.5.2]****5.1.5.2**

Water supplies and environmental conditions shall be evaluated for conditions that contribute to unusual corrosive properties. Where conditions are found that contribute to unusual corrosive properties, the owner(s) shall notify the sprinkler system installer and a plan shall be developed to treat the system using one of the following methods:

- (1) Install a water pipe that is corrosion resistant.
- (2) Treat water that enters the system using a listed corrosion inhibitor.
- (3) Implement an approved plan for monitoring the interior conditions of the pipe at established intervals and locations.
- (4) Install corrosion monitoring station and monitor at established intervals.
- (5) Fill dry-pipe or preaction systems with nitrogen as a supervisory gas to mitigate against corrosion.
- (6) When using a generator, use an approved nitrogen generator.

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Wed Jun 28 11:23:10 EDT 2017

Committee Statement

Committee Statement: The TC removed this section from the code, which removes all recommendations to treat the water with a corrosion inhibitor. NFPA 13 section 7.8.1 'Additives to the water supply intended for control of Microbiological or other corrosion shall be listed for use within fire sprinkler systems'. UL and Huguenot Laboratories are in contract to produce a listed and approved inhibitor within the calendar year of 2017. Copies of the developed testing standard are being provided as verification of compliance that a listed inhibitor is forthcoming. Please return this section to the code now that a listing standard exists. A copy of the testing standard and contract between UL and Huguenot Laboratories are being provided as proof of compliance. Thank you.

Response Message:

[Public Comment No. 35-NFPA 13-2017 \[Section No. 5.1.5.2\]](#)

**Second Revision No. 386-NFPA 13-2017 [Section No. 5.2.2.2.1]****5.2.2.2.1***

Where a waterflow test is conducted, the volume and pressure available for use for a fire protection system shall be determined in accordance with 5.2.2.2.1.1. If knowledge of the water supply is unavailable, the volume and pressure shall be determined in accordance with 5.2.2.2.1.2. Water supply information shall be adjusted to account for seasonal and daily pressure fluctuations based on information from the water supply authority through testing or modeling and as approved by the authority having jurisdiction.

A.5.2.2.2.1

The adjustment should take into account the following variables, which will be applicable to different degrees depending on how and when the test or modeling was conducted:

- (1) Maximum daily use of the water supply
- (2) Peak hour demand of the water supply
- (3) Water supply degradation due to planned development
- (4) Time of day the test was conducted
- (5) Time of year the test was conducted
- (6) Elevation of the test location compared to the building where the sprinkler system will be installed
- (7) Elevation of the water supply at the time of the test
- (8) How close the flow generated during the test was to the system demand

There is no single specific adjustment that can be applied to every water supply that would be appropriate for every sprinkler system. The design professional needs to work in conjunction with the authority having jurisdiction to determine an appropriate adjustment. Where an authority having jurisdiction has already determined a specific buffer between test results and the demand of the sprinkler system, there is no intent to add an additional safety factor or safety margin due to this requirement. Instead, the buffer mandated by the authority having jurisdiction serves the purpose of this adjustment.

In the absence of information from the design professional and the authority having jurisdiction, it would be appropriate to make an adjustment to the raw data from a flow test by either obtaining information from the water utility or using an arbitrary adjustment. The value to use for an arbitrary adjustment should be determined through a conversation with the authority having jurisdiction.

It is important to note that not all water supplies have a linear relationship of flow to pressure. As flow demand increases, additional water can be provided into the system through multiple pumps, causing complex geometries to the pressure and flow relationship at any given point in the system. Creating multiple flow conditions during a test and getting as close as possible to the sprinkler system demand will help in gaining a complete understanding of the water supply.

5.2.2.2.2*

Water supply adjustments shall be based on knowledge of the water supply and engineering judgment, taking into account daily and seasonal fluctuations, not extreme conditions.

5.2.2.2.3*

If knowledge of the water supply is unavailable, the following formula shall be used to determine volume and pressure:

$$P = (P_R - P_S) \left(\frac{Q}{Q_R} \right)^{1.85} + P_L$$

[5.2.2.2.1.2]

where:

P = pressure available from the water supply to use for a fire protection system that will be calculated for a given flow (Q)

P_R = residual pressure measured during the waterflow test while the flow Q_R was discharging from the water supply

P_S = static pressure measured during the waterflow test

Q = flow that will be used to calculate the available pressure from the water supply

Q_R = flow discharging from the water supply when P_R was measured

P_L = expected low static pressure at the location of the test results accounting for daily and seasonal fluctuations (not extreme conditions) obtained from the water utility

A.5.2.2.2.1.2

Consider the following example: A waterflow test is conducted at a location where a city water main is going to be tapped for a new sprinkler system. During the test, the static pressure is measured at 70 psi (4.8 bar) the residual pressure is measured at 50 psi (3.5 bar) while 1300 gpm (4920 L/min) was discharging from a nearby hydrant. The water utility is contacted, and they indicate that a reasonable low static pressure accounting for typical daily and seasonal fluctuations in this area is 55 psi (3.8 bar). The following equation describes the water supply available for a fire sprinkler system:

$$P = (50 - 70) \left(\frac{Q}{1300} \right)^{1.85} + 55 \quad \text{[A.5.2.2.2.1.2a]}$$

There are two ways to use this formula:

Assume two different values for Q , calculate P , and then draw a graph on log 1.85 paper. Any fire sprinkler system demand falling on or below the line on this graph would be acceptable in accordance with NFPA 13 to work with this water supply. In this case, the two easiest flows to pick for Q would be 0 and 1300 gpm (4920 L/min). Where $Q = 0$, P is simply 55 psi (3.8 bar). Where $Q = 1300$ gpm (4920 L/min), $P = 35$ psi (2.4 bar). These two points can be plotted on log 1.85 paper as shown in Figure A.5.2.2.2.1.2.

Calculate the fire protection system and determine the flow necessary to make the system work. Plug this flow into the preceding formula to determine the available pressure from the water supply at that flow. For example, if a sprinkler system connected to this water supply had a demand of 580 gpm (2195 L/min) the available pressure from the water supply would be as follows:

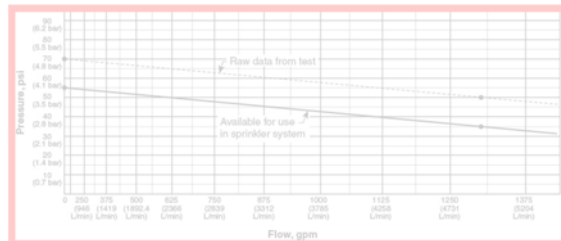
$$P = (50 - 70) \left(\frac{580}{1300} \right)^{1.85} + 55 \quad \text{[A.5.2.2.2.1.2b]}$$

$$P = (-20) (0.225) + 55$$

$$P = 50.5 \text{ psi}$$

So, as long as the sprinkler system has a pressure demand less than or equal to 50.5 psi (3.5 bar), it will work with this water supply.

Figure A.5.2.2.2.1.2 Available Water Supply Curve for Example in A.5.2.2.2.1.2.

**5.2.2.2.4**

Where the water authority does not provide a value for P_L , the value of P_L shall be calculated from the following formula:

$$P_L = P_s (0.9) \quad \text{[5.2.2.2.1.3]}$$

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]
Street Address:
City:
State:
Zip:
Submittal Date: Thu Jul 13 13:48:41 EDT 2017

Committee Statement

Committee Statement: It is difficult to provide a prescriptive safety factor that would apply to every water supply throughout the world. However, certain conditions should be considered or analyzed when determining if a water supply is adequate to meet the needs of a fire protection system. Safety factors should be the purview of local jurisdictions and where required adopted into an enforceable code amendment.

Response Message:

[Public Comment No. 133-NFPA 13-2017 \[Section No. 5.2.2.2\]](#)

[Public Comment No. 302-NFPA 13-2017 \[Section No. 5.2.2.2.1\]](#)

[Public Comment No. 324-NFPA 13-2017 \[Section No. 5.2.2.2.1\]](#)

[Public Comment No. 134-NFPA 13-2017 \[Section No. A.5.2.2.2.1.1\]](#)

[Public Comment No. 135-NFPA 13-2017 \[Section No. A.5.2.2.2.1.2\]](#)



Second Revision No. 1051-NFPA 13-2017 [Chapter 19 [Title Only]]

Design Approaches and Calculations

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: National Fire Protection Assoc

Street Address:

City:

State:

Zip:

Submittal Date: Mon Oct 16 14:31:39 EDT 2017

Committee Statement

Committee Statement: Calculations have been relocated to Chapter 27.

Response Message:

**Second Revision No. 1052-NFPA 13-2017 [Section No. 19.1]****19.1 General.**

Chapter 19 shall be utilized for design approaches ~~and calculation procedures~~ .

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: National Fire Protection Assoc

Street Address:

City:

State:

Zip:

Submittal Date: Mon Oct 16 14:32:48 EDT 2017

Committee Statement

Committee Statement: Calculations have been relocated to Chapter 27.

Response Message:

**Second Revision No. 306-NFPA 13-2017 [Section No. 19.2]****19.2 General Design Approaches.**

The requirements of Section 19.2 shall apply to all sprinkler systems unless modified by a specific section of Chapter 44 19 or Chapter 42 20.

19.2.1

A building or portion thereof shall be permitted to be protected in accordance with any applicable design approach at the discretion of the designer.

19.2.2* Adjacent Hazards or Design Methods.

For buildings with two or more adjacent hazards or design methods, the following shall apply:

- (1) Where areas are not physically separated by a draft curtain, barrier, or partition capable of delaying heat from a fire in one area from fusing sprinklers in the adjacent area, the required sprinkler protection for the more demanding design basis shall extend 15 ft (4.6 m) beyond its perimeter.
- (2) The requirements of 19.2.2(1) shall not apply where the areas are separated by a draft curtain, or barrier located above an aisle, where the aisle has a minimum 2 ft (600 mm) horizontal separation from the adjacent hazard on each side, or a partition that is capable of delaying heat from a fire in one area from fusing sprinklers in the adjacent area.
- (3) The requirements of 19.2.2(1) shall not apply to the extension of more demanding criteria from an upper ceiling level to beneath a lower ceiling level where the difference in height between the ceiling levels is at least 2 ft (600 mm), located above an aisle, where the aisle has a minimum 2 ft (600 mm) horizontal separation from the adjacent hazard on each side.

19.2.3

For hydraulically calculated systems, the total system water supply requirements for each design basis shall be determined in accordance with the procedures of Section 27.2 unless modified by a section of Chapter 44 19 or Chapter 42 20.

19.2.4 Water Demand.**19.2.4.1***

The water demand requirements shall be determined from the following:

- (1) Occupancy hazard fire control approach and special design approaches of Chapter 44 19
- (2) Storage design approaches of Chapter 42 20 through Chapter 20 25
- (3) Special occupancy approaches of Chapter 25 26

19.2.4.2*

The minimum water demand requirements for a sprinkler system shall be determined by adding the hose stream allowance to the water demand for sprinklers.

19.2.5 Water Supplies.**19.2.5.1**

The minimum water supply shall be available for the minimum duration specified in Chapter 44 19.

19.2.5.2*

Tanks shall be sized to supply the equipment that they serve.

19.2.5.3*

Pumps shall be sized to supply the equipment that they serve.

19.2.6 Hose Allowance.

19.2.6.1 Systems with Multiple Hazard Classifications.

For systems with multiple hazard classifications, the hose stream allowance and water supply duration shall be in accordance with one of the following:

- (1) The water supply requirements for the highest hazard classification within the system shall be used.
- (2) The water supply requirements for each individual hazard classification shall be used in the calculations for the design area for that hazard.
- (3)* For systems with multiple hazard classifications where the higher classification only lies within single rooms less than or equal to 400 ft² (37 m²) in area with no such rooms adjacent, the water supply requirements for the principal occupancy shall be used for the remainder of the system.

19.2.6.2*

Water allowance for outside hose shall be added to the sprinkler requirement at the connection to the city main or a private fire hydrant, whichever is closer to the system riser.

19.2.6.3

Where inside hose connections are planned or are required, the following shall apply:

- (1) A total water allowance of 50 gpm (190 L/min) for a single hose connection installation shall be added to the sprinkler requirements.
- (2) A total water allowance of 100 gpm (380 L/min) for a multiple hose connection installation shall be added to the sprinkler requirements.
- (3) The water allowance shall be added in 50 gpm (190 L/min) increments beginning at the most remote hose connection, with each increment added at the pressure required by the sprinkler system design at that point.

19.2.6.3.1

Where the system is a combined sprinkler/standpipe system (Class I or Class III) and the building is fully sprinklered in accordance with NFPA 13, no inside hose demand shall be required at any of the standpipe outlets.

19.2.6.4*

When hose valves for fire department use are attached to wet pipe sprinkler system risers in accordance with 16.15.2, the following shall apply:

- (1) The sprinkler system demand shall not be required to be added to standpipe demand as determined from NFPA 14.
- (2) Where the combined sprinkler system demand and hose stream allowance of Table 19.3.3.1.2 exceeds the requirements of NFPA 14, this higher demand shall be used.
- (3) For partially sprinklered buildings, the sprinkler demand, not including hose stream allowance, as indicated in Figure 19.3.3.1.1 shall be added to the requirements given in NFPA 14.

19.2.7* High Volume Low Speed (HVLS) Fans.

The installation of HVLS fans in buildings equipped with sprinklers, including ESFR sprinklers, shall comply with the following:

- (1) The maximum fan diameter shall be 24 ft (7.3 m).
- (2) The HVLS fan shall be centered approximately between four adjacent sprinklers.
- (3) The vertical clearance from the HVLS fan to sprinkler deflector shall be a minimum of 3 ft (0.9 m).
- (4) All HVLS fans shall be interlocked to shut down immediately upon a waterflow alarm. Where the building is protected with a fire alarm system, this interlock shall be in accordance with the requirements of *NFPA 72*.

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]
Street Address:
City:
State:
Zip:
Submittal Date: Wed Jun 28 14:13:43 EDT 2017

Committee Statement

Committee Statement: In Sections 19.2, 19.2.3 and 19.2.4.1, the references are from the 2016 edition of the NFPA 13. These matters need to be revised to match the new chapter structure for the standard.

Response Message:

[Public Comment No. 215-NFPA 13-2017 \[Section No. 19.2\]](#)

**Second Revision No. 1021-NFPA 13-2017 [Section No. 19.3.3.1.2.1]****19.3.3.1.2.1**

The maximum design area for miscellaneous and low-piled storage shall be 3000 ft² (279 m²).

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: National Fire Protection Assoc

Street Address:

City:

State:

Zip:

Submittal Date: Thu Aug 10 13:56:13 EDT 2017

Committee Statement

Committee Statement: This section has been deleted and the text has been relocated to Chapter 4.

Response Message:

[Public Comment No. 172-NFPA 13-2017 \[Section No. 19.3.3.1.2.1\]](#)

**Second Revision No. 379-NFPA 13-2017 [Section No. 19.3.3.2.7]****19.3.3.2.7**

Where K-11.2 (160) or larger sprinklers are used with ~~EH1 or EH2 design curves from Figure 13.2.4~~ Extra Hazard Group 1 or Extra Hazard Group 2 design curves and 19.3.3.1.1 , the design area shall be permitted to be reduced by 25 percent but not below 2000 ft² (186 m²), regardless of temperature rating.

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Thu Jun 29 15:07:39 EDT 2017

Committee Statement

Committee Statement: The exiting figure has been deleted and replaced with references in the standard.

Response Message:



Second Revision No. 309-NFPA 13-2017 [Section No. 19.3.3.2.3.1]

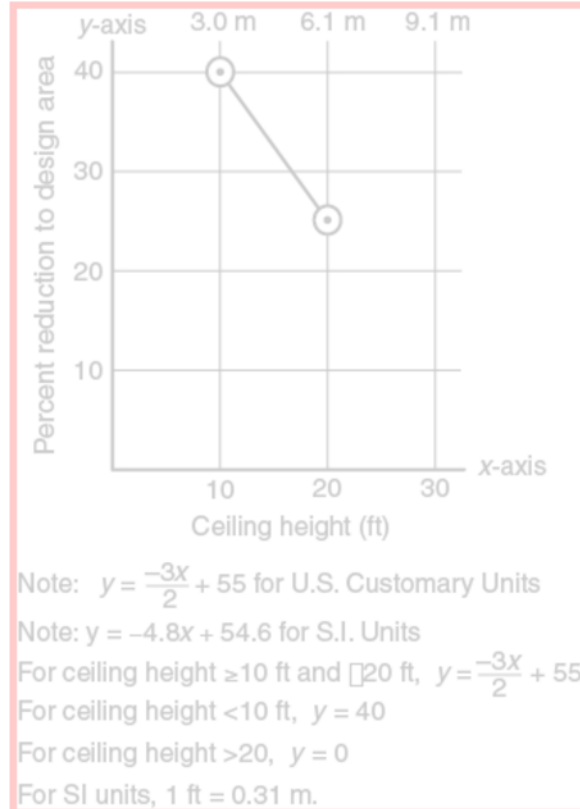


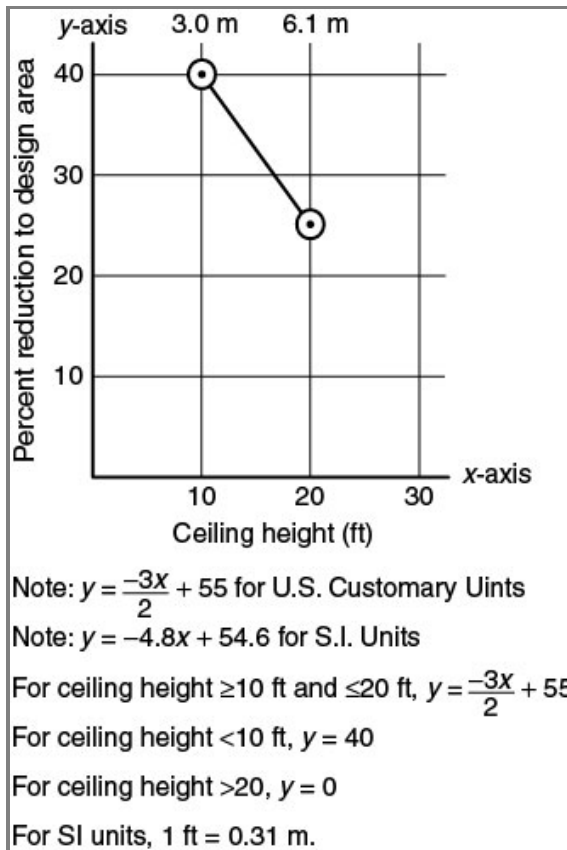
19.3.3.2.3.1

Where listed quick-response sprinklers, including extended coverage quick-response sprinklers, are used throughout a system or portion of a system having the same hydraulic design basis, the system area of operation shall be permitted to be reduced without revising the density as indicated in Figure 19.3.3.2.3.1 when all of the following conditions are satisfied:

- (1) Wet pipe system
- (2) Light hazard or ordinary hazard occupancy
- (3) 20 ft (6.1 m) maximum ceiling height
- (4) No unprotected ceiling pockets as allowed by 10.2.9 and 11.2.8 exceeding 32 ft² (3.0 m²)
- (5) No unprotected areas above cloud ceilings as allowed by 9.2.7

Figure 19.3.3.2.3.1 Design Area Reduction for Quick-Response Sprinklers.





Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Wed Jun 28 14:18:26 EDT 2017

Committee Statement

Committee Statement: In the figure that was re-drawn after the reorganization, the sign did not print correctly in the note, which alters the meaning of the figure incorrectly.

Response Message:

[Public Comment No. 160-NFPA 13-2017 \[Section No. 19.3.3.2.3.1\]](#)

**Second Revision No. 1013-NFPA 13-2017 [Detail]**

Relocate all of section 19.6, 19.7, 19.8, and 19.9 to new Chapter 27 as request by the attached PC#68.

Supplemental Information

<u>File Name</u>	<u>Description</u> <u>Approved</u>
13-SSD_SR-1013_order_for_new_Ch_27.docx	For staff use.

Submitter Information Verification

Submitter Full Name: AUT-SSD
Organization: National Fire Protection Assoc
Street Address:
City:
State:
Zip:
Submittal Date: Tue Aug 01 08:03:21 EDT 2017

Committee Statement

Committee Statement: The hydraulic calculations should not be separated from the working plan requirements and should not be before the design approaches for storage. In the flow of the proposed new standard, the design approaches for storage are separated from the design approaches for light, ordinary and extra hazard occupancies by the calculation rules. That just does not flow correctly. It forces the user to circle backwards through the standard for storage protection.

Response Message:

[Public Comment No. 68-NFPA 13-2017 \[Sections 19.6, 19.7, 19.8, 19.9\]](#)

**Second Revision No. 1003-NFPA 13-2017 [Section No. 20.5.2]****20.5.2 Palletized Storage.**

On floor storage of commodities on pallets or other storage aids that form horizontal spaces between tiers of storage shall be considered as palletized storage.

20.5.2.1 Closed Array.

Where the vertical flues between pallet loads are 6 in. (152 mm) or less, the arrangement shall be considered closed array.

20.5.2.2 Open Array.

Where the vertical flues between pallet loads are greater than 6 in. (152 mm), the arrangement shall be considered open array.

20.5.2.3 Pile Stability, Stable Piles.

Those arrays where collapse, spillage of contents, or leaning of stacks across flue spaces is not likely to occur soon after initial fire development shall be considered as stable piles.

20.5.2.4* Pile Stability, Unstable Piles.

Those arrays where collapse, spillage of contents, or leaning of stacks across flue spaces occurs soon after initial fire development shall be considered as unstable piles.

A.20.5.2.4

Few commodities are anticipated to form unstable piles. An example of a commodity that has demonstrated in full-scale fire tests a behavior of progressively collapsing soon after a fire develops is uncartoned, empty, plastic, beverage bottles. Care should be exercised when applying the favorable protection allowance for unstable piles. Few commodities are likely to display unstable pile behavior.

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: National Fire Protection Assoc

Street Address:

City:

State:

Zip:

Submittal Date: Fri Jul 28 10:03:30 EDT 2017

Committee Statement

Committee Statement: Duplicate From Chapter 3.3.8.1. Belongs in Chapter 3

Response Message:

[Public Comment No. 238-NFPA 13-2017 \[Section No. 20.5.2.4\]](#)

[Public Comment No. 237-NFPA 13-2017 \[Section No. 20.5.2.3\]](#)

[Public Comment No. 235-NFPA 13-2017 \[Section No. 20.5.2.1\]](#)

[Public Comment No. 236-NFPA 13-2017 \[Section No. 20.5.2.2\]](#)

[Public Comment No. 233-NFPA 13-2017 \[Section No. 20.5.2 \[Excluding any Sub-Sections\]\]](#)



Second Revision No. 310-NFPA 13-2017 [Section No. 20.3.1 [Excluding any Sub-Sections]]

Commodity classification and the corresponding protection requirements shall be determined based on the makeup of individual storage units, ~~pallet load, or module held together in some manner and normally transported by material handling equipment .~~

Supplemental Information

<u>File Name</u>	<u>Description</u>	<u>Approved</u>
13_SSI_SR-310_A.20.3.1.docx	Annex changes	

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Wed Jun 28 14:24:06 EDT 2017

Committee Statement

Committee Statement: The intent of this Comment is to return the text to that from the 2016 edition of NFPA 13. In the First Draft Report, Section 20.3.1 it states that a commodity must be held together and normally transported by material handling equipment. This is very limiting and does not match the reality of many typical storage configurations. Shelf storage, solid piles, loose cartons/containers placed on racks and bin box storage do not fit that profile, so the new text should not be accepted.

Response Message:

[Public Comment No. 227-NFPA 13-2017 \[Section No. 20.3.1 \[Excluding any Sub-Sections\]\]](#)

SR-310, SSD

A.20.3.1

~~Commodity classification and the corresponding protection requirements shall be determined based on the makeup of individual storage units. Unit loads and pallet loads are examples of individual storage units.~~

**Second Revision No. 311-NFPA 13-2017 [Section No. 20.3.2.5]****20.3.2.5 Slave Pallet.**

Where solid, flat-bottom, combustible pallets are used for rack storage of Class I through IV commodity up to 25 ft (7.6 m) in height in combination with CMDA sprinklers, ~~Section 21.4.1.4.2~~ shall apply. (See ~~Figure A.3.9.1.10~~, ~~Figure A.3.3.148.1~~ .)

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Wed Jun 28 14:29:29 EDT 2017

Committee Statement

Committee Statement: The reference in Chapter 20 did not seem correct. I believe that the intent was to reference the one section where we tell the user what to do with slave pallets, which ended up in Chapter 21. However, this section in Chapter 21 only applies to rack storage up to 25 ft in height of Class I - IV commodities. For other commodities, we have never required an increase in ceiling sprinkler design (probably because there were in-rack sprinklers involved). During the rewrite, there was a decision to insert a warning in the "General" chapter, but we should not make new requirements for all storage when we do that.

Response Message:

Public Comment No. 169-NFPA 13-2017 [Section No. 20.3.2.5]

**Second Revision No. 394-NFPA 13-2017 [Section No. 20.3.3]****20.3.3 Open-Top Container.**

A container of any shape that is entirely or partially open on the top and arranged so as to allow for the collection of discharging sprinkler water cascading through the storage array shall be considered outside the protection criteria of rack storage protection outlined in Chapters 21 through ~~24~~ 25.

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Fri Jul 14 12:26:27 EDT 2017

Committee Statement

Committee Statement: Editorial revision.

Response Message:

**Second Revision No. 312-NFPA 13-2017 [Section No. 20.3.5]**

20.3.5 ~~Encapsulation.~~

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Wed Jun 28 14:52:21 EDT 2017

Committee Statement

Committee Statement: Deleted section without requirements.

Response Message:



Second Revision No. 397-NFPA 13-2017 [Section No. 20.4.3.3]



20.4.3.3

Class III commodities containing a mix of both Group A expanded and nonexpanded plastics shall comply with Figure 20.4.3.3(a) where they are within cartons, boxes, or crates or with Figure 20.4.3.3(b) where they are exposed.

Figure 20.4.3.3(a) Commodities, Cartoned or Within a Wooden Container, Containing a Mixture of Expanded and Nonexpanded Group A Plastics.

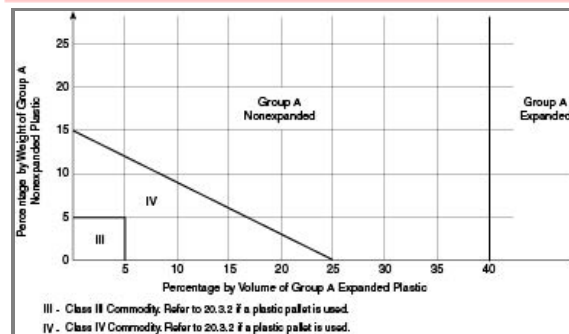
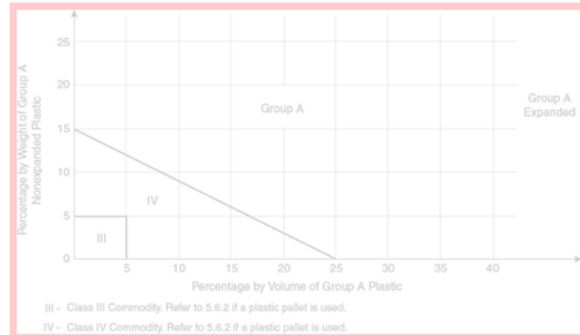
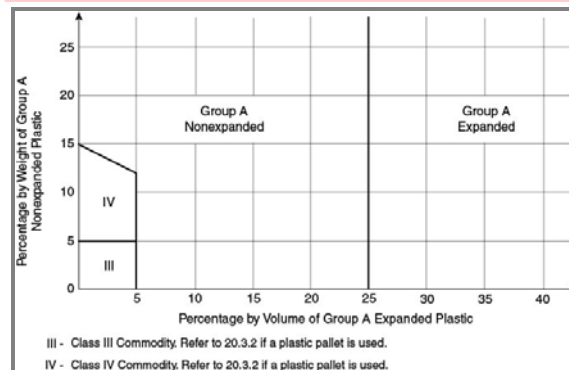
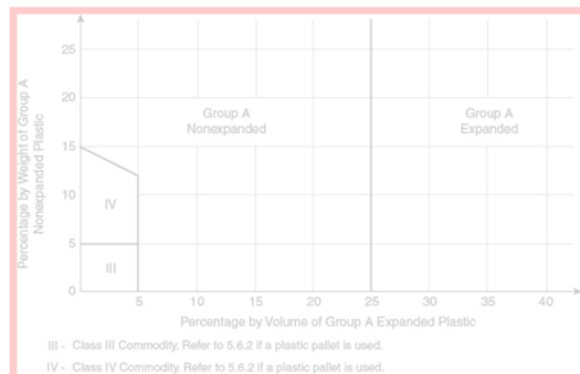


Figure 20.4.3.3(b) Exposed Commodities Containing a Mixture of Expanded and Nonexpanded Group A Plastics.



<u>File Name</u>	<u>Description</u>	<u>Approved</u>
Figure_20.4.3.3_a_and_Figure_20.4.3.3_b.docx	Figure_20.4.3.3_a_and_Figure_20.4.3.3_b--for staff use	
Submitter Information Verification		
Submitter Full Name: AUT-SSD		
Organization: [Not Specified]		
Street Address:		
City:		
State:		
Zip:		
Submittal Date: Fri Jul 14 14:37:28 EDT 2017		
Committee Statement		
Committee Statement: Align Figures with TIA 1183 and 1184 and as shown on attached word doc.		
Response Message:		

**Second Revision No. 398-NFPA 13-2017 [Section No. 20.4.4.2]****20.4.4.2**

The remaining materials shall be permitted to be ~~metal~~ noncombustible , wood, paper, natural or synthetic fibers, or Group B or Group C plastics.

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Fri Jul 14 14:51:32 EDT 2017

Committee Statement

Committee Statement: Editorial revision to align with TIA 1183 and 1184.

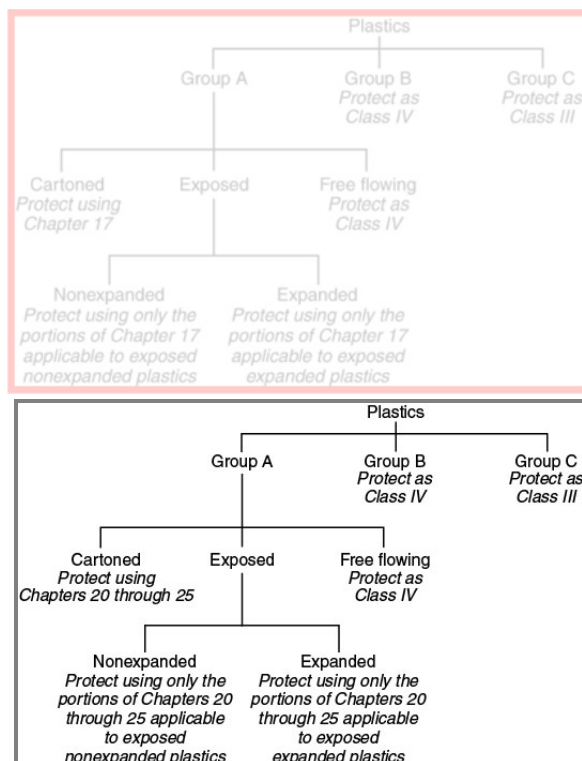
Response Message:



Second Revision No. 382-NFPA 13-2017 [Section No. 20.4.8 [Excluding any Sub-Sections]]

Plastic commodities shall be protected in accordance with Figure 20.4.8. (See Section C.21.)

Figure 20.4.8 Decision Tree.



Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Thu Jun 29 15:24:46 EDT 2017

Committee Statement

Committee Statement: Revise figure reference Chapter 17 to Chapters 20 through 25 due to reorg of document.

Response Message:

**Second Revision No. 341-NFPA 13-2017 [Section No. 20.5.3]****20.5.3 ~~Solid-Piled Storage.~~**

~~Storage of commodities stacked on each other shall be considered as solid piled storage.~~

20.5.3.1 ~~Closed Array.~~

~~Where solid piled storage has vertical flues between the piles of 6 in. (152 mm) or less, the storage arrangement shall be considered as closed array.~~

20.5.3.2 ~~Open Array.~~

~~Where solid piled storage has vertical flues between the piles that are greater than 6 in. (152 mm), the storage arrangement shall be considered as open array.~~

20.5.3.3 ~~Pile Stability, Stable Piles.~~

~~Those arrays where collapse, spillage of content, or leaning of stacks across flue spaces is not likely to occur soon after initial fire development shall be considered as stable piles.~~

20.5.3.4* ~~Pile Stability, Unstable Piles.~~

~~Those arrays where collapse, spillage of contents, or leaning of stacks across flue spaces occurs soon after initial fire development shall be considered as unstable piles.~~

A.20.5.3.4

~~Few commodities are anticipated to form unstable piles. An example of a commodity that has demonstrated in full-scale fire tests a behavior of progressively collapsing soon after a fire develops is uncartoned, empty, plastic, beverage bottles. Care should be exercised when applying the favorable protection allowance for unstable piles. Few commodities are likely to display unstable pile behavior.~~

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Wed Jun 28 21:24:53 EDT 2017

Committee Statement

Committee Statement: All of these definitions are found in Chapter 3 and are duplicates. They belong in Chapter 3.

Response Message:

[Public Comment No. 240-NFPA 13-2017 \[Section No. 20.5.3\]](#)

[Public Comment No. 239-NFPA 13-2017 \[Section No. 20.5.3 \[Excluding any Sub-Sections\]\]](#)

**Second Revision No. 342-NFPA 13-2017 [Section No. 20.5.4]****20.5.4 Bin-Box Storage-**

~~Storage in five-sided wood, metal, or cardboard boxes with open face on the aisles in which boxes are self-supporting or supported by a structure so designed that little or no horizontal or vertical space exists around boxes shall be considered as bin-box storage.~~

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Wed Jun 28 21:30:34 EDT 2017

Committee Statement

Committee Statement: Duplicate From Chapter 3.3.18. Belongs in Chapter 3

Response Message:

[Public Comment No. 241-NFPA 13-2017 \[Section No. 20.5.4\]](#)

**Second Revision No. 343-NFPA 13-2017 [Section No. 20.5.5]****20.5.5 Shelf Storage.**

~~Storage on structures up to and including 30 in. (0.76 m) deep and separated by aisles at least 30 in. (0.76 m) wide shall be considered as shelf storage.~~

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Wed Jun 28 21:32:57 EDT 2017

Committee Statement

Committee Statement: Duplicate From Chapter 3.3.189. Belongs in Chapter 3

Response Message:

[Public Comment No. 242-NFPA 13-2017 \[Section No. 20.5.5\]](#)

**Second Revision No. 344-NFPA 13-2017 [Section No. 20.5.6]****20.5.6 Back-to-Back Shelf Storage.**

~~Two solid or perforated shelves up to 30 in. (0.76 m) in depth each, not exceeding a total depth of 60 in. (1.52 m), separated by a longitudinal vertical barrier such as plywood, particleboard, sheet metal, or equivalent, with a maximum 0.25 in. (6.4 mm) diameter penetrations and no longitudinal flue space and a maximum storage height of 15 ft (4.57 m) shall be considered as back-to-back storage.~~

Submitter Information Verification**Submitter Full Name:** AUT-SSD**Organization:** [Not Specified]**Street Address:****City:****State:****Zip:****Submittal Date:** Wed Jun 28 21:35:40 EDT 2017**Committee Statement****Committee Statement:** Duplicate From Chapter 3.3.13. Belongs in Chapter 3**Response Message:**[Public Comment No. 243-NFPA 13-2017 \[Section No. 20.5.6\]](#)



Second Revision No. 345-NFPA 13-2017 [Section No. 20.5.7 [Excluding any Sub-Sections]]

Racks on fixed rails or guides that can be moved back and forth only in a horizontal, two-dimensional plane shall be protected as movable racks. Rack storage in movable racks shall be protected in the same manner as multiple-row racks.

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Wed Jun 28 21:37:14 EDT 2017

Committee Statement

Committee Statement: Duplicate From Chapter 3.3.126. Belongs in Chapter 3.

Response Message:

Public Comment No. 244-NFPA 13-2017 [Section No. 20.5.7 [Excluding any Sub-Sections]]

**Second Revision No. 346-NFPA 13-2017 [Section No. 20.5.8.1]****20.5.8.1 Open Rack.**

~~Racks without shelving or with shelving in racks that are fixed in place with shelves having a solid surface and a shelf area equal to or less than 20 ft² (1.9 m²) or with shelves having a wire mesh, slatted surface, or other material with openings representing at least 50 percent of the shelf area, including the horizontal area of rack members and where the flue spaces are maintained, shall be protected as open rack.~~

Submitter Information Verification**Submitter Full Name:** AUT-SSD**Organization:** [Not Specified]**Street Address:****City:****State:****Zip:****Submittal Date:** Wed Jun 28 21:38:45 EDT 2017**Committee Statement****Committee Statement:** Duplicate From Chapter 3.3.141. Belongs in Chapter 3**Response Message:**[Public Comment No. 246-NFPA 13-2017 \[Section No. 20.5.8.1\]](#)

**Second Revision No. 347-NFPA 13-2017 [Section No. 20.5.8.2]****20.5.3.1 Shelving.****20.5.3.1.1**

Shelving material that is less than 50 percent open, or placement of loads that block openings that would otherwise serve as the required flue spaces, greater than 20 ft² (1.9 m²) in area shall be treated as solid shelf racks.

20.5.3.1.2

Where multiple-row racks of any height have no longitudinal flue or where double-row racks with storage up to 25 ft (7.6 m) in height have no longitudinal flue, the situation shall not be considered solid shelves where transverse flues exist at maximum 5 ft (1.5 m) intervals, and additional in-rack sprinklers shall not be required in accordance with 46.1.6.1 [25.6.3.1](#) and 46.1.6.2 [25.6.3.2](#).

20.5.8.2.1 Rack Shelf Area.

~~The area of the horizontal surface of a shelf in a rack defined by perimeter aisle(s) or nominal 6 in. (152 mm) flue spaces on all four sides, or by the placement of loads that block openings that would otherwise serve as the required flue spaces, shall be considered to determine the rack shelf area.~~

20.5.8.2.2 Slatted Shelf Rack.

~~A rack where shelves are fixed in place with a series of narrow individual solid supports used as the shelf material and spaced apart with regular openings shall be protected as a slatted shelf rack.~~

20.5.8.2.3 Solid Shelf Rack.

~~A rack that is not defined as an open rack where shelves are fixed in place with a solid, slatted, or wire mesh barrier used as the shelf material and having limited openings in the shelf area shall be protected as a solid shelf rack.~~

20.5.8.2.4 Solid Shelving.

~~The area of a shelf shall be measured by perimeter aisle or flue space on all four sides or by the placement of loads that block openings that would otherwise serve as the required flue spaces.~~

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Wed Jun 28 21:40:42 EDT 2017

Committee Statement

Committee Statement: Duplicate information in Chapter 3. Belongs in Chapter 3. Revisions to references to the correct locations.

Response Message:

[Public Comment No. 248-NFPA 13-2017 \[Section No. 20.5.8.2\]](#)

**Second Revision No. 348-NFPA 13-2017 [Section No. 20.5.8.3.2]****20.5.8.3.2 Aisle Width.**

~~The horizontal dimension between the face of the loads in racks under consideration shall determine the aisle width for protection criteria.~~

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Wed Jun 28 21:42:34 EDT 2017

Committee Statement

Committee Statement: Duplicate From Chapter 3.3.4. Belongs in Chapter 3.

Response Message:

[Public Comment No. 257-NFPA 13-2017 \[Section No. 20.5.8.3.2\]](#)



Second Revision No. 349-NFPA 13-2017 [Section No. 20.5.8.4.1 [Excluding any Sub-Sections]]

~~The space between rows of storage perpendicular to the direction of loading with a width not exceeding 24 in. (610 mm) between storage shall be considered as the longitudinal flue.~~

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submission Date: Wed Jun 28 21:44:21 EDT 2017

Committee Statement

Committee Statement: Duplicate From Chapter 3.3.118. Belongs in Chapter 3.

Response Message:

[Public Comment No. 258-NFPA 13-2017 \[Section No. 20.5.8.4.1 \[Excluding any Sub-Sections\]\]](#)



Second Revision No. 350-NFPA 13-2017 [Section No. 20.5.8.4.2 [Excluding any Sub-Sections]]

~~The space between rows of storage parallel to the direction of loading shall be considered as the transverse flue. (See Figure A.3.9.3.6.)~~

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Wed Jun 28 21:46:20 EDT 2017

Committee Statement

Committee Statement: Duplicate From Chapter 3.3.221. Belongs in Chapter 3.

Response Message:

Public Comment No. 259-NFPA 13-2017 [Section No. 20.5.8.4.2 [Excluding any Sub-Sections]]

**Second Revision No. 351-NFPA 13-2017 [Section No. 20.5.8.5]****20.5.8.5 Bulkhead.**

~~A vertical barrier across the rack shall be considered a bulkhead.~~

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Wed Jun 28 21:47:52 EDT 2017

Committee Statement

Committee Statement: Duplicate from Chapter 3.3.20. Belongs in Chapter 3

Response Message:

[Public Comment No. 260-NFPA 13-2017 \[Section No. 20.5.8.5\]](#)

**Second Revision No. 352-NFPA 13-2017 [Section No. 20.5.8.6]****20.5.8.6 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 shall be considered a horizontal barrier.~~

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Wed Jun 28 21:50:32 EDT 2017

Committee Statement

Committee Statement: Duplicate from Chapter 3.3.97. Belongs in Chapter 3

Response Message:

[Public Comment No. 261-NFPA 13-2017 \[Section No. 20.5.8.6\]](#)

**Second Revision No. 353-NFPA 13-2017 [Section No. 20.5.8.7]****20.5.8.7 Single-Row Racks.**

~~Racks that have no longitudinal flue space and that have a depth up to 6 ft (1.8 m) with aisles having a width of at least 3.5 ft (1.1 m) between loads on racks shall be protected as single-row racks.~~

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Wed Jun 28 21:52:31 EDT 2017

Committee Statement

Committee Statement: Duplicate from Chapter 3.3.192. Belongs in Chapter 3

Response Message:

[Public Comment No. 262-NFPA 13-2017 \[Section No. 20.5.8.7\]](#)

**Second Revision No. 354-NFPA 13-2017 [Section No. 20.5.8.8]****20.5.8.8 Double-Row Racks.**

~~Racks less than or equal to 12 ft (3.7 m) in depth or single-row racks placed back to back having an aggregate depth up to 12 ft (3.7 m), with aisles having an aisle width of at least 3.5 ft (1.1 m) between loads on racks shall be protected as double-row racks.~~

Submitter Information Verification**Submitter Full Name:** AUT-SSD**Organization:** [Not Specified]**Street Address:****City:****State:****Zip:****Submittal Date:** Wed Jun 28 21:54:14 EDT 2017**Committee Statement****Committee Statement:** Duplicate from Chapter 3.3.57. Belongs in Chapter 3**Response Message:**[Public Comment No. 263-NFPA 13-2017 \[Section No. 20.5.8.8\]](#)

**Second Revision No. 355-NFPA 13-2017 [Section No. 20.5.8.9]****20.5.8.9 Multiple-Row Racks.**

~~Racks greater than 12 ft (3.7 m) in depth or single or double row racks separated by aisles less than 3.5 ft (1.1 m) wide having an overall width greater than 12 ft (3.7 m) shall be protected as multiple row racks.~~

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Wed Jun 28 21:56:05 EDT 2017

Committee Statement

Committee Statement: Duplicate from Chapter 3.3.128. Belongs in Chapter 3

Response Message:

[Public Comment No. 264-NFPA 13-2017 \[Section No. 20.5.8.9\]](#)

**Second Revision No. 356-NFPA 13-2017 [Section No. 20.5.8.10]****20.5.8.10 Movable Racks.**

~~Racks on fixed rails or guides that can be moved back and forth only in a horizontal, two-dimensional plane shall be protected as movable racks.~~

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Wed Jun 28 21:58:05 EDT 2017

Committee Statement

Committee Statement: Duplicate from Chapter 3.3.126. Belongs in Chapter 3

Response Message:

[Public Comment No. 265-NFPA 13-2017 \[Section No. 20.5.8.10\]](#)

**Second Revision No. 357-NFPA 13-2017 [Section No. 20.5.8.11]****20.5.8.11 Portable Racks.**

~~Racks that are not fixed in place and can be arranged in any number of configurations shall be protected as portable racks.~~

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Wed Jun 28 22:00:07 EDT 2017

Committee Statement

Committee Statement: Duplicate from Chapter 3.3.158. Belongs in Chapter 3

Response Message:

[Public Comment No. 266-NFPA 13-2017 \[Section No. 20.5.8.11\]](#)

**Second Revision No. 358-NFPA 13-2017 [Section No. 20.5.9]****20.5.4 Rubber Tires.**

~~Paragraphs 20.5.9.1 through 20.5.9.7 cover the general terms of rubber tire storage that identify which type of protection criteria shall be used in Chapters 21 to 24.~~

20.5.9.1 Banded Tires.

~~When tires are strapped together, they shall be considered as banded.~~

20.5.9.2 Horizontal Channel.

~~Any uninterrupted space in excess of 5 ft (1.5 m) in length between horizontal layers of stored tires shall be considered as the horizontal channel.~~

20.5.9.3 Laced Tire Storage.

~~Tires stored where the sides of the tires overlap, creating a woven or laced appearance, shall be considered as laced tire storage. [See Figure A.3.9.4.9(g).]~~

20.5.9.4 On-Side Tire Storage.

~~Tires stored horizontally or flat shall be considered as on-side storage.~~

20.5.9.5 On-Tread Tire Storage.

~~Tires stored vertically or on their treads shall be considered as on-tread storage.~~

20.5.9.6 Palletized Tire Storage.

~~Storage on portable racks of various types utilizing a conventional pallet as a base shall be considered as palletized storage.~~

20.5.9.7 Pyramid Tire Storage.

~~On-floor storage in which tires are formed into a pyramid to provide pile stability shall be considered as pyramid storage.~~

20.5.4.1 Water Supplies.

Total water supplies shall be capable of providing flow for automatic sprinklers, hose streams, and foam systems (if provided) for the duration required in Table 20.12.2.6.

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Wed Jun 28 22:02:17 EDT 2017

Committee Statement

Committee Statement: Duplicate definitions from Chapter 3. Belongs in Chapter 3

Response Message:

[Public Comment No. 267-NFPA 13-2017 \[Section No. 20.5.9\]](#)

**Second Revision No. 359-NFPA 13-2017 [Section No. 20.5.10]****20.5.5 Roll Paper.**

~~Paragraphs 20.5.9.1 through 20.5.9.11 cover the general terms of roll paper that identify which type of protection criteria shall be used in Chapters 21 through 24.~~

20.5.10.1 Paper.

~~Storage of all kinds of felted sheets made from natural fibrous materials, usually vegetable but sometimes mineral or animal, and formed on a fine wire screen from water suspension, where stored in rolled form shall be protected as roll paper storage.~~

20.5.10.2 Closed Array (Paper).

~~Where a vertical storage arrangement in which the distances between columns in both directions are short [not more than 2 in. (50 mm) in one direction and 1 in. (25 mm) in the other], the storage array shall be considered as closed array.~~

20.5.10.3 Open Array (Paper).

~~Where a vertical storage arrangement in which the distance between columns in both directions is lengthy (all vertical arrays other than closed or standard), the storage array shall be considered as open array.~~

20.5.10.4 Standard Array (Paper).

~~Where a vertical storage arrangement in which the distance between columns in one direction is short [1 in. (25 mm) or less] and is in excess of 2 in. (50 mm) in the other direction, the storage array shall be considered as standard array.~~

20.5.10.5 Banded Roll Paper Storage.

~~Where rolls are provided with a circumferential steel strap [$\frac{3}{8}$ in. (9.5 mm) or wider] at each end of the roll, the rolls shall be considered banded.~~

20.5.10.6 Column.

~~A single vertical stack of rolls shall be considered a column.~~

20.5.10.7 Core.

~~The central tube around which paper is wound to form a roll shall be considered as the core.~~

20.5.10.8 Horizontal Roll Paper Storage.

~~Rolls stored with the cores in the horizontal plane (on-side storage) shall be considered as horizontal storage.~~

20.5.10.9 Vertical Roll Paper Storage.

~~Rolls stored with the cores in the vertical plane (on-end storage) shall be considered as vertical storage.~~

20.5.10.10 Wrapped Roll Paper Storage.

~~Rolls provided with a complete heavy kraft covering around both sides and ends shall be considered as wrapped storage.~~

20.5.10.11 Roll Paper Storage Height.

~~The maximum vertical distance above the floor at which roll paper is normally stored shall be considered as the storage height.~~

20.5.5.1* Protection Criteria for Roll Paper Storage.**20.5.5.2**

Wet pipe systems shall be used in tissue storage areas.

20.5.5.2.1

The water supply design shall include the demand of the automatic sprinkler system plus the hose stream allowance plus, where provided, the high-expansion foam system for the duration specified in Table 20.12.2.6.

20.5.5.3

Horizontal storage of heavyweight or mediumweight paper shall be protected as a closed array.

20.5.5.4

Mediumweight paper shall be permitted to be protected as heavyweight paper where wrapped completely on the sides and both ends, or where wrapped on the sides only with steel bands. Wrapping material shall be either a single layer of heavyweight paper with a basis weight of 40 lb (18.1 kg) or two layers of heavyweight paper with a basis weight of less than 40 lb (18.1 kg).

20.5.5.5

Lightweight paper or tissue paper shall be permitted to be protected as mediumweight paper where wrapped completely on the sides and both ends, or where wrapped on the sides only with steel bands. Wrapping material shall be either a single layer of heavyweight paper with a basis weight of 40 lb (18.1 kg) or two layers of heavyweight paper with a basis weight of less than 40 lb (18.1 kg).

20.5.5.6

For purposes of sprinkler system design criteria, lightweight class paper shall be protected as tissue.

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Wed Jun 28 22:04:07 EDT 2017

Committee Statement

Committee Statement: Duplicate definitions from Chapter 3. Belongs in Chapter 3

Response Message:

[Public Comment No. 268-NFPA 13-2017 \[Section No. 20.5.10\]](#)

**Second Revision No. 360-NFPA 13-2017 [Section No. 20.5.11]****20.5.6 Plastic Motor Vehicle Components.**

Group A plastic automotive components and associated packaging material consisting of exposed, expanded Group A plastic dunnage, instrument panels, and plastic bumper fascia shall be permitted to be protected as defined in Chapter 23.

20.5.6.1

Automotive components covered in this section shall not include the storage of air bags, tires, and seats on portable racks. Paragraphs 20.5.11.1 through 20.5.11.3 cover the general terms of plastic motor vehicle components that identify which protection criteria shall be used in Chapter 23.

20.5.6.2 Automotive Components on Portable Racks.

Instrument panels, windshields, metal and plastic gasoline tanks, heater housings, door panels, interior trim, bumper fascia, wiring harnesses, sheet metal, body components, engines, driveline components, steering mechanisms, auxiliary motors, and lighting, all with or without expanded Group A plastic dunnage, shall be permitted to be protected as automotive components in Chapter 23.

20.5.6.3 Closed Array.

Where portable racks have vertical flues between the racks that are 6 in. (152 mm) or less, the storage arrangement shall be considered as closed array.

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Wed Jun 28 22:06:28 EDT 2017

Committee Statement

Committee Statement: Duplicate from Chapter 3. Belongs in Chapter 3

Response Message:

[Public Comment No. 269-NFPA 13-2017 \[Section No. 20.5.11\]](#)

**Second Revision No. 361-NFPA 13-2017 [Section No. 20.5.12]****20.5.7 Retail Display/Storage-**

~~Paragraph 20.5.7.1 covers the general terms of retail display/storage that identify which type of protection criteria shall be used in Chapters 21 through 24.~~

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Wed Jun 28 22:08:32 EDT 2017

Committee Statement

Committee Statement: This paragraph has no bearing in this location. Paragraph 20.5.7.1 deals with movable rack only, and is currently addressed.

Response Message:

[Public Comment No. 270-NFPA 13-2017 \[Section No. 20.5.12\]](#)

**Second Revision No. 362-NFPA 13-2017 [Section No. 20.5.13]****20.5.8 Baled Cotton Storage.**

~~Paragraph 20.5.13.1 covers the general terms of baled cotton storage that identify which type of protection criteria shall be used in Chapter 21.~~

20.5.8.1 Tiered Storage.

~~An arrangement in which bales are stored directly on the floor, two or more bales high, shall be considered as tiered storage.~~

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Wed Jun 28 22:10:42 EDT 2017

Committee Statement

Committee Statement: Paragraph 20.5.13.1 is currently defined in Chapter 3. This definition belongs in Chapter 3. Chapter 21 defines the protection requirements.

Response Message:

[Public Comment No. 271-NFPA 13-2017 \[Section No. 20.5.13\]](#)

**Second Revision No. 314-NFPA 13-2017 [Section No. 20.5.14]****20.5.9** ~~Cartoned Record Storage.~~

~~Paragraphs 20.5.14.1 and 20.5.14.2 cover the general terms of cartoned record storage that identify which type of rack and shelving criteria shall be used in Chapters 21 through 24.~~

20.5.9.1 ~~Cartoned Records Storage.~~

~~The protection criteria in Chapter 21 for cartoned records storage shall be based on a Class III commodity consisting predominantly of paper records in cardboard cartons.~~

20.5.9.2* ~~Catwalk.~~

~~For the purposes of cartoned records storage, catwalks shall be considered a storage aid consisting of either open metal grating or solid horizontal barriers supported from a rack storage system that is utilized as a walkway for access to storage at elevated levels.~~

A.20.5.14.2

~~Catwalks are accessed using stairs and are not separate floors of a building.~~

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submission Date: Wed Jun 28 15:02:30 EDT 2017

Committee Statement

Committee Statement: The Protection Criteria is provided in Chapter 21 and Definitions are currently located in Chapter 3.

Response Message:

[Public Comment No. 272-NFPA 13-2017 \[Section No. 20.5.14\]](#)

**Second Revision No. 313-NFPA 13-2017 [Section No. 20.6.4.2]****20.6.4.3**

Protection of Class I through Class IV commodities with excessive clearance from the top of storage to the ceiling sprinkler deflectors using CMDA criteria that exceed the maximum allowable clearance in Table 20.6.4.2 shall be in accordance with Table 20.6.4.3.

Table 20.6.4.3 Class I Through Class IV Commodities

<u>Storage Configuration</u>	<u>Where the clearance to ceiling exceeds</u>	<u>Protection is based upon the storage height that would result in a clearance to ceiling of...</u>	<u>In-rack Sprinklers*</u>
Palletized, solid-piled, bin box, shelf, or back-to-back shelf storage	20 ft (6.1 m)	20 ft (6.1 m)	N/A
Rack storage up to and including 25 ft (7.6 m) in height	20 ft (6.1 m)	20 ft (6.1 m)	Permitted as alternative to presumed clearance of 20 ft (6.1 m)
Rack storage over 25 ft (7.6 m) in height	10 ft (3.1 m)	10 ft (3.1 m)	Permitted as alternative to presumed clearance of 10 ft (3.1 m)

*When applying the supplemental in-rack sprinkler option, the ceiling density is based upon the given storage height with an assumed acceptable clearance to ceiling. Provide one level of supplemental, quick response in-rack sprinklers located directly below the top tier of storage and at every flue space intersection.

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submission Date: Wed Jun 28 14:55:37 EDT 2017

Committee Statement

Committee Statement: This eliminates the use of the word "excessive", which is not enforceable and clarifies that this rule only applies to CMDA approaches. The Tables for CMSA and ESFR sprinklers handle the maximum clearance situation in a much better manner and do not need to be addressed in this general section.

Response Message:

Public Comment No. 186-NFPA 13-2017 [Section No. 20.6.4.2]

**Second Revision No. 315-NFPA 13-2017 [Section No. 20.6.4.3]****20.6.4.4**

Protection of plastic and rubber commodities with ~~excessive~~ CMDA criteria having clearance from ~~exceeding~~ the top of storage to the ceiling sprinkler deflectors allowable limits of Table 20.6.4.3 shall be in accordance with Table 20.6.4.4.

Table 20.6.4.4 Plastics and Rubber Commodities

<u>Storage Configuration</u>	<u>Where the clearance to ceiling exceeds</u>	<u>Protection is based upon the storage height that would result in a clearance to ceiling of...</u>	<u>In-rack Sprinklers*</u>
Palletized, solid-piled, bin box, shelf, or back-to-back shelf storage	20 ft (6.1 m)	20 ft (6.1 m)	N/A
Rack storage up to and including 25 ft (7.6 m) in height	10 ft (3.1 m)	10 ft (3.1 m)	Permitted as alternative to presumed clearance of 10 ft (3.1 m)
Rack storage over 25 ft (7.6 m) in height	10 ft (3.1 m)	N/A	Required

*If in-rack sprinklers are required for the actual storage height with an acceptable clearance to ceiling, in-rack sprinklers are installed as indicated by that criteria. Provide one level of supplemental, quick response in-rack sprinklers located directly below the top tier of storage and at every flue space intersection.

Submitter Information Verification**Submitter Full Name:** AUT-SSD**Organization:** [Not Specified]**Street Address:****City:****State:****Zip:****Submission Date:** Wed Jun 28 15:05:01 EDT 2017**Committee Statement**

Committee Statement: This eliminates the use of the word "excessive", which is not enforceable and clarifies that these maximum clearance rules only apply to spray sprinklers using CMDA criteria. The situation with CMSA and ESFR sprinklers is handled much better in the Tables in Chapters 22 and 23 and does not need to be addressed here. Also, this helps to clarify that it is the ceiling clearance being calculated here, not the sprinkler clearance. The difference can be about 22 inches depending on the type of construction of the ceiling, and we have gone to great lengths to tell people how to measure this in previous parts of this section.

Response Message:

Public Comment No. 190-NFPA 13-2017 [Section No. 20.6.4.3]

**Second Revision No. 316-NFPA 13-2017 [Section No. 20.6.4.4]****20.6.4.2**

For spray sprinkler CMDA criteria where the clearance to ceiling exceeds those identified in Table 20.6.4.2, the requirements of 20.6.4.5 through 20.6.4.10 Table 20.6.4.3 and Table 20.6.4.4 shall apply.

Table 20.6.4.2 Maximum Clearance from Top of Storage to Ceiling for CMDA Protection Criteria

<u>Commodity</u>	<u>Class I to IV</u>	<u>Group A Plastic</u>
Palletized, solid-piled, bin box, ~~Shelf shelf~~ , or back-to-back shelf storage	20 ft (6.1 m)	20 ft (6.1 m)
Rack storage up to 25 ft (7.6 m)	20 ft (6.1 m)	10 ft (3.1 m)
Rack storage >25 ft (7.6 m)	10 ft (3.1 m)	10 ft (3.1 m)

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Wed Jun 28 15:06:46 EDT 2017

Committee Statement

Committee Statement: This table should come first. It establishes the maximum clearance for each type of storage protected by spray sprinklers using CMDA criteria.

Response Message:

Public Comment No. 183-NFPA 13-2017 [Section No. 20.6.4.4]

**Second Revision No. 317-NFPA 13-2017 [Sections****20.6.4.5, 20.6.4.6, 20.6.4.7, 20.6.4.8, 20.6.4.9]****20.6.4.5**

~~Where the clearance to ceiling exceeds 20 ft (6.1 m) for palletized, solid-piled, bin box, shelf, or back-to-back shelf storage, the protection shall be based on the storage height that would result in a clearance to ceiling of 20 ft (6.1 m).~~

20.6.4.6

~~Where the clearance to ceiling exceeds 20 ft (6.1 m) for rack storage of Class I through IV storage up to and including 25 ft (7.6 m) in height, the protection shall be based upon the storage height that would result in a clearance to ceiling of 20 ft (6.1 m) or providing one level of supplemental, quick-response in-rack sprinklers in accordance with Chapter 25.~~

20.6.4.7

~~Where the clearance to ceiling exceeds 10 ft (3.0 m) for rack storage of Class I to IV above 25 ft (7.6 m) in height or Group A plastic up to 25 ft (7.6 m) in height, protection shall be based upon the storage height that would result in a clearance to ceiling of 10 ft (3.0 m) or providing one level of supplemental, quick-response in-rack sprinklers in accordance with Chapter 25.~~

20.6.4.8

~~Where the clearance exceeds 10 ft (3.0 m) for rack storage of Group A plastic above 25 ft (7.6 m) in height, protection shall be based on providing one level of supplemental, quick-response in-rack sprinklers in accordance with Chapter 25.~~

20.6.4.9

~~When applying the supplemental in-rack sprinkler option, the ceiling density shall be based upon the given storage height with an assumed acceptable clearance to ceiling.~~

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submission Date: Wed Jun 28 15:08:15 EDT 2017

Committee Statement

Committee Statement: All of this material is redundant with the tables earlier in 20.6.4.

Response Message:

Public Comment No. 182-NFPA 13-2017 [Sections 20.6.4.5, 20.6.4.6, 20.6.4.7, 20.6.4.8, 20.6.4.9]

**Second Revision No. 318-NFPA 13-2017 [Section No. 20.6.4.10]****20.6.4.5**

If in-rack sprinklers are required for the actual storage height with an acceptable clearance to ceiling, in-rack sprinklers shall be installed as indicated by that criteria.

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Wed Jun 28 15:09:25 EDT 2017

Committee Statement

Committee Statement: This section is important and needs to stay. I intentionally did not include it in the proposal to remove many of the previous sections. While this renumbering would have probably happened without my submitting this comment, I wanted to be clear that I did not intend to omit this section.

Response

Message:

[Public Comment No. 191-NFPA 13-2017 \[Section No. 20.6.4.10\]](#)

**Second Revision No. 319-NFPA 13-2017 [Section No. 20.7.2]****20.7.2**

The following unsprinklered combustibile concealed spaces shall not require a minimum design area of sprinkler operation of 3000 ft² (280 m²):

- (1) Noncombustible and limited-combustible concealed spaces with minimal combustibile loading having no access. The space shall be considered a concealed space even with small openings such as those used as return air for a plenum.
- (2) Noncombustible and limited-combustible concealed spaces with limited access and not permitting occupancy or storage of combustibles. The space shall be considered a concealed space even with small openings such as those used as return air for a plenum.
- (3) Combustible concealed spaces filled entirely with noncombustible insulation.
- (4) Concealed spaces where rigid materials are used and the exposed surfaces have a flame spread index of 25 or less and the materials have been demonstrated to not propagate fire more than 10.5 ft (3.2 m) when tested in accordance with ASTM E84, *Standard Test Method for Surface Burning Characteristics of Building Materials*, or ANSI/UL UL 723, *Standard for Test for Surface Burning Characteristics of Building Materials*, extended for an additional 20 minutes in the form in which they are installed in the space.
- (5) Concealed spaces in which the exposed materials are constructed entirely of fire retardant-treated wood as defined by NFPA 703.
- (6) Concealed spaces over isolated small compartments not exceeding 55 ft² (5.1 m²) in area.
- (7) Vertical pipe chases under 10 ft² (0.9 m²), provided that in multifloor buildings the chases are firestopped at each floor using materials equivalent to the floor construction. Such pipe chases shall contain no sources of ignition, piping shall be noncombustible, and pipe penetrations at each floor shall be properly sealed.
- (8) Exterior columns under 10 ft² (0.9 m²) in area formed by studs or wood joists, supporting exterior canopies that are fully protected with a sprinkler system.
- (9) Cavities within unsprinklered wall spaces.

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Wed Jun 28 15:12:43 EDT 2017

Committee Statement

Committee Statement: This needs to be consistent with Chapter 19, which accepted this chance at the First Draft. There are two other items that are in Chapter 19 that are not here, but I have not had time to compare them to see what else is missing.

Response Message:

[Public Comment No. 194-NFPA 13-2017 \[Section No. 20.7.2\]](#)

**Second Revision No. 320-NFPA 13-2017 [Section No. 20.12.2.5]****20.12.2.5**

When hose valves for fire department use are attached to wet pipe sprinkler system risers in accordance with 16.15.2, the following shall apply:

- (1) The water supply shall not be required to be added to standpipe demand as determined from NFPA 14.
- (2) Where the combined sprinkler system demand and hose stream allowance of ~~Chapter 12 and Chapters 14 through 20 through 25~~ exceeds the requirements of NFPA 14, this higher demand shall be used.
- (3) For partially sprinklered buildings, the sprinkler demand, not including hose stream allowance, as indicated in ~~Chapter 12 and Chapters 14 through 20 through 25~~ shall be added to the requirements given in NFPA 14.

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Wed Jun 28 15:15:04 EDT 2017

Committee Statement

Committee Statement: In Section 20.12.2.5 the references are from the 2016 edition of the NFPA 13. These matters need to be revised to match the new chapter structure for the standard.

Response Message:

[Public Comment No. 228-NFPA 13-2017 \[Section No. 20.12.2.5\]](#)

**Second Revision No. 396-NFPA 13-2017 [Section No. 20.12.5]****20.12.5**

Total system water supply requirements shall be determined in accordance with the hydraulic calculation procedures of Chapter 2723 .

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Fri Jul 14 12:44:14 EDT 2017

Committee Statement

Committee Statement: Editorial revision.

Response Message:

**Second Revision No. 801-NFPA 13-2017 [Section No. 20.12.3]****20.12.3**

The minimum water supply requirements shall be determined by adding the hose stream allowance from Section 20.12.2 to the water supply for sprinklers as determined by ~~Chapter 12 through~~ Chapter 20 through 25 .

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Mon Jul 17 14:43:15 EDT 2017

Committee Statement

Committee Statement: Editorial revision.

Response Message:



Second Revision No. 1024-NFPA 13-2017 [Chapter D]

Annex D Sprinkler System Information from the 2012 2018 Edition of the *Life Safety Code*

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

D.1 Introduction.

This annex is provided as an aid to the user of NFPA 13 by identifying those portions of the 2012 edition of NFPA 101 that pertain to sprinkler system design and installation. It is not intended that this annex provide complete information regarding all aspects of fire protection addressed by NFPA 101. It is important to note that this information was copied from NFPA 101 but did not use NFPA's extract policy and is not intended to be a part of the requirements of NFPA 13.

D.1.1

The following sections cover situations where NFPA 101 provides different guidance on the design or installation of a fire sprinkler system from NFPA 13. In some cases, this different guidance is based on descriptions of unique situations handled by NFPA 101. In other cases, this different guidance stems from the different objective for NFPA 101, life safety of the occupant, rather than the property protection afforded by NFPA 13.

D.1.1.1 Features of Fire Protection.

D.1.1.1.1 Atriums.

Glass walls and inoperable windows shall be permitted in lieu of the fire barriers where all the following are met:

- (1) Automatic sprinklers are spaced along both sides of the glass wall and the inoperable windows at intervals not to exceed 6 ft (1830 mm).
- (2) The automatic sprinklers specified in 8.6.7(1)(c)(i) of NFPA 101 are located at a distance from the glass wall not to exceed 12 in. (305 mm) and arranged so that the entire surface of the glass is wet upon operation of the sprinklers.
- (3) The glass wall is of tempered, wired, or laminated glass held in place by a gasket system that allows the glass framing system to deflect without breaking (loading) the glass before the sprinklers operate.
- (4) The automatic sprinklers required by 8.6.7(1)(c)(i) of NFPA 101 are not required on the atrium side of the glass wall and the inoperable window where there is no walkway or other floor area on the atrium side above the main floor level. [**101:8.6.7(1)(c)**]

D.1.1.2 Special Structures and High-Rise Buildings.

D.1.1.2.1

High-rise buildings shall be protected throughout by an approved, supervised automatic sprinkler system in accordance with NFPA 101, Section 9.7. A sprinkler control valve and a waterflow device shall be provided for each floor. [**101:11.8.3.1**]

D.1.1.3 Lodging or Rooming Houses.

D.1.1.3.1

In buildings sprinklered in accordance with NFPA 13, closets that contain equipment such as washers, dryers, furnaces, or water heaters shall be sprinklered regardless of size. [**101:26.3.6.3.5** 26.3.6.2.5]

D.1.1.3.2

In existing lodging or rooming houses, sprinkler installations shall not be required in closets not exceeding 24 ft² (2.2 m²) and in bathrooms not exceeding 55 ft² (5.1 m²). [**101:26.3.6.3.6** 26.3.6.2.6]

D.1.1.4 New Hotels and Dormitories.

D.1.1.4.1

The provisions for draft stops and closely spaced sprinklers in NFPA 13 shall not be required for openings complying with NFPA 101, 8.6.9.1, where the opening is within the guest room or guest suite. [101:28.3.5.4]

D.1.1.4.2

Listed quick-response or listed residential sprinklers shall be used throughout guest rooms and guest room suites. [101:28.3.5.6]

D.1.1.5 Existing Hotels and Dormitories.**D.1.1.5.1**

In guest rooms and in guest room suites, sprinkler installations shall not be required in closets not exceeding 24 ft² (2.2 m²) and in bathrooms not exceeding 55 ft² (5.1 m²). [101:29.3.5.5]

D.1.1.6 New Apartment Buildings.**D.1.1.6.1**

In buildings sprinklered in accordance with NFPA 13, :

- (1) ~~closets~~ Closets less than 12 ft² (1.1 m²) ~~in area~~ in individual dwelling units shall not be required to be sprinklered.
- (2) Closets that contain equipment such as washers, dryers, furnaces, or water heaters shall be sprinklered regardless of size.

[101:30.3.5.3]

D.1.1.6.2

Listed quick-response or listed residential sprinklers shall be used throughout all dwelling units. [101:30.3.5.5 30.3.5.6]

D.1.1.6.3

The draft stop and closely spaced sprinkler requirements of NFPA 13 shall not be required for convenience openings complying with NFPA 101, 8.6.9.1, where the convenience opening is within the dwelling unit. [101:30.3.5.4 30.3.5.5]

D.1.1.7 Existing Apartment Buildings.**D.1.1.7.1**

In individual dwelling units, sprinkler installation shall not be required in closets not exceeding 24 ft² (2.2 m²) and in bathrooms not exceeding 55 ft² (5.1 m²). Closets that contain equipment such as washers, dryers, furnaces, or water heaters shall be sprinklered regardless of size. [101:31.3.5.3]

D.1.1.7.2

In buildings sprinklered in accordance with NFPA 13, bathrooms not greater than 55 ft² (5.1 m²) in individual dwelling units shall not be required to be sprinklered. [101 : 31.3.5.4]

D.1.1.7.3

The draft stop and closely spaced sprinkler requirements of NFPA 13 shall not be required for convenience openings complying with NFPA 101, 8.6.9.1, where the convenience opening is within the dwelling unit. [101:31.3.5.4 31.3.5.5]

D.1.1.8 Existing Residential Board and Care Occupancies.**D.1.1.8.1**

Standard-response sprinklers shall be permitted for use in hazardous areas in accordance with NFPA 101, 33.2.3.2. [101:33.2.2.2.4]

D.1.1.8.2

Where an automatic sprinkler system is installed, for either total or partial building coverage, all of the following requirements shall be met:

- (1) The system shall be in accordance with NFPA 101, Section 9.7, and shall initiate the fire alarm system in accordance with 33.2.3.4.1, as modified by 33.2.3.5.3.1 through 33.2.3.5.3.6 of NFPA 101.
- (2) The adequacy of the water supply shall be documented to the authority having jurisdiction.

[101:33.2.3.5.3]

D.1.1.8.2.1

In prompt evacuation capability facilities, all of the following shall apply:

- (1) An automatic sprinkler system in accordance with NFPA 13D shall be permitted.
- (2) Automatic sprinklers shall not be required in closets not exceeding 24 ft² (2.2 m²) and in bathrooms not exceeding 55 ft² (5.1 m²), provided that such spaces are finished with lath and plaster or materials providing a 15-minute thermal barrier.

[101:33.2.3.5.3.1]

D.1.1.8.2.2

In slow and impractical evacuation capability facilities, all of the following shall apply:

- (1) An automatic sprinkler system in accordance with NFPA 13D with a 30-minute water supply, shall be permitted.
- (2) All habitable areas and closets shall be sprinklered.
- (3) Automatic sprinklers shall not be required in bathrooms not exceeding 55 ft² (5.1 m²), provided that such spaces ~~ster~~ are finished with lath and plaster or materials providing a 15-minute thermal barrier.

[101:33.2.3.5.3.2]

D.1.1.8.2.3

In prompt and slow evacuation capability facilities, where an automatic sprinkler system is in accordance with NFPA 13, sprinklers shall not be required in closets not exceeding 24 ft² (2.2 m²) and in bathrooms not exceeding 55 ft² (5.1 m²), provided that such spaces are finished with lath and plaster or materials providing a 15-minute thermal barrier. [101:33.2.3.5.3.3]

D.1.1.8.2.4

In prompt and slow evacuation capability facilities in buildings four or fewer stories above grade plane, systems in accordance with NFPA 13R shall be permitted. [101:33.2.3.5.3.4]

D.1.1.8.2.5

In impractical evacuation capability facilities in buildings four or fewer stories above grade plane, systems in accordance with NFPA 13R shall be permitted. All habitable areas and closets shall be sprinklered.

Automatic sprinklers shall not be required in bathrooms not exceeding 55 ft² (5.1 m²), provided that such spaces are finished with lath and plaster or materials providing a 15-minute thermal barrier.

[101:33.2.3.5.3.5]

D.1.1.8.2.6

Initiation of the fire alarm system shall not be required for existing installations in accordance with NFPA 101, 33.2.3.5.6. [101:33.2.3.5.3.6]

D.1.1.8.2.7

All impractical evacuation capability facilities shall be protected throughout by an approved, supervised automatic sprinkler system in accordance with NFPA 101, 33.2.3.5.3. [101:33.2.3.5.3.7]

D.1.1.9 New Mercantile Occupancies.

D.1.1.9.1 Protection of Vertical Openings.

Any vertical opening shall be protected in accordance with NFPA 101, Section 8.6, except under the following conditions:

- (1) In Class A or Class B mercantile occupancies protected throughout by an approved, supervised automatic sprinkler system in accordance with NFPA 101, 9.7.1.1(1), unprotected vertical openings shall be permitted at one of the following locations:
 - (a) Between any two floors
 - (b) Among the street floor, the first adjacent floor below, and adjacent floor (or mezzanine) above
- (2) In Class C mercantile occupancies, unprotected openings shall be permitted between the street floor and the mezzanine.
- (3) The draft stop and closely spaced sprinkler requirements of NFPA 13 shall not be required for unenclosed vertical openings permitted in NFPA 101, 36.3.1(1) and (2).

[101:36.3.1]

D.1.1.9.2

Rooms housing building service equipment, janitor closets, and service elevators shall be permitted to open directly onto exit passageways, provided that all of the following criteria are met:

- (1) The required fire resistance rating between such rooms or areas and the exit passageway shall be maintained in accordance with NFPA 101, 7.1.3.2.
- (2) Such rooms or areas shall be protected by an approved, supervised automatic sprinkler system in accordance with NFPA 101, 9.7.1.1(1), but the exceptions in NFPA 13 allowing the omission of sprinklers from such rooms shall not be permitted.

[101:36.4.4.6.2 36.4.4.9.2]

D.1.1.10 Existing Mercantile Occupancies.**D.1.1.10.1** Protection of Vertical Openings.

Any vertical opening shall be protected in accordance with NFPA 101, Section 8.6, except under any of the following conditions:

- (1) In Class A or Class B mercantile occupancies protected throughout by an approved, supervised automatic sprinkler system in accordance with NFPA 101, 9.7.1.1(1), unprotected vertical openings shall be permitted at one of the following locations:
 - (a) Between any two floors
 - (b) Among the street floor, the first adjacent floor below, and the adjacent floor (or mezzanine) above
- (2) In Class C mercantile occupancies, unprotected openings shall be permitted between the street floor and the mezzanine.
- (3) The draft stop and closely spaced sprinkler requirements of NFPA 13 shall not be required for unenclosed vertical openings permitted in NFPA 101, ~~37.3.1(1)~~ 36.3.1(1) and (2).

[101:37.3.1]

D.1.1.10.2

Rooms housing building service equipment, janitor closets, and service elevators shall be permitted to open directly onto exit passageways, provided that all of the following criteria are met:

- (1) The required fire resistance rating between such rooms or areas and the exit passageway shall be maintained in accordance with NFPA 101, 7.1.3.2.
- (2) Such rooms or areas shall be protected by an approved automatic sprinkler system in accordance with NFPA 101, 9.7.1.1(1) but the exceptions in NFPA 13 allowing the omission of sprinklers from such rooms shall not be permitted.

[101:37.4.4.6.2 37.4.4.9.2]

D.1.1.11 Industrial Occupancies.

D.1.1.11.1 Special Provisions — High-Rise Buildings.

The provisions of NFPA 101, 11.8.5.2.4(2) 11.8.5.3.4(2) for jockey pumps and NFPA 101, 11.8.5.2.4(3) 11.8.5.3.4(3) for air compressors serving dry-pipe and preaction systems shall not apply to special-purpose industrial occupancies. [101:40.4.1 40.4.2.2]

D.2 Life Safety Code.**D.2.1 Features of Fire Protection.****D.2.1.1 Design Requirements. (Reserved)****D.2.1.2 Installation Requirements.****D.2.1.2.1 Atriums.**

Glass walls and inoperable windows shall be permitted in lieu of the fire barriers where all the following are met:

- (1) Automatic sprinklers are spaced along both sides of the glass wall and the inoperable windows at intervals not to exceed 6 ft (1830 mm).
- (2) The automatic sprinklers specified in NFPA 101, 8.6.7(1)(c)(i) are located at a distance from the glass wall not to exceed 12 in. (305 mm) and arranged so that the entire surface of the glass is wet upon operation of the sprinklers.
- (3) The glass wall is of tempered, wired, or laminated glass held in place by a gasket system that allows the glass framing system to deflect without breaking (loading) the glass before the sprinklers operate.
- (4) The automatic sprinklers required by NFPA 101, 8.6.7(1)(c)(i) are not required on the atrium side of the glass wall and the inoperable window where there is no walkway or other floor area on the atrium side above the main floor level. [101:8.6.7(1)(c)]

D.2.2 Special Structures and High-Rise Buildings.**D.2.2.1 Design Criteria.****D.2.2.1.1**

High-rise buildings shall be protected throughout by an approved, supervised automatic sprinkler system in accordance with NFPA 101, Section 9.7. A sprinkler control valve and a waterflow device shall be provided for each floor. [101:11.8.3.1]

D.2.3 New Assembly Occupancies.**D.2.3.1 Design Criteria.****D.2.3.1.1 Protection of Vertical Openings.**

Any vertical opening shall be enclosed or protected in accordance with Section 8.6 of NFPA 101, unless otherwise permitted by one of the following:

- (1) Stairs or ramps shall be permitted to be unenclosed between balconies or mezzanines and main assembly areas located below, provided that the balcony or mezzanine is open to the main assembly area.
- (2) Exit access stairs from lighting and access catwalks, galleries, and gridirons shall not be required to be enclosed.
- (3) Assembly occupancies protected by an approved, supervised automatic sprinkler system in accordance with Section 9.7 of NFPA 101 shall be permitted to have unprotected vertical openings between any two adjacent floors, provided that such openings are separated from unprotected vertical openings serving other floors by a barrier complying with 8.6.5 of NFPA 101.
- (4) Assembly occupancies protected by an approved, supervised automatic sprinkler system in accordance with Section 9.7 of NFPA 101 shall be permitted to have convenience stair openings in accordance with 8.6.9.2 of NFPA 101.

[101:12.3.1]

D.2.3.2 Installation Requirements. (Reserved)**D.2.4 Existing Assembly Occupancies.****D.2.4.1 Design Criteria.**

D.2.4.1.1 Protection of Vertical Openings.

Any vertical opening shall be enclosed or protected in accordance with NFPA 101, Section 8.6, unless otherwise permitted by one of the following:

- (1) Stairs or ramps shall be permitted to be unenclosed between balconies or mezzanines and main assembly areas located below, provided that the balcony or mezzanine is open to the main assembly area.
- (2) Exit access stairs from lighting and access catwalks, galleries, and gridirons shall not be required to be enclosed.
- (3) Assembly occupancies protected by an approved, supervised automatic sprinkler system in accordance with NFPA 101, Section 9.7, shall be permitted to have unprotected vertical openings between any two adjacent floors, provided that such openings are separated from unprotected vertical openings serving other floors by a barrier complying with NFPA 101, 8.6.5.
- (4) Assembly occupancies protected by an approved, supervised automatic sprinkler system in accordance with NFPA 101, Section 9.7, shall be permitted to have convenience stair openings in accordance with NFPA 101, 8.6.9.2.

[101:13.3.1]

D.2.4.2 Installation Requirements. (Reserved)

D.2.5 New Educational Occupancies. (Reserved)

D.2.6 Existing Educational Occupancies. (Reserved)

D.2.7 New Day-Care Occupancies. (Reserved)

D.2.8 Existing Day-Care Occupancies. (Reserved)

D.2.9 New Health Care Occupancies. (Reserved)

D.2.10 Existing Health Care Occupancies. (Reserved)

D.2.11 New Ambulatory Health Care Occupancies. (Reserved)

D.2.12 Existing Ambulatory Health Care Occupancies. (Reserved)

D.2.13 New Detention and Correctional Occupancies. (Reserved)

D.2.14 Existing Detention and Correctional Occupancies. (Reserved)

D.2.15 One- and Two-Family Dwellings. (Reserved)

D.2.16 Lodging or Rooming Houses.

D.2.16.1 Design Requirements. (Reserved)

D.2.16.2 Installation Requirements.

D.2.16.2.1

In buildings sprinklered in accordance with NFPA 13 closets that contain equipment such as washers, dryers, furnaces, or water heaters shall be sprinklered, regardless of size. [~~101:26.3.6.3.5~~ 26.3.6.2.5]

D.2.16.2.2

In existing lodging or rooming houses, sprinkler installations shall not be required in closets not exceeding 24 ft² (2.2 m²) and in bathrooms not exceeding 55 ft² (5.1 m²). [~~101:26.3.6.3.6~~ 26.3.6.2.6]

D.2.17 New Hotels and Dormitories.

D.2.17.1 Design Requirements. (Reserved)

D.2.17.2 Installation Requirements.

D.2.17.2.1

The provisions for draft stops and closely spaced sprinklers in NFPA 13 shall not be required for openings complying with NFPA 101, 8.6.9.1, where the opening is within the guest room or guest suite.

[~~101:28.3.5.4~~]

D.2.17.2.2

Listed quick-response or listed residential sprinklers shall be used throughout guest rooms and guest room suites. [101:28.3.5.6]

D.2.18 Existing Hotels and Dormitories.**D.2.18.1 Design Requirements. (Reserved)****D.2.18.2 Installation Requirements.****D.2.18.2.1**

In guest rooms and in guest room suites, sprinkler installations shall not be required in closets not exceeding 24 ft² (2.2 m²) and in bathrooms not exceeding 55 ft² (5.1 m²). [101:29.3.5.5]

D.2.19 New Apartment Buildings.**D.2.19.1 Design Requirements. (Reserved)****D.2.19.2 Installation Requirements.****D.2.19.2.1**

In buildings sprinklered in accordance with NFPA 13, :

- (1) ~~closets~~ Closets less than 12 ft² (1.1 m²) ~~in area~~ in individual dwelling units shall not be required to be sprinklered.
- (2) Closets that contain equipment such as washers, dryers, furnaces, or water heaters shall be sprinklered regardless of size.

[101:30.3.5.3]

D.2.19.2.2

Listed quick-response or listed residential sprinklers shall be used throughout all dwelling units.

[101:30.3.5.5 30.3.5.6]

D.2.19.2.3

The draft stop and closely spaced sprinkler requirements of NFPA 13 shall not be required for convenience openings complying with NFPA 101, 8.6.9.1, where the convenience opening is within the dwelling unit. [101:30.3.5.4 30.3.5.5]

D.2.20 Existing Apartment Buildings.**D.2.20.1 Design Requirements. (Reserved)****D.2.20.2 Installation Requirements.****D.2.20.2.1**

In individual dwelling units, sprinkler installation shall not be required in closets not exceeding 24 ft² (2.2 m²) and in bathrooms not exceeding 55 ft² (5.1 m²). Closets that contain equipment such as washers, dryers, furnaces, or water heaters shall be sprinklered, regardless of size. [101:31.3.5.3]

D.2.20.2.2

The draft stop and closely spaced sprinkler requirements of NFPA 13 shall not be required for convenience openings complying with NFPA 101, 8.6.9.1, where the convenience opening is within the dwelling unit. [101:31.3.5.4 31.3.5.5]

D.2.21 New Residential Board and Care Occupancies. (Reserved)**D.2.22 Existing Residential Board and Care Occupancies.****D.2.22.1 Design Requirements. (Reserved)****D.2.22.2 Installation Requirements.****D.2.22.2.1**

Standard-response sprinklers shall be permitted for use in hazardous areas in accordance with NFPA 101, 33.2.3.2. [101:33.2.2.2.4]

D.2.22.2.2

In prompt and slow evacuation facilities, where an automatic sprinkler system is in accordance with NFPA 13 sprinklers shall not be required in closets not exceeding 24 ft² (2.2 m²) and in bathrooms not exceeding 55 ft² (5.1 m²), provided that such spaces are finished with lath and plaster or materials providing a 15-minute thermal barrier. [101:33.2.3.5.3.3]

D.2.23 New Mercantile Occupancies.**D.2.23.1 Design Requirements. (Reserved)****D.2.23.2 Installation Requirements.****D.2.23.2.1 Protection of Vertical Openings.**

Any vertical opening shall be protected in accordance with NFPA 101, Section 8.6, except under any of the following conditions:

- (1) In Class A or Class B mercantile occupancies protected throughout by an approved, supervised automatic sprinkler system in accordance with NFPA 101, 9.7.1.1(1), unprotected vertical openings shall be permitted at one of the following locations:
 - (a) Between any two floors
 - (b) Among the street floor, the first adjacent floor below, and adjacent floor (or mezzanine) above
- (2) In Class C mercantile occupancies, unprotected openings shall be permitted between the street floor and the mezzanine.
- (3) The draft stop and closely spaced sprinkler requirements of NFPA 13 shall not be required for unenclosed vertical openings permitted in NFPA 101, 36.3.1(1) and (2).

[101:36.3.1]

D.2.23.2.2

Rooms housing building service equipment, janitor closets, and service elevators shall be permitted to open directly onto exit passageways, provided that all of the following criteria are met:

- (1) The required fire resistance rating between such rooms or areas and the exit passageway shall be maintained in accordance with NFPA 101, 7.1.3.2.
- (2) Such rooms or areas shall be protected by an approved, supervised automatic sprinkler system in accordance with NFPA 101, 9.7.1.1(1) but the exceptions in NFPA 13 allowing the omission of sprinklers from such rooms shall not be permitted.

[101:36.4.4.6.2 36.4.4.9.2]

D.2.24 Existing Mercantile Occupancies.**D.2.24.1 Design Requirements. (Reserved)****D.2.24.2 Installation Requirements.****D.2.24.2.1 Protection of Vertical Openings.**

Any vertical opening shall be protected in accordance with NFPA 101, Section 8.6, except under any of the following conditions:

- (1) In Class A or Class B mercantile occupancies protected throughout by an approved, supervised automatic sprinkler system in accordance with NFPA 101, 9.7.1.1(1), unprotected vertical openings shall be permitted at one of the following locations:
 - (a) Between any two floors
 - (b) Among the street floor, the first adjacent floor below, and the adjacent floor (or mezzanine) above
- (2) In Class C mercantile occupancies, unprotected openings shall be permitted between the street floor and the mezzanine.
- (3) The draft stop and closely spaced sprinkler requirements of NFPA 13 shall not be required for unenclosed vertical openings permitted in NFPA 101, ~~37.3.1(1)~~ 36.3.1(1) and (2). [101:37.3.1]

D.2.24.2.2

Rooms housing building service equipment, janitor closets, and service elevators shall be permitted to open directly onto exit passageways, provided that all of the following criteria are met:

- (1) The required fire resistance rating between such rooms or areas and the exit passageway shall be maintained in accordance with NFPA 101, 7.1.3.2.
- (2) Such rooms or areas shall be protected by an approved, supervised automatic sprinkler system in accordance with NFPA 101, 9.7.1.1(1), but the exceptions in NFPA 13 allowing the omission of sprinklers from such rooms shall not be permitted.

[~~101:37.4.4.6.2~~ 37.4.4.9.2]

D.2.25 New Business Occupancies.**D.2.25.1** Design Requirements. (Reserved)**D.2.25.2** Installation Requirements. (Reserved)**D.2.26** Existing Business Occupancies.**D.2.26.1** Design Requirements. (Reserved)**D.2.26.2** Installation Requirements. (Reserved)**D.2.27** Industrial Occupancies. (Reserved)**D.2.27.1** Design Criteria.**D.2.27.1.1** Special Provisions — High-Rise Buildings.

The provisions of NFPA 101, ~~11.8.5.2.4(2)~~ 11.8.5.3.4(2) , for jockey pumps and NFPA 101, ~~11.8.5.2.4(3)~~ 11.8.5.3.4(3) , for air compressors serving dry-pipe and pre-action systems shall not apply to special-purpose industrial occupancies. [~~101:40.4.1~~ 40.2.2]

D.2.28 Storage Occupancies. (Reserved)**Supplemental Information**

<u>File Name</u>	<u>Description</u> <u>Approved</u>
Annex_D_Sprinkler_System_Information_from_the.docx	For staff use.

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: National Fire Protection Assoc

Street Address:

City:

State:

Zip:

Submittal Date: Wed Aug 16 10:39:15 EDT 2017

Committee Statement

Committee Statement: Updates extract information from the 2015 edition of the life Safety Code.

Response Message:



Second Revision No. 380-NFPA 13-2017 [Section No. 20.14.1.2 [Excluding any Sub-Sections]]

Wood pallets, where stored indoors, shall be protected in accordance with one of the following:

- (1) Control mode density/area sprinkler protection as specified in Table 20.14.1.2(a).
- (2) CMSA sprinkler protection in accordance with Table 20.14.1.2(b).
- (3) ESFR sprinkler protection in accordance with Table 20.14.1.2(c).
- (4) Control mode density/area sprinkler protection in accordance with the OH2 curve of Figure 13.2.1 existing Ordinary Hazard Group 2 curve and Figure 19.3.3.1.1 with a hose stream demand of at least 250 gpm (950 L/min) for a duration of at least 60 minutes when pallets are stored no higher than 6 ft (1.8 m) and each pile of no more than four stacks is separated from other pallet piles by at least 8 ft (2.4 m) of clear space or 25 ft (7.6 m) of commodity. The maximum clearance to ceiling of 20 ft (6.1 m) specified in 20.6.4 shall not apply to arrangement 20.14.1.2(4).

Table 20.14.1.2(a) Control Mode Density/Area Sprinkler Protection for Indoor Storage of Idle Wood Pallets

<u>Type of Sprinkler</u>	<u>Location of Storage</u>	<u>Nominal K-Factor</u>	<u>Maximum Storage Height</u>		<u>Maximum Ceiling/Roof Height</u>		<u>Sprinkler Density</u>		<u>Areas of Operation</u>	
			<u>ft</u>	<u>m</u>	<u>ft</u>	<u>m</u>	<u>gpm/ft²</u>	<u>mm/min</u>	<u>ft²</u>	<u>m²</u>
Control mode density/area	On floor	8 (115) or larger	Up to 6	Up to 1.8	20	6.1	0.20	8.1	3000*	280*
	On floor	11.2 (160) or larger	Up to 8	Up to 2.4	30	9.1	0.45	18.3	2500	230
	On floor or rack without solid shelves	11.2 (160) or larger	8 to 12	2.4 to 3.7	30	9.1	0.6	24.4	3500	325
			12 to 20	3.7 to 6.1	30	9.1	0.6	24.4	4500	420
	On floor	16.8 (240) or larger	Up to 20	Up to 6.1	30	9.1	0.6	24.4	2000	185

*The area of sprinkler operation should be permitted to be reduced to 2000 ft² (186 m²) when sprinklers having a nominal K-factor of 11.2 or larger are used or if high-temperature-rated sprinklers with a nominal K-factor of 8.0 are used.

Table 20.14.1.2(b) CMSA Sprinkler Protection for Indoor Storage of Idle Wood Pallets

<u>Storage Arrangement</u>	<u>Commodity Class</u>	<u>Maximum Storage Height</u>		<u>Maximum Ceiling/Roof Height</u>		<u>K-Factor/Orientation</u>	<u>Type of System</u>	<u>Number of Design Sprinklers</u>	<u>Minimum Operating Pressure</u>	
		<u>ft</u>	<u>m</u>	<u>ft</u>	<u>m</u>				<u>psi</u>	<u>bar</u>
On floor	Idle wood pallets	20	6.1	30	9.1	11.2 (160) Upright	Wet	15	25	1.7
							Dry	25	25	1.7
						16.8 (240) Upright	Wet	15	15	1.0
							Dry	25	15	1.0
				35	11	19.6 (280) Pendent	Wet	15	16	1.1
						19.6 (280) Pendent	Wet	15	25	1.7
						19.6 (280) Pendent	Wet	15	30	2.1

Table 20.14.1.2(c) ESFR Sprinkler Protection for Indoor Storage of Idle Wood Pallets

<u>Type of Sprinkler (Orientation)</u>	<u>Location of Storage</u>	<u>Nominal K-Factor</u>	<u>Maximum Storage Height</u>	<u>Maximum Ceiling/ Roof Height</u>	<u>Minimum Operating Pressure</u>

			<u>ft</u>	<u>m</u>	<u>ft</u>	<u>m</u>	<u>psi</u>	<u>bar</u>
ESFR (pendent)	On floor or rack without solid shelves	14.0 (200)	25	7.6	30	9.1	50	3.4
			25	7.6	32	10	60	4.1
			25	7.6	30	9.1	35	2.4
		16.8 (240)	25	7.6	32	10	42	2.9
			35	11	40	12	52	3.6
			25	7.6	30	9.1	25	1.7
	22.4 (320)		30	9.1	35	11	35	2.4
			35	11	40	12	40	2.7
			25	7.6	30	9.1	15	1.0
		25.2 (360)	30	9.1	35	11	20	1.4
			35	11	40	12	25	1.7
			20	6.1	30	9.1	50	3.4
ESFR (upright)	On floor	14.0 (200)	20	6.1	35	11	75	5.2
			20	6.1	30	9.1	35	2.4
		16.8 (240)	20	6.1	30	9.1	35	2.4
			20	6.1	35	11	52	3.6

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Thu Jun 29 15:11:32 EDT 2017

Committee Statement

Committee Statement: The exiting figure has been deleted and replaced with references in the standard.

Response Message:



Second Revision No. 321-NFPA 13-2017 [Section No. 20.15.1 [Excluding any Sub-Sections]]

Where fireproofing of building columns is not provided and storage heights are in excess of 15 ft (4.6 m), protection of building columns located wholly or partially within the rack footprint inclusive of flue spaces or within 12 in. (300 mm) of the footprint shall be protected in accordance with one of the following:

- (1) In-rack sprinklers
- (2) Sidewall sprinklers at the 15 ft (4.6 m) elevation, pointed toward one side of the steel column
- (3) Provision of ceiling sprinkler density for a minimum of 2000 ft² (186 m²) with ordinary 165°F (74°C) or high-temperature 286°F (140°C) rated sprinklers as shown in Table 20.15.1 for storage heights above 15 ft (4.6 m), up to and including 20 ft (6.1 m)
- (4) Provision of CMSA or ESFR ceiling sprinkler protection

Table 20.15.1 Ceiling Sprinkler Densities for Protection of Steel Building Columns

<u>Commodity Classification</u>	<u>Aisle Width</u>			
	<u>4 ft (1.2 m)</u>		<u>8 ft (2.4 m)</u>	
	<u>gpm/ft²</u>	<u>(L/min)/m²</u>	<u>gpm/ft²</u>	<u>(L/min)/m²</u>
Class I	0.37	15.1	0.33	13.4
Class II	0.44	17.9	0.37	15.1
Class III	0.49	20.0	0.42	17.1
Class IV <u>and Group A plastics</u>	0.68	27.7	0.57	23.2

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Wed Jun 28 15:16:28 EDT 2017

Committee Statement

Committee Statement: In the First Draft Report, Section 20.15.1 only addresses Class I to IV commodities. Section 17.1.4 of the 2016 edition of NFPA 13, contains the provisions for column protection are provided of Group A plastics, which are the same as for Class IV. This Comment is to bring that information over into the new Chapter 20.

Response Message:

Public Comment No. 229-NFPA 13-2017 [Section No. 20.15.1 [Excluding any Sub-Sections]]



Second Revision No. 395-NFPA 13-2017 [Section No. 20.16]

20.16 Alternative Protection Scheme A.

~~Class I, II, III, IV commodities requiring a greater level of protection than is available from the overhead sprinkler system shall be permitted to be protected in accordance with 20.16.1.1 through 20.16.1.7 .~~

20.16.1

~~Class I, II, III, IV, and Group A plastic commodities requiring a greater level of protection than is available from the overhead sprinkler system shall be permitted to be protected in accordance with 20.16.1.1 through 20.16.1.7 .~~

20.16.1.1

~~Where the storage rack will not be solely dedicated to the storage of commodities requiring a greater level of protection than is available from the overhead sprinkler system, either of the following shall apply:~~

~~Extend the protection prescribed by Section 20.16 horizontally one pallet load in all directions beyond the commodity storage area requiring the higher level of protection.~~

~~Install a vertical barrier to segregate the commodities requiring the higher level of protection from any adjacent commodities.~~

20.16.1.2

~~Commodities that can be protected by the ceiling-level sprinkler system shall be permitted to be stored vertically above and horizontally adjacent to the portions of the storage rack equipped as prescribed by Section 20.16 .~~

20.16.1.3 Horizontal Barriers.

~~Horizontal barriers shall be installed at every tier level of the dedicated storage rack where the rack is equipped with solid shelves.~~

20.16.1.3.1

~~Where the dedicated storage rack is open-frame, horizontal barriers shall be installed at vertical increments not exceeding 12 ft (3.6 m).~~

20.16.1.3.2

~~The barriers shall span horizontally so that all flue spaces within the rack bay are covered.~~

20.16.1.3.3

~~A maximum 3 in. (75 mm) wide gap shall be permitted at rack uprights.~~

20.16.1.3.4

~~The solid barrier shall be installed on a horizontal plane within a rack, beneath which in-rack sprinklers shall be installed, as follows:~~

~~The barrier shall be constructed of minimum 22-gauge (0.7 mm) sheet metal or of minimum $\frac{3}{4}$ in. (10 mm) plywood.~~

~~The barrier shall extend to both aisle faces of the racks, covering up both the longitudinal and the transverse flue spaces of the rack bays in which they are installed.~~

~~The barrier shall be fitted to within 3 in. (75 mm) of any vertical rack member or other equipment that would create an opening, such as vertical in-rack sprinkler pipe drops.~~

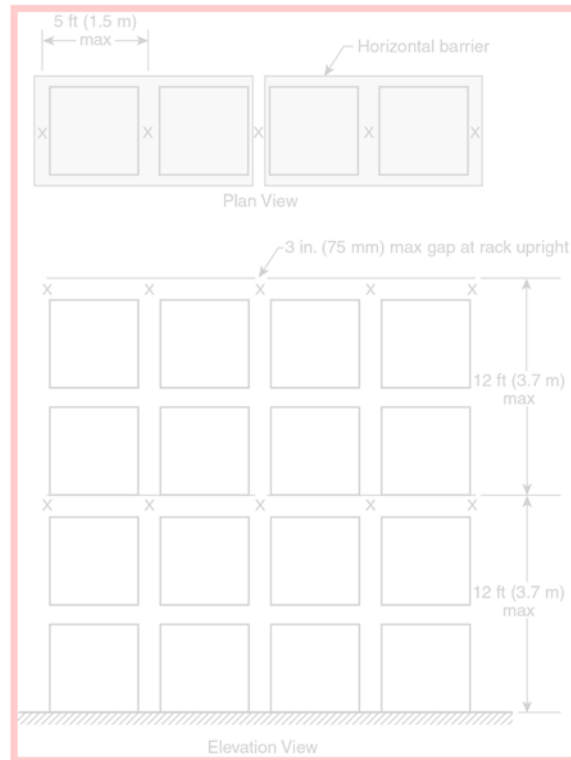
20.16.1.4 In-Rack Sprinklers.

~~Minimum K-8.0 (K-115) quick-response sprinklers (ceiling-level or in-rack) shall be installed beneath each horizontal barrier. The deflector of the sprinkler shall be located as close to the underside of the horizontal barrier as possible.~~

20.16.1.4.1 Single-Row Racks.**(A)**

For single-row racks, sprinklers shall be installed at each rack upright and at each rack mid-bay as shown in Figure 20.16.1.4.1(A).

Figure 20.16.1.4.1(A) Alternative Protection for Single-Row Racks.

**(B)**

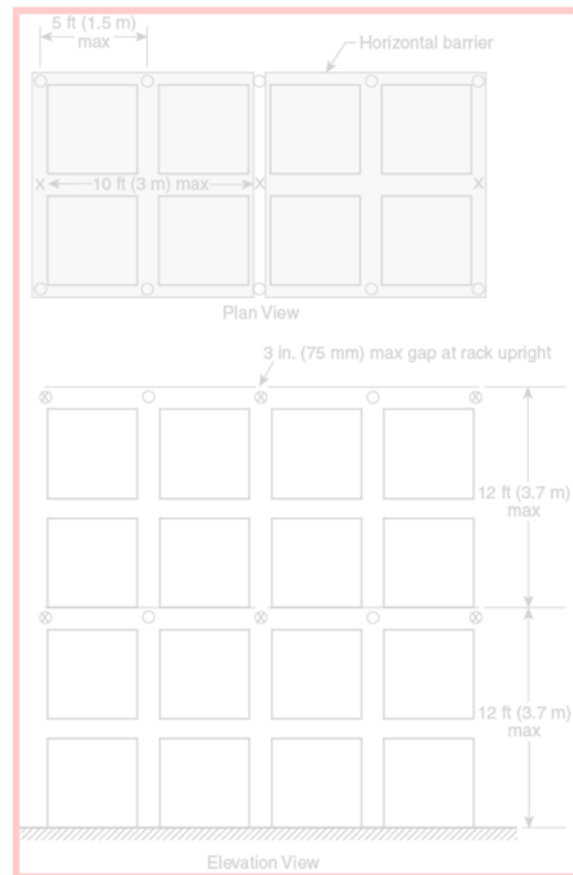
The maximum linear spacing between sprinklers shall not exceed 5 ft (1.5 m).

20.16.1.4.2 Double-Row Racks.

(A)

For double-row racks, sprinklers shall be installed at each rack upright within the longitudinal flue space and at the face of the rack and at the mid-bay face of each rack bay as shown in Figure 20.16.1.4.2(A) .

Figure 20.16.1.4.2(A) Alternative Protection for Double-Row Racks.

**(B)**

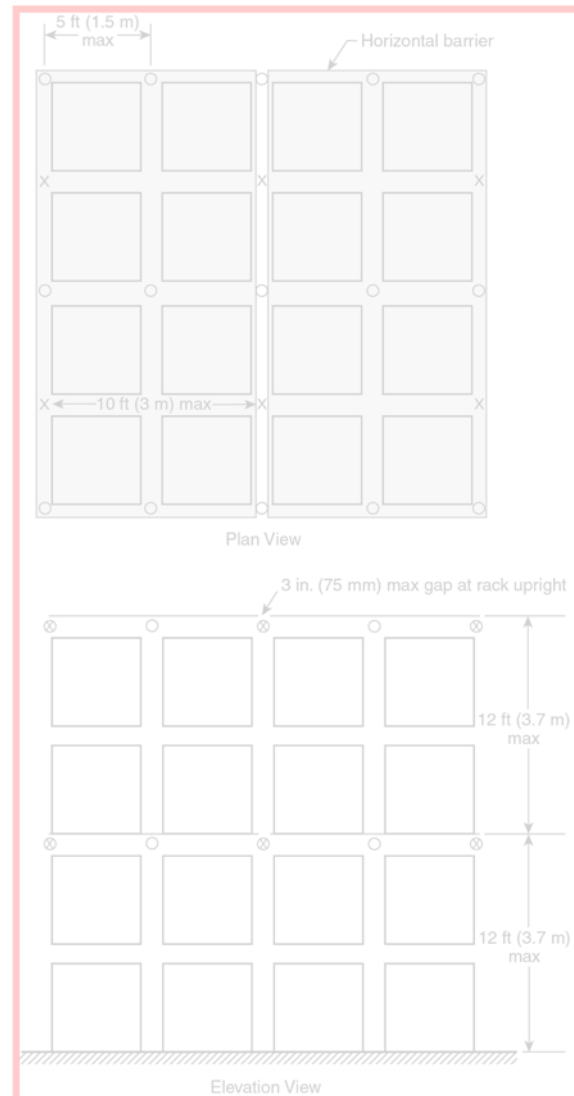
The maximum linear spacing between sprinklers shall not exceed 5 ft (1.5 m) at the rack face and 10 ft (3.0 m) within the longitudinal flue space.

20.16.1.4.3 Multiple-Row Racks.

(A)

For multiple-row racks, an alternating sprinkler arrangement shall be installed within adjacent transverse flue spaces as shown in Figure 20.16.1.4.3(A), with sprinklers at the face of each flue space.

Figure 20.16.1.4.3(A) Alternative Protection for Multiple-Row Racks.

**(B)**

The maximum linear spacing between sprinklers at the face and at each alternating bay shall not exceed 5 ft (1.5 m) and shall not exceed 10 ft (3.0 m) between sprinklers at every other bay.

20.16.1.5

The design of an in-rack sprinkler system shall be based on a minimum flow of 60 gpm (230 L/min) from the most remote six sprinklers for single-row racks or the most remote eight sprinklers for both double-row and multiple-row racks.

20.16.1.6

The in-rack sprinkler demand shall not be required to be hydraulically balanced with the ceiling-level sprinkler system.

20.16.1.7 Ceiling Sprinkler System.

The ceiling-level sprinkler system shall be designed based on the highest commodity hazard not protected by the criteria prescribed by 20.16 :

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Committee Statement

Street Address:

City:

Committee

State:

Zip:

Response Message:

Submission Date: Fri Jul 14 12:35:09 EDT 2017

The text is redundant and can be found in Chapter 25 under Alternative In-Rack Sprinkler Protection Option 1.

**Second Revision No. 1015-NFPA 13-2017 [Section No. 21.1.10]****21.1.10 Discharge Considerations.****21.1.10.1**

The water supply for sprinklers only shall be determined either from the density/area requirements of Chapter ~~12~~ 20 through Chapter 25 or shall be based upon the room design method in accordance with Section 20.8, at the discretion of the designer.

21.1.10.2

The calculations shall satisfy any single point on appropriate density/area curves.

21.1.10.3

When using the density/area method, the design area shall meet the requirements of ~~19.6.4.2.1~~ 27.2.4.2.1.

21.1.10.4

The minimum design density shall be not less than 0.15 gpm/ft² (6.1 mm/min) after all adjustments are made.

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: National Fire Protection Assoc

Street Address:

City:

State:

Zip:

Submittal Date: Tue Aug 01 08:26:22 EDT 2017

Committee Statement

Committee Statement: Editorial revision.

Response Message:



Second Revision No. 381-NFPA 13-2017 [Section No. 21.3.3]

21.3.3*

Design areas and densities for the appropriate storage configuration shall be selected from Table 21.3.3(a) or Table 21.3.3(b) as appropriate.

Table 21.3.3(a) Design Densities for Palletized, Solid-Piled, Bin Box, or Shelf Storage of Group A Plastic Commodities (U.S. Customary Units)

Maximum Storage Height (ft)	Roof/Ceiling Height (ft)	Density (gpm/ft ²)				
		A	B	C	D	E
>5 to ≤12	Up to 15	0.2	EH2	0.3	EH1	EH2
	>15 to 20	0.3	0.6	0.5	EH2	EH2
	>20 to 32	0.4	0.8	0.6	0.45	0.7
15	Up to 20	0.3	0.6	0.5	0.4	0.45
	>20 to 25	0.4	0.8	0.6	0.45	0.7
	>25 to 35	0.45	0.9	0.7	0.55	0.85
20	Up to 25	0.4	0.8	0.6	0.45	0.7
	>25 to 30	0.45	0.9	0.7	0.55	0.85
	>30 to 35	0.6	1.2	0.85	0.7	1.1
25	Up to 30	0.45	0.9	0.7	0.55	0.85
	>30 to 35	0.6	1.2	0.85	0.7	1.1

Notes:

(1) Minimum clearance between sprinkler deflector and top of storage shall be maintained as required.

(2) Column designations correspond to the configuration of plastics storage as follows:

A: (1) Nonexpanded, unstable

(2) Nonexpanded, stable, solid unit load

B: Expanded, exposed, stable

C: (1) Expanded, exposed, unstable

(2) Nonexpanded, stable, cartoned

D: Expanded, cartoned, unstable

E: (1) Expanded, cartoned, stable

(2) Nonexpanded, stable, exposed

(3) EH1 = Density required by Figure 13.2.1 for Curve EH1 Extra Hazard Group 1 design curve and 19.3.3.1.1

EH2 = Density required by Figure 13.2.1 for Curve EH2 Extra Hazard Group 2 design curve and 19.3.3.1.1

(4) Roof/ceiling height >35 ft is not permitted.

Table 21.3.3(b) Design Densities for Palletized, Solid-Piled, Bin Box, or Shelf Storage of Group A Plastic Commodities (S.I. Units)

Maximum Storage Height (m)	Roof/Ceiling Height (m)	Density (mm/min)				
		A	B	C	D	E
>1.5 to ≤3.6	Up to 4.6	8.1	EH2	12.2	EH1	EH2
	>4.6 to 6.1	12.2	24.4	20.4	EH2	EH2
	>6.1 to 9.7	16.3	32.6	24.4	18.3	28.5
4.6	Up to 6.1	12.2	24.4	20.4	16.3	18.3
	>6.1 to 7.6	16.3	32.6	24.4	18.3	28.5
	>7.6 to 11	18.3	36.7	28.5	22.4	34.6
	Up to 7.6	16.3	32.6	24.4	18.3	28.5

<u>Maximum Storage Height (m)</u>	<u>Roof/Ceiling Height (m)</u>	<u>Density (mm/min)</u>				
		<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>E</u>
6.1	>7.6 to 9.1	18.3	36.7	28.5	22.4	34.6
	>9.1 to 11	24.4	48.9	34.6	28.5	44.8
7.6	Up to 9.1	18.3	36.7	28.5	22.4	34.6
	>9.1 to 11	24.4	48.9	34.6	28.5	44.8

Notes:

(1) Minimum clearance between sprinkler deflector and top of storage shall be maintained as required.

(2) Column designations correspond to the configuration of plastics storage as follows:

A: (1) Nonexpanded, unstable

(2) Nonexpanded, stable, solid unit load

B: Expanded, exposed, stable

C: (1) Expanded, exposed, unstable

(2) Nonexpanded, stable, cartoned

D: Expanded, cartoned, unstable

E: (1) Expanded, cartoned, stable

(2) Nonexpanded, stable, exposed

(3) EH1 = Density required by Figure 13.2.1 for Curve EH1 Extra Hazard Group 1 design curve and 19.3.3.1.1

EH2 = Density required by Figure 13.2.1 for Curve EH2 Extra Hazard Group 1 design curve and 19.3.3.1.1

(4) Roof/ceiling height >35 ft is not permitted.

Detail SR-1058

21.3.3.1*

For Table 21.3.3(a) and Table 21.3.3(b), the design areas shall be as follows:

- (1) The area shall be a minimum of 2500 ft² (232 m²).
- (2) Where Table 21.3.3(a) and Table 21.3.3(b) allow densities and areas to be selected in accordance with curve EH1 and Curve EH2 of Figure 13.2.1, any density/area from the curves in Figure 13.2.1 shall be permitted. When selecting a point from the EH1 or EH2 density/area curves of Figure 13.2.1 Extra Hazard Group 1 and Group 2, including 19.3.3.1.1, the following area reductions shall be permitted:
 - (a) For K-8.0 (115) sprinklers used with curve EH1 Extra Hazard Group 1, the design area shall be permitted to be reduced by 25 percent, but not below 2000 ft² (186 m²), where high temperature sprinklers are used.
 - (b) For K-11.2 (160) or larger sprinklers, the design area shall be permitted to be reduced by 25 percent, but not below 2000 ft² (186 m²), regardless of temperature rating.
- (3) For closed arrays, the area shall be permitted to be reduced to 2000 ft² (186 m²).

21.3.3.2*

Interpolation of densities between storage heights shall be permitted.

21.3.6.1

~~Densities shall be based on the 2500 ft² (232 m²) design area.~~

21.3.3.2.1

Interpolation of ceiling/roof heights shall not be permitted.

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Thu Jun 29 15:15:12 EDT 2017

Committee Statement

Committee Statement: The exiting figure has been deleted and replaced with references in the standard.

Response Message:

**Second Revision No. 322-NFPA 13-2017 [Section No. 21.3.4]****21.3.4**

The ceiling-only protection criteria specified in Chapter 17 21 for rack storage of Group A plastic commodities shall be permitted to be used for solid-piled and palletized storage of the same commodity at the same height and clearance to ceiling.

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Wed Jun 28 15:56:11 EDT 2017

Committee Statement

Committee Statement: Corrected Chapter reference.

Response Message:

[Public Comment No. 195-NFPA 13-2017 \[Section No. 21.3.4\]](#)



Second Revision No. 1058-NFPA 13-2017 [Detail]

Move current 21.3.5 and 21.3.6 as subsections to 21.3.3:

21.3.3.1*

For Table 21.3.3(a) and Table 21.3.3(b), the design areas shall be as follows:

- (1) The area shall be a minimum of 2500 ft² (232 m²).
- (2) Where Table 21.3.3(a) and Table 21.3.3(b) allow densities and areas to be selected in accordance with curve EH1 and Curve EH2 of Figure 13.2.1, any density/area from the curves in Figure 13.2.1 shall be permitted. When selecting a point from the EH1 or EH2 density/area curves of Figure 13.2.1 Extra Hazard Group 1 and Group 2, including 19.3.3.1.1, the following area reductions shall be permitted:
 - (a) For K-8.0 (115) sprinklers used with curve EH1 Extra Hazard Group 1, the design area shall be permitted to be reduced by 25 percent, but not below 2000 ft² (186 m²), where high temperature sprinklers are used.
 - (b) For K-11.2 (160) or larger sprinklers, the design area shall be permitted to be reduced by 25 percent, but not below 2000 ft² (186 m²), regardless of temperature rating.
- (3) For closed arrays, the area shall be permitted to be reduced to 2000 ft² (186 m²).

21.3.3.2*

Interpolation of densities between storage heights shall be permitted.

21.3.6.4

~~Densities shall be based on the 2500 ft² (232 m²) design area.~~

21.3.3.2.1

Interpolation of ceiling/roof heights shall not be permitted.

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Wed Oct 25 13:48:31 EDT 2017

Committee Statement

Committee Statement: Some of the information is redundant and can be eliminated. The rest of the information in 21.3.5 and 21.3.6 specifically applies to 21.3.3 and should be subsections to that sections, rather than after that section. Finally, section 21.3.7 needs to be renumbered to 21.3.5 since there is already a section 21.3.4.

Response Message:

Public Comment No. 197-NFPA 13-2017 [Sections 21.3.5, 21.3.6, 21.3.7]



Second Revision No. 1004-NFPA 13-2017 [Section No. 21.4.1.2]

21.4.1.2*

For single- or double-row racks for Class I, Class II, Class III, or Class IV commodities, encapsulated or nonencapsulated in single- or double-row racks, ceiling sprinkler water demand in terms of density [gpm/ft² (mm/min)] and area of sprinkler operation [ft² (m²) of ceiling or roof] shall be selected from the density/area curves of Figure 21.4.1.2(a) through Figure 21.4.1.2(e) that are appropriate for each commodity and configuration as shown in Table 21.4.1.2 and shall be modified as appropriate by 21.4.1.4. These requirements shall apply to portable racks arranged in the same manner as single- or double-row racks.

Figure 21.4.1.2(a) Sprinkler System Design Curves — 20 ft (6.1 m) High Rack Storage — Class I Nonencapsulated Commodities — Conventional Pallets

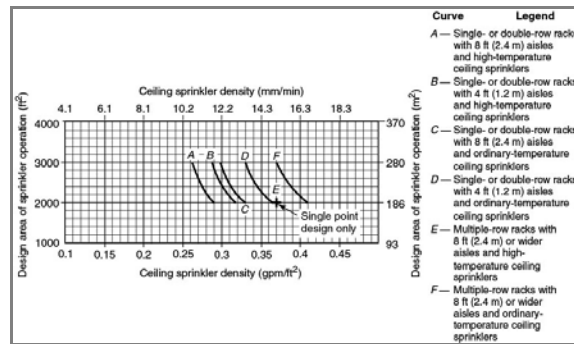


Figure 21.4.1.2(b) Sprinkler System Design Curves — 20 ft (6.1 m) High Rack Storage — Class II Nonencapsulated Commodities — Conventional Pallets.

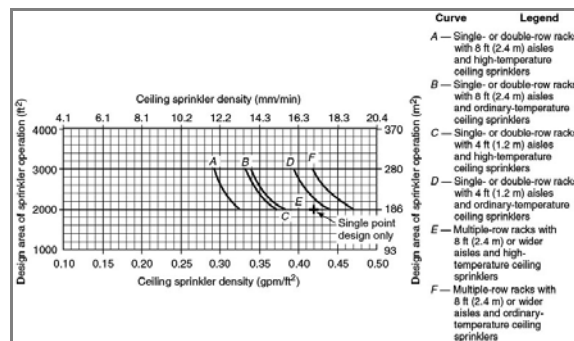


Figure 21.4.1.2(c) Sprinkler System Design Curves — 20 ft (6.1 m) High Rack Storage — Class III Nonencapsulated Commodities — Conventional Pallets.

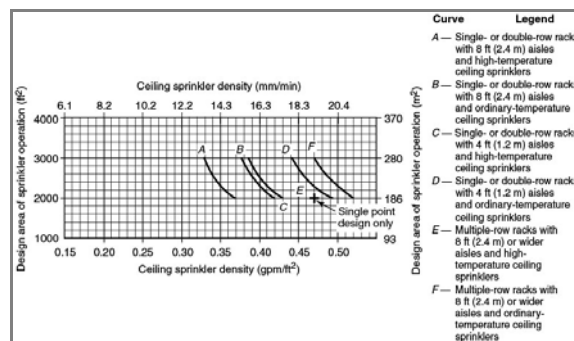
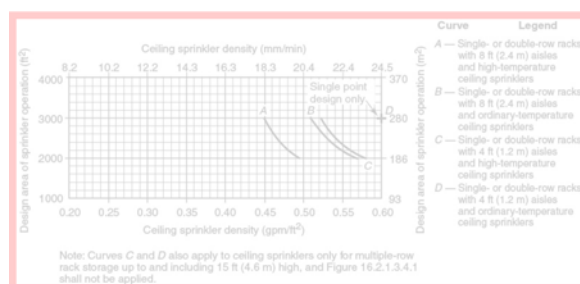


Figure 21.4.1.2(d) Sprinkler System Design Curves — 20 ft (6.1 m) High Rack Storage — Class IV Nonencapsulated Commodities — Conventional Pallets.



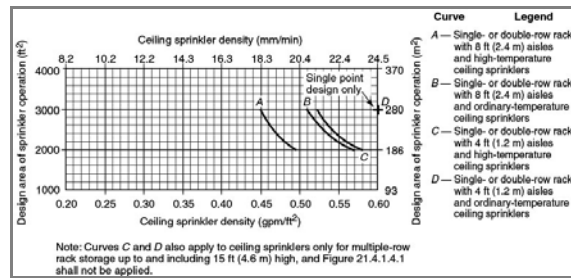


Figure 21.4.1.2(e) Single- or Double-Row Racks — 20 ft (6.1 m) High Rack Storage — Sprinkler System Design Curves — Class I and Class II Encapsulated Commodities — Conventional Pallets.

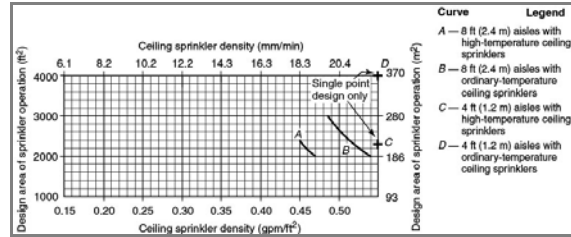


Table 21.4.1.2 Single- or Double-Row Racks — Storage Height Over 12 ft (3.7 m) Up to and Including 25 ft (7.6 m)

<u>Height</u>	<u>Commodity Class</u>	<u>Encapsulated</u>	<u>- Aisles*</u>		<u>Sprinklers Mandatory In-Rack</u>	<u>Ceiling Sprinkler</u>			
			<u>ft</u>	<u>m</u>		<u>With In-Rack Sprinklers</u>		<u>Apply Figure 16.2.1.3.4.1</u>	<u>Fi</u>
						<u>Figure</u>	<u>Curves</u>		
Over 12 ft (3.7 m) up to and including 20 ft (6.1 m)	I	No	4	1.2	No	16.2.1.3.2(a)	C and D	Yes	16.2.1.3.2(a)
			8	2.4			A and B		
		Yes	4	1.2	No	16.2.1.3.2(e)	C and D		16.2.1.3.2(e)
			8	2.4			A and B		
	II	No	4	1.2	No	16.2.1.3.2(b)	C and D		16.2.1.3.2(b)
			8	2.4			A and B		
		Yes	4	1.2	No	16.2.1.3.2(e)	C and D		16.2.1.3.2(e)
			8	2.4			A and B		
	III	No	4	1.2	No	16.2.1.3.2(c)	C and D		16.2.1.3.2(c)
			8	2.4			A and B		

<u>Height</u>	<u>Commodity Class</u>	<u>Encapsulated</u>	<u>Aisles*</u>		<u>Sprinklers Mandatory In-Rack</u>	<u>With In-Rack Sprinklers</u>		<u>Apply Figure 16.2.1.3.4.1</u>	<u>Figure</u>	<u>Curves</u>	<u>Ceiling Sprinkler</u>	
			<u>ft</u>	<u>m</u>							<u>Figure</u>	<u>Curves</u>
Over 20 ft (6.1 m) up to and including 22 ft (6.7 m)	IV	Yes	8	2.4						A and B		
			4	1.2	1-level	16.2.1.3.2(f)				C and D	In-rack required.	
			8	2.4						A and B		
		No	4	1.2						C and D		
			8	2.4	No	16.2.1.3.2(d)					16.2.1.3.2(e)	
			8	2.4						A and B		
	I	Yes	4	1.2	1-level	16.2.1.3.2(g)				C and D	In-rack required.	
			8	2.4						A and B		
			4	1.2						C and D		
		No	8	2.4	No	16.2.1.3.2(a)					16.2.1.3.2(e)	
			8	2.4						A and B		
			4	1.2	1-level	16.2.1.3.2(e)				C and D	In-rack required.	
Over 20 ft (6.1 m) up to and including 22 ft (6.7 m)	II	Yes	8	2.4						A and B		
			4	1.2	1-level	16.2.1.3.2(e)				C and D	In-rack required.	
			8	2.4				No		A and B		
		No	4	1.2						C and D		
			8	2.4	No	16.2.1.3.2(b)					16.2.1.3.2(f)	
			8	2.4						A and B		
	III	Yes	4	1.2	1-level	16.2.1.3.2(f)				C and D	In-rack required.	
			8	2.4						A and B		
			4	1.2						C and D		
		No	8	2.4	No	16.2.1.3.2(c)					16.2.1.3.2(g)	
			8	2.4						A and B		
			4	1.2						C and D		
Over 20 ft (6.1 m) up to and including 22 ft (6.7 m)	IV	No	8	2.4	No	16.2.1.3.2(d)					16.2.1.3.2(h)	
			8	2.4						A and B		
			4	1.2						C and D		
			4	1.2						C and D		

Ceiling Sprinkler									
			Aisles*		With In-Rack Sprinklers				
Height	Commodity Class	Encapsulated	ft	m	Sprinklers Mandatory In-Rack	Figure	Curves	Apply Figure 16.2.1.3.4.1	Fi
Over 22 ft (6.7 m) up to and including 25 ft (7.6 m)	I	Yes	4	1.2	1-level	16.2.1.3.2(g)	C and D		In-rack required. S
			8	2.4			A and B		2
		No	4	1.2	No	16.2.1.3.2(a)	C and D		16.2.1.3.2(f)
			8	2.4			A and B		
		Yes	4	1.2	1-level	16.2.1.3.2(e)	C and D	No	In-rack required. S
			8	2.4			A and B		2
	II	No	4	1.2	No	16.2.1.3.2(b)	C and D		16.2.1.3.2(f)
			8	2.4			A and B		
		Yes	4	1.2	1-level	16.2.1.3.2(e)	C and D	No	In-rack required. S
			8	2.4			A and B		2
		No	4	1.2	No	16.2.1.3.2(c)	C and D		16.2.1.3.2(g)
			8	2.4			A and B		
	III	Yes	4	1.2	1-level	16.2.1.3.2(f)	C and D		In-rack required. S
			8	2.4			A and B		2
		No	4	1.2	No	16.2.1.3.2(d)	C and D		In-rack required. S
			8	2.4			A and B		2
		Yes	4	1.2	1-level	16.2.1.3.2(g)	C and D	No	In-rack required. S
			8	2.4			A and B		2

*See 16.2.1.3.2.1 21.4.1.2.1 for interpolation of aisle widths.

NA: Not applicable.

21.4.1.2.1*

Design densities for single- and double-row racks shall be selected to correspond to aisle width. (See Section C.15.)

(A)

For aisle widths between 4 ft (1.2 m) and 8 ft (2.4 m), the rules for 4 ft (1.2 m) aisle width shall be used or direct linear interpolation between the densities shall be permitted.

(B)

The density given for 8 ft (2.4 m) wide aisles shall be applied to aisles wider than 8 ft (2.4 m).

(C)

The density given for 4 ft (1.2 m) wide aisles shall be applied to aisles more narrow than 4 ft (1.2 m) down to 3½ ft (1.1 m).

(D)

Where aisles are more narrow than 3½ ft (1.1 m), racks shall be considered to be multiple-row racks.

Supplemental Information

<u>File Name</u>	<u>Description</u>	<u>Approved</u>
13_Table_21.4.1.2_With_Mark-Ups.docx	Revised Table 21.4.1.2. For staff use.	

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: National Fire Protection Assoc

Street Address:

City:

State:

Zip:

Submittal Date: Sun Jul 30 17:37:43 EDT 2017

Committee Statement

Committee Statement: Table 21.4.1.2 has been revised showing ceiling only protection, for in-rack see Chapter 25.

Response Message:



Second Revision No. 811-NFPA 13-2017 [Section No. 21.4.1.3.1]

21.4.1.3.1 Multiple-Row Racks — Rack Depth Up to and Including 16 ft (4.9 m) with Aisles 8 ft (2.4 m) or Wider.

For Class I, Class II, Class III, or Class IV commodities, encapsulated or nonencapsulated, ceiling sprinkler water demand in terms of density [gpm/ft² (mm/min)] and area of sprinkler operation [ft² (m²) of ceiling or roof] shall be selected from the density/area curves of Figure 21.4.1.2(a) through Figure 21.4.1.2(e) that are appropriate for each commodity and configuration as shown in Table 21.4.1.3.1 and shall be modified as appropriate by 21.4.1.4. The protection criteria shall apply to portable racks arranged in the same manner as multiple-row racks.

Table 21.4.1.3.1 Multiple-Row Racks — Rack Depth Up to and Including 16 ft (4.9 m), Aisles 8 ft (2.4 m) or Wider and Storage Height Over 12 ft (3.7 m) Up to 25 ft (7.6 m)

Height	Commodity Class	Encap- sulated	Sprinklers Mandatory In-Rack	Ceiling Sprinkler Water				
				With In-Rack Sprinklers				Figure
				Figure	Curves	Apply Figure 16.2.1.3.4.1	1.25 × Density	
Over 12 ft (3.7 m) up to and including 15 ft (4.6 m)	I	No	No	16.2.1.3.2(a)	C and D	Yes	No	16.2.1.3.2(a) 21.4
		Yes		16.2.1.3.2(a)			Yes	16.2.1.3.2(a) 21.4
	II	No		16.2.1.3.2(b)			No	16.2.1.3.2(b) 21.4
		Yes		16.2.1.3.2(b)			Yes	16.2.1.3.2(b) 21.4
	III	No	No	16.2.1.3.2(c)	No		16.2.1.3.2(c) 21.4	
		Yes	1 level	16.2.1.3.2(c)	Yes		In-rack sprinklers required. See Chapter 25.	
	IV	No	No	16.2.1.3.2(d)	No		16.2.1.3.2(d) In-rack sprinklers required. See Chapter 25.	
		Yes	1 level	16.2.1.3.2(d)	A and B		1.50 × density	In-rack sprinklers required. See Chapter 25.
Over 15 ft (4.6 m) up to and including 20 ft (6.1 m)	I	No	No	16.2.1.3.2(a)	C and D	Yes	No	16.2.1.3.2(a) 21.4
		Yes		16.2.1.3.2(a)			Yes	16.2.1.3.2(a) 21.4
	II	No		16.2.1.3.2(b)			No	16.2.1.3.2(b) 21.4
		Yes		16.2.1.3.2(b)			Yes	16.2.1.3.2(b) 21.4

		<u>Ceiling Sprinkler Water</u>					
		<u>With In-Rack Sprinklers</u>					
<u>Height</u>	<u>Commodity Class</u>	<u>Encapsulated</u>	<u>Sprinklers Mandatory In-Rack</u>	<u>Figure</u>	<u>Curves</u>	<u>Apply Figure 16.2.1.3.4.1</u>	<u>Figure</u>
Over 20 ft (6.1 m) up to and including 25 ft (7.6 m)	III	No	No	16.2.1.3.2(c)		No	16.2.1.3.2(c) 21.4
		Yes	1-level	16.2.1.3.2(c)		Yes	
		No		16.2.1.3.2(d)		No	NA In-rack sprinkler required. See Chapter 25.
	IV		1-level				
		Yes		16.2.1.3.2(d)	A and B	1.50 × density	25.
	I	No	No	16.2.1.3.2(a)		No	16.2.1.3.2(a) 21.4
		Yes	1-level	16.2.1.3.2(a)		Yes	
		No		16.2.1.3.2(b)	C and D	No	
	II	Yes		16.2.1.3.2(b)		No	
			1-level			Yes	
		No		16.2.1.3.2(c)		No	NA In-rack sprinkler required. See Chapter 25.
	III	Yes		16.2.1.3.2(c)		Yes	
		No		16.2.1.3.2(d)		No	
			2-levels				
	IV	Yes		16.2.1.3.2(d)	A and B	1.50 × density	

NA: Not applicable.

Supplemental Information

<u>File Name</u>	<u>Description</u>	<u>Approved</u>
13_Table_21.4.1.3.1_With_Mark-Ups.docx	Revised Table 21.4.1.3.1. For staff use.	

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Mon Jul 24 07:24:40 EDT 2017

Committee Statement

Committee Statement: Table 21.4.1.3.1 has been revised to represent ceiling only design, for in-rack design see Chapter 25.

Response Message:



Second Revision No. 812-NFPA 13-2017 [Section No. 21.4.1.3.2]



21.4.1.3.2 Multiple-Row Racks — Rack Depth Over 16 ft (4.9 m) or Aisles More Narrow Than 8 ft (2.4 m).

For Class I, Class II, Class III, or Class IV commodities, encapsulated or nonencapsulated, ceiling sprinkler water demand in terms of density [gpm/ft² (mm/min)] and area of sprinkler operation [ft² (m²) of ceiling or roof] shall be selected from the density/area curves of Figure 21.4.1.2(a) through Figure 21.4.1.2(e) that are appropriate for each commodity and configuration as shown in Table 21.4.1.3.2 and shall be modified as appropriate by 21.4.1.4. The protection criteria shall apply to portable racks arranged in the same manner as multiple-row racks.

Table 21.4.1.3.2 Multiple-Row Racks — Rack Depth Over 16 ft (4.9 m) or Aisles Narrower Than 8 ft (2.4 m), Storage Height Over 12 ft (3.7 m) Up to and Including 25 ft (7.6 m)

<u>Height</u>	<u>Commodity Class</u>	<u>Encapsulated</u>	<u>Sprinklers Mandatory In-Rack</u>	<u>Ceiling Sprinkler Water</u>				
				<u>With In-Rack Sprinklers</u>				<u>Figure</u>
				<u>Figure</u>	<u>Curves</u>	<u>Apply Figure 16.2.1.3.4.1</u>	<u>1.25 × Density</u>	
Over 12 ft (3.7 m) up to and including 15 ft (4.6 m)	I	No	No	16.2.1.3.2(a)	C and D	Yes	No	16.2.1.3.2(a) 21.4
		Yes		16.2.1.3.2(a)			Yes	16.2.1.3.2(a) 21.4
	II	No		16.2.1.3.2(b)			No	16.2.1.3.2(b) 21.4
		Yes		16.2.1.3.2(b)			Yes	16.2.1.3.2(b) 21.4
	III	No	1-level	16.2.1.3.2(c)			No	16.2.1.3.2(c) 21.4
		Yes		16.2.1.3.2(c)			Yes	In-rack sprink required. See C 25.
	IV	No	No	16.2.1.3.2(d)			No	16.2.1.3.2(d) In sprinklers require Chapter 25
		Yes	1-level	16.2.1.3.2(d)			1.50 × density	In-rack sprink required. See C 25.
Over 15 ft (4.6 m) up to and including 20 ft (6.1 m)	I	No	1-level	16.2.1.3.2(a)	C and D	Yes	No	NA In-rack sprink required. See C 25.
		Yes		16.2.1.3.2(a)			Yes	
	II	No		16.2.1.3.2(b)			No	
		Yes		16.2.1.3.2(b)			Yes	
	III	No		16.2.1.3.2(c)			No	
		Yes		16.2.1.3.2(c)			Yes	
	IV	No		16.2.1.3.2(d)			No	
		Yes		16.2.1.3.2(d)			1.50 × density	
Over 20 ft (6.1 m) up to and	I	No	1-level	16.2.1.3.2(a)	C and D	No	No	NA In-rack sprink required. See C 25.
		Yes		16.2.1.3.2(a)			Yes	
	II	No		16.2.1.3.2(b)			No	

							Ceiling Sprinkler Water	
With In-Rack Sprinklers								
Height	Commodity Class	Encap- sulated	Sprinklers Mandatory In-Rack	Figure	Curves	Apply Figure 16.2.1.3.4.1	1.25 × Density	Figure
including 25 ft (7.6 m)	III	Yes		16.2.1.3.2(b)			Yes	
		No		16.2.1.3.2(c)			No	
		Yes		16.2.1.3.2(c)			Yes	
		No		16.2.1.3.2(d)			No	
	IV		2-levels					
		Yes		16.2.1.3.2(d)			1.50 × density	
NA: Not applicable.								

Supplemental Information

<u>File Name</u>	<u>Description</u>	<u>Approved</u>
13_Table_21.4.1.3.2_With_Mark-Ups.docx	Revise Table 21.4.1.3.2	

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Mon Jul 24 07:33:03 EDT 2017

Committee Statement

Committee Statement: Table 21.4.1.3.2 has been revised to represent ceiling only design, for in-rack design see Chapter 25.

Response Message:

Table 21.4.1.3.2 Multiple-Row Racks — Rack Depth Over 16 ft (4.9 m) or Aisles Narrower Than 8 ft (2.4 m), Storage Height Over 12 ft (3.7 m) Up to and Including 25 ft (7.6 m)

Height	Commodity Class	Encap- sulated	Sprinklers Mandatory In-Rack	Ceiling Sprinkler Water Demand								
				With In-Rack Sprinklers				Without In-Rack Sprinklers				
				Figure	Curves	Apply Figure 16.2.1.3.4.1	1.25 x Density	Figure	Curves	Apply Figure 21.4.1.4.116.2.1.3.4.1	1.25 x Density	
Over 12 ft (3.7 m) up to and including 15 ft (4.6 m)	I	No	No	16.2.1.3.2(a)	C and D	Yes	No	21.4.1.216.2.1.3.2(a)	I and J	Yes	No	
		Yes		16.2.1.3.2(a)			Yes	21.4.1.216.2.1.3.2(a)	I and J		Yes	
	II	No		16.2.1.3.2(b)			No	21.4.1.216.2.1.3.2(b)	I and J	Yes	No	
		Yes		16.2.1.3.2(b)			Yes	21.4.1.216.2.1.3.2(b)	I and J		Yes	
	III	No		16.2.1.3.2(e)			No	21.4.1.216.2.1.3.2(c)	I and J	Yes	No	
		Yes		1-level			16.2.1.3.2(e)	Yes	In-Rack Sprinklers Required. See Chapter 25		NA	NA
	IV	No		No			16.2.1.3.2(d)	No	21.4.1.216.2.1.3.2(d)	C and D	No	No
		Yes		1-level			16.2.1.3.2(d)	1.50 x density	In-Rack Sprinklers Required. See Chapter 25	NA	NA	
Over 15 ft (4.6 m) up to and including 20 ft (6.1 m)	I	No	1-level	16.2.1.3.2(a)	C and D	Yes	No	In-Rack Sprinklers Required. See Chapter 25 NA	NA	NA	NA	
		Yes		16.2.1.3.2(a)			Yes					
	II	No		16.2.1.3.2(b)			No					
		Yes		16.2.1.3.2(b)			Yes					
	III	No		16.2.1.3.2(c)			No					
		Yes		16.2.1.3.2(c)			Yes					
	IV	No		16.2.1.3.2(d)			No					
		Yes		16.2.1.3.2(d)			1.50 x density					
Over 20 ft (6.1 m) up to and including 25 ft (7.6 m)	I	No	1-level	16.2.1.3.2(a)	C and D	No	No	In-Rack Sprinklers Required. See Chapter 25 NA	NA	NA	NA	
		Yes		16.2.1.3.2(a)			Yes					
	II	No		16.2.1.3.2(b)			No					
		Yes		16.2.1.3.2(b)			Yes					
	III	No		16.2.1.3.2(c)			No					
		Yes		16.2.1.3.2(c)			Yes					
	IV	No		16.2.1.3.2(d)			No					
		Yes	2-levels	16.2.1.3.2(d)			1.50 x density					

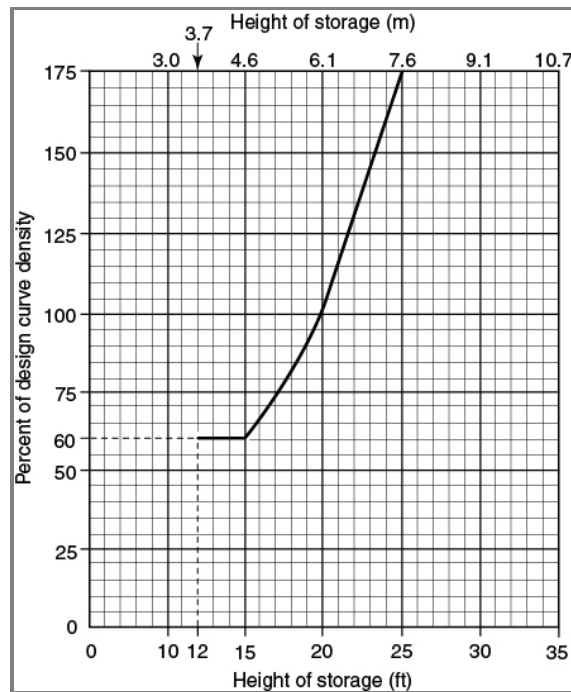
NA: Not applicable.

Formatted: Centered

**Second Revision No. 804-NFPA 13-2017 [Section No. 21.4.1.4]****21.4.1.4 Ceiling Sprinkler Density Adjustments.****21.4.1.4.1**

For storage height over 12 ft (3.7 m) up to and including 25 ft (7.6 m) protected with ceiling sprinklers only and for storage height over 12 ft (3.7 m) up to and including 20 ft (6.1 m) protected with ceiling sprinklers and minimum required in-rack sprinklers, densities obtained from design curves, densities obtained from design curves shall be adjusted in accordance with Figure 21.4.1.4.1.

Figure 21.4.1.4.1 Ceiling Sprinkler Density vs. Storage Height.

**21.4.1.4.2**

For storage height over 20 ft (6.1 m) up to and including 25 ft (7.6 m) protected with ceiling sprinklers and minimum required in-rack sprinklers, densities obtained from design curves shall be used. Densities shall not be adjusted in accordance with Figure 21.4.1.4.1.

21.4.1.4.3

For storage height over 12 ft (3.7 m) up to and including 20 ft (6.1 m) protected with ceiling sprinklers and with more than one level of in-rack sprinklers, but not in every tier, densities obtained from design curves and adjusted in accordance with Figure 21.4.1.4.1 shall be permitted to be reduced an additional 20 percent, as indicated in Table 21.4.1.4.3.

Table 21.4.1.4.3 Adjustment to Ceiling Sprinkler Density for Storage Height and In-Rack Sprinklers

Storage Height	In-Rack Sprinklers	Apply Figure 16.2.1.3.4.1 for Storage Height Adjustment	Permitted Ceiling Sprinklers Density Adjustments Where In-Rack Sprinklers Are Installed
Over 12 ft (3.7 m) through 25 ft (7.6 m)	None	Yes	None
	Minimum required	Yes	None
Over 12 ft (3.7 m) through 20 ft (6.1 m)	More than minimum, but not in every tier	Yes	Reduce density 20% from that of minimum in-rack sprinklers
	In every tier except above the top tier	Yes	Reduce density 40% from that of minimum in-rack sprinklers
	Minimum required	No	None
Over 20 ft (6.1 m) through 25 ft (7.3 m)	More than minimum, but not in every tier	No	Reduce density 20% from that of minimum in-rack sprinklers
	In every tier except above the top tier	No	Reduce density 40% from that of minimum in-rack sprinklers
	Minimum required	No	None

21.4.1.4.4

For storage height over 20 ft (6.1 m) up to and including 25 ft (7.6 m) protected with ceiling sprinklers and with more than the minimum required level of in-rack sprinklers, but not in every tier, densities obtained from design curves shall be permitted to be reduced 20 percent, as indicated in Table 21.4.1.4.3. Densities shall not be adjusted in accordance with Figure 21.4.1.4.1 for storage height.

21.4.1.4.5*

For storage height over 12 ft (3.7 m) up to and including 20 ft (6.1 m) protected with ceiling sprinklers and in-rack sprinklers at each tier, densities obtained from design curves and adjusted in accordance with Figure 21.4.1.4.1 shall be permitted to be reduced an additional 40 percent, as indicated in Table 21.4.1.4.3.

A.21.4.1.4.5

It is not the intent that an in-rack sprinkler be installed above the top tier of storage when utilizing "in-rack sprinklers in every tier."

21.4.1.4.6

For storage height over 20 ft (6.1 m) up to and including 25 ft (7.6 m) protected with ceiling sprinklers and in-rack sprinklers at each tier except above the top tier, densities obtained from design curves shall be permitted to be reduced 40 percent, as indicated in Table 21.4.1.4.3. Densities shall not be adjusted in accordance with Figure 21.4.1.4.1 for storage height.

21.4.1.4.2

Where solid, flat-bottom, combustible pallets (slave pallets) are used with storage height up to and including 25 ft (7.6 m), the densities that are indicated in the design curves shown in Figure 21.4.1.2(a) through Figure 21.4.1.2(e), based on conventional pallets, shall be increased 20 percent for the given area.

(A)

The percentage shall be applied to the density determined in accordance with 21.4.1.4.

(B)

The increase in density shall not apply where in-rack sprinklers are utilized in the design.

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Mon Jul 17 15:21:49 EDT 2017

Committee Statement

Committee Statement: This is redundant text that is covered by Chapter 25.

Response Message:



Second Revision No. 813-NFPA 13-2017 [Section No. 21.4.2.1 [Excluding any Sub-Sections]]

For single- and double-row racks, the water demand for nonencapsulated storage separated by aisles at least 4 ft (1.2 m) wide and with a clearance to ceiling up to and including 10 ft (3.0 m) shall be in accordance with Table 21.4.2.1. The protection criteria requirements for rack storage of Class I through Class IV commodities stored over 25 ft (7.6 m) in height protected by CMDA sprinklers shall be in accordance with Chapter 25.

Table 21.4.2.1 Single- or Double-Row Racks of Class I Through Class IV Commodities Stored Over 25 ft (7.6 m) in Height with Aisles 4 ft (1.2 m) or More in Width

Commodity Class	In-Rack Sprinklers Approximate Vertical Spacing at Tier Nearest the Vertical Distance and Maximum Horizontal Spacing a,b,c		Figure	Maximum Storage Height	Stagger	Ceiling Sprinkler Operating Area		Ceiling Sprinkler Ceiling Uprate Ordinary Temperature	
	Longitudinal Flue d	Face e,f				ft 2	m 2	gpm/ft 2	mm/min
I	Vertical 20 ft (6.1 m) Horizontal 10 ft (3.0 m) under horizontal barriers	None	16.3.1.3.1.1(A)(a)	30 ft (9.1 m)	No	2000	186	0.25	10.2
	Vertical 20 ft (6.1 m) Horizontal 10 ft (3.0 m)	Vertical 20 ft (6.1 m) Horizontal 10 ft (3.0 m)	16.3.1.3.1.1(A)(b)	Higher than 25 ft (7.6 m)	Yes			0.25	10.2
I, II, III	Vertical 10 ft (3.0 m) or at 15 ft (4.6 m) and 25 ft (7.6 m)	None	16.3.1.3.1.1(A)(c)	30 ft (9.1 m)	Yes	2000	186	0.3	12.2
	Vertical 10 ft (3.0 m) Horizontal 10 ft (3.0 m)	Vertical 30 ft (9.1 m) Horizontal 10 ft (3.0 m)	16.3.1.3.1.1(A)(d)	Higher than 25 ft (7.6 m)	Yes			0.3	12.2
	Vertical 20 ft (6.1 m) Horizontal 10 ft (3.0 m)	Vertical 20 ft (6.1 m) Horizontal 5 ft (1.5 m)	16.3.1.3.1.1(A)(e)		Yes			0.3	12.2
	Vertical 25 ft (7.6 m) Horizontal 5 ft (1.5 m)	Vertical 25 ft (7.6 m) Horizontal 5 ft (1.5 m)	16.3.1.3.1.1(A)(f)		No			0.3	12.2
	Horizontal barriers at 20 ft (6.1 m) Vertical		16.3.1.3.1.1(A)(g)		Yes			0.3	12.2

<u>Commodity Class</u>	<u>In-Rack Sprinklers</u> <u>Approximate Vertical Spacing at Tier Nearest the Vertical Distance and Maximum Horizontal Spacing</u> ^{a,b,c}		<u>Figure</u>	<u>Maximum Storage Height</u>	<u>Stagger</u>	<u>Ceiling Sprinkler Operating Area</u>		<u>Ceiling Sprinkler Ceiling Underlay Temperature</u>	
	<u>Longitudinal Flue</u> ^d	<u>Face</u> ^{e,f}				<u>ft²</u>	<u>m²</u>	<u>gpm/ft²</u>	<u>mm/r</u>
I, II, III, IV	intervals — two lines of sprinklers under barriers — maximum horizontal spacing 10 ft (3.0 m); staggered								
	Vertical 15 ft (4.6 m) Horizontal 10 ft (3.1 m)	Vertical 20 ft (6.1 m) Horizontal 10 ft (3.0 m)	16.3.1.3.1.1(A)(h)		Yes			0.35	14.3
	Vertical 20 ft (6.1 m) Horizontal 5 ft (1.5 m)	Vertical 20 ft (6.1 m) Horizontal 5 ft (1.5 m)	16.3.1.3.1.1(A)(i)		No			0.35	14.2
	Horizontal barriers at 15 ft (4.6 m)			Higher than 25 ft (7.6 m)		2000	186		
	Vertical intervals — two lines of sprinklers under barriers — maximum horizontal spacing 10 ft (3.0 m); staggered		16.3.1.3.1.1(A)(j)		Yes			0.35	14.2

^a Minimum in-rack sprinkler discharge, 30 gpm (114 L/min).

^b Water shields required.

^c All in-rack sprinkler spacing dimensions start from the floor.

^d Install sprinklers at least 3 in. (75 mm) from uprights.

^e Face sprinklers shall not be required for a Class I commodity consisting of noncombustible products on wood pallets (without combustible containers), except for arrays shown in Figure 16.3.1.3.1.1(A)(g) and Figure 16.3.1.3.1.1(A)(j).

^f In Figure 16.3.1.3.1.1(A)(a) through Figure 16.3.1.3.1.1(A)(j), each square represents a storage cube that measures 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. to 10 ft (450 mm to 3.0 m). Therefore, there can be one load to six or seven loads between in-rack

~~sprinklers that are spaced 10 ft (3.0 m) apart vertically.~~

~~9 For encapsulated commodity, increase density 25 percent.~~

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Mon Jul 24 07:37:15 EDT 2017

Committee Statement

Committee Statement: Table 21.4.2.1 has been deleted, for in-rack design see Chapter 25. A statement has been provided directing the user to Chapter 25.

Response Message:



Second Revision No. 814-NFPA 13-2017 [Section No. 21.4.2.2 [Excluding any Sub-Sections]]

For multiple-row racks, the water demand for nonencapsulated storage separated by aisles at least 4 ft (1.2 m) wide and with a clearance to ceiling up to and including 10 ft (3.0 m) shall be in accordance with Table 21.4.2.2.

Table 21.4.2.2 Multiple-Row Racks of Class I Through Class IV Commodities Stored Over 25 ft (7.6 m) in Height

Commodity Class	Encapsulated	In-Rack Sprinklers ^{a,b,c}						Height Limit (ft)	Stagger	Figure	Maximum Spacing from Storage to High In-Rack Sprinkler	
		Maximum Vertical Spacing		Maximum Horizontal Spacing in A-Flue		Maximum Horizontal Spacing across Flue					ft	in
		ft	m	ft	m	ft	m					
I	No	20	6.1	12	3.7	10	3.0	None	Between adjacent flues	16.3.1.3.1.3(A)(a)	10	
	Yes											
I, II, and III	No	15	4.6	10	3.0	10	3.0			16.3.1.3.1.3(A)(b)	10	
	Yes											
I, II, III, and IV	No	10	3.1	10	3.0	10	3.0			16.3.1.3.1.3(A)(c)	5	
	Yes											

For SI units, °C = $\frac{5}{9} (°F - 32)$; 1 gpm/ft² = 40.746 mm/min.

^a All four rack faces shall be protected by sprinklers located within the racks and no more than 18 in. (450 mm) from the faces, as indicated in Figure 16.3.1.3.1.3(A)(a) through Figure 16.3.1.3.1.3(A)(c). It shall not be required for each sprinkler level to protect all faces.

^b All in-rack sprinkler spacing dimensions start from the floor.

^c In Figure 16.3.1.3.1.3(A)(a) through Figure 16.3.1.3.1.3(A)(c), each square represents a storage cube measuring 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. to 10 ft (450 mm to 3.0 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.1 m) apart vertically.

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Mon Jul 24 07:40:04 EDT 2017

Committee Statement

Committee Statement: Table 21.4.2.2 has been deleted, for in-rack design see Chapter 25.

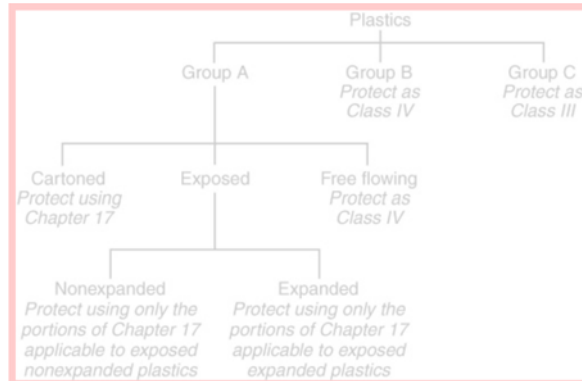
Response Message:



Second Revision No. 383-NFPA 13-2017 [Section No. 21.5.1 [Excluding any Sub-Sections]]

Plastic commodities shall be protected in accordance with [Figure 21.5.1 this section](#) . (See [Section C.21.](#))

Figure 21.5.1 Decision Tree.



Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Thu Jun 29 15:28:33 EDT 2017

Committee Statement

Committee Statement: The figure has been deleted as it is redundant, the figure can be found in Chapter 20.

Response Message:



Second Revision No. 815-NFPA 13-2017 [Section No. 21.5.1.1]

21.5.1.1

For Group A plastic commodities in cartons, encapsulated or nonencapsulated in single-, double-, and multiple-row racks and with a clearance to ceiling up to and including 10 ft (3.1 m), ceiling sprinkler water demand in terms of density [gpm/ft² (mm/min)] and area of operation [ft² (m²)] shall be selected from Table 21.5.1.1.

Table 21.5.1.1 Control Mode Density/Area Sprinkler Protection Criteria for Single-, Double-, and Multiple-Row Racks for Group A Plastic Commodities in Cartons Stored Up to and Including 25 ft (7.6 m) in Height

<u>Commodity</u>	<u>Storage height</u>	<u>Maximum Clearance from Top of Storage to Ceiling</u>	<u>Maximum Ceiling Height</u>	<u>In-Racks Requirements</u>	<u>Ceiling Sprinklers Density Clearance to Ceiling Up to 10 ft</u>	<u>Ceiling Sprinkler Operating Area</u>
-	<u>ft (m)</u>	<u>ft (m)</u>	<u>ft (m)</u>		<u>gpm/ft²(mm/min)</u>	<u>ft² (m²)</u>
Group A plastic commodities in cartons, encapsulated	5 ft to 10 ft (1.5 m to 3.1 m)	<5 ft (1.5 m)	<15 ft (3.1 4.6 m)	Not Required	0.30 gpm/ft ² (12.2 mm/min)	2000 ft ² (186 m ²)
		5 ft to 10 ft (1.5 m to 3.1 m)	20 ft (6.1 m)	Not Required	0.45 gpm/ft ² (18.3 mm/min)	
	15 ft (4.6 m)	5 ≥ 5 ft (1.5 m)-and-up	22 ft (6.7 m)	Not Required	0.45 gpm/ft ² (18.3 mm/min)	
		Up to 10 ≤ 10 ft (3.1 m)	25 ft (7.6 m)	Not Required	0.60 gpm/ft ² (24.5 mm/min)	
				Figure 25.9.3.2(a)	0.30 gpm/ft ² (12.2 mm/min)	
	20 ft (6.1 m)	<5 ft (1.5 m)	<25 ft (7.6 m)	Not Required 1,2	0.60 gpm/ft ² (24.5 mm/min) ^{a,b}	
				Figure 25.9.3.2(b)	0.45 gpm/ft ² (18.3 mm/min)	
				Figure 25.9.3.2(c)	0.30 gpm/ft ² (12.2 mm/min)	
		5 ft to 10 ft (1.5 m to 3.1 m)	27 ft (8.2 m)	Not Required 4	0.60 gpm/ft ² (24.5 mm/min) ^a	
			30 ft (9.1 m)	Figure 25.9.3.2(d)	0.45 gpm/ft ² (18.3 mm/min)	
				Figure 25.9.3.2(e)	0.30 gpm/ft ² (12.2 mm/min)	
				Figure 25.9.3.2(f)	0.30 gpm/ft ² (12.2 mm/min)	
				Figure 25.9.3.2(g)	0.30 gpm/ft ² (12.2 mm/min)	
	25 ft (7.6 m)	<5 ft (1.5 m)	30 ft (9.1 m)	Not Required 2	0.8 gpm/ft ² (32.6 mm/min) ^c	
				Figure 25.9.3.2(h)	0.45 gpm/ft ² (18.3 mm/min)	
				Figure 25.9.3.2(i)	0.30 gpm/ft ² (12.2 mm/min)	

<u>Commodity</u>	<u>Storage height</u>	<u>Maximum Clearance from Top of Storage to Ceiling</u>	<u>Maximum Ceiling Height</u>	<u>In-Racks Requirements</u>	<u>Ceiling Sprinklers Density Clearance to Ceiling Up to 10 ft</u>	<u>Ceiling Sprinkler Operating Area</u>
-	<u>ft (m)</u>	<u>ft (m)</u>	<u>ft (m)</u>		<u>gpm/ft²(mm/min)</u>	<u>ft² (m²)</u>
		5 ft to 10 ft (1.5 m to 3.1 m)	35 ft (10.7 m)	Figure 25.9.3.2(j)	0.30 gpm/ft ² (12.2 mm/min)	

Notes

(1)- ^a Ceiling-only protection is not permitted for this storage configuration except where K-11.2 or larger spray sprinklers listed for storage use are installed.

(2)- ^b For the protection of single- and double-row rack only.

(3)- ^c Ceiling-only protection shall not be permitted for this storage configuration except where K-16.8 spray sprinklers listed for storage use are installed.

Supplemental Information

<u>File Name</u>	<u>Description</u>	<u>Approved</u>
13_Table_21.5.1.1_With_Mark-Ups_.docx	Revised Table 21.5.1.1. For staff use.	

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Mon Jul 24 07:42:58 EDT 2017

Committee Statement

Committee Statement: Table 21.5.1.1 has been revised to represent ceiling only design, for in-rack design see Chapter 25.

Response Message:

**Second Revision No. 1009-NFPA 13-2017 [Section No. 21.5.1.4.1]****21.5.1.4.1**

~~The density/area criteria shall be applied to the ceiling sprinklers and the in-rack sprinklers shown in the option (if any) shall be provided.~~

21.5.1.4.2

~~Options that do not show multiple-row racks in the figures shall not be permitted to protect multiple-row rack storage.~~

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: National Fire Protection Assoc

Street Address:

City:

State:

Zip:

Submission Date: Sun Jul 30 20:04:35 EDT 2017

Committee Statement

Committee Statement: In-rack sprinklers are covered by Chapter 25. Delete section 21.5.1.4.2 as the figures no longer exist.

Response Message:

**Second Revision No. 1010-NFPA 13-2017 [Section No. 21.5.1.4.3]****21.5.1.4.3**

~~Notes in each figure shall be permitted to clarify options or to present additional options not shown in the figures.~~

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: National Fire Protection Assoc

Street Address:

City:

State:

Zip:

Submittal Date: Sun Jul 30 20:06:02 EDT 2017

Committee Statement

Committee Statement: Delete section 21.5.1.4.3 as the figures no longer exist.

Response Message:



Second Revision No. 816-NFPA 13-2017 [Section No. 21.5.3]

Global SR-531

21.5.3

Exposed nonexpanded Group A plastics protected with control mode density/area sprinklers shall be protected in accordance with Table 21.5.3.

Table 21.5.3 Control Mode Density/Area Sprinkler Protection Criteria for Exposed
Unexpanded Nonexpanded Group A Plastics

<u>Commodity</u>	<u>Storage height</u>	<u>Maximum Ceiling Height</u>	<u>In-Racks Requirements</u>	<u>Ceiling Sprinklers Density Clearance to Ceiling Up to 10 ft</u>	<u>Ceiling Sprinkler Operating Area</u>
	<u>ft (m)</u>	<u>ft (m)</u>		<u>gpm/ft² (mm/min)</u>	<u>ft² (m²)</u>
Exposed Unexpanded nonexpanded Group A plastic	10 ft (3.1 m)	20 ft (6.1 m)	Not Required	0.80 gpm/ft ² (32.6 mm/min)	2500 ft ² (232 m ²)
			Figure 25.9.3.2(a)	0.45 gpm/ft ² (18.3 mm/min)	2000 ft ² (186 m ²)
			Figure 25.9.3.2(b)	0.30 gpm/ft ² (12.2 mm/min)	
	15 ft (4.6 m)	25 ft (7.6 m)	Figure 25.9.3.2(c)	0.45 gpm/ft ² (18.3 mm/min)	
			Figure 25.9.3.2(d)	0.30 gpm/ft ² (12.2 mm/min)	
	20 ft (6.1 m)	25 ft (7.6 m)	Figure 25.9.3.2(e)	0.60 gpm/ft ² (24.5 mm/min)	
			Figure 25.9.3.2(f)	0.45 gpm/ft ² (18.3 mm/min)	
		30 ft (9.1 m)	Figure 25.9.3.2(g)	0.80 gpm/ft ² (32.6 mm/min)	1500 ft ² (139 m ²)
			Figure 25.9.3.2(h)	0.60 gpm/ft ² (24.5 mm/min)	2000 ft ² (186 m ²)
			Figure 25.9.3.2(i)	0.30 gpm/ft ² (12.2 mm/min)	
	25 ft (7.6 m)	35 ft (10.7 m)	Figure 25.9.3.2(j)	0.80 gpm/ft ² (32.6 mm/min)	1500 ft ² (139 m ²)
			Figure 25.9.3.2(k)	0.30 gpm/ft ² (12.2 mm/min)	2000 ft ² (186 m ²)

Supplemental Information

File Name

Description

Approved

13_Table_21.5.3_With_Mark-Ups_.docx

Revised Table 21.5.3. For staff use.

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Mon Jul 24 07:45:51 EDT 2017

Committee Statement

Committee Statement: Table 21.5.3 has been revised to represent ceiling only design, for in-rack design see Chapter 25.

Response Message:

**Second Revision No. 1011-NFPA 13-2017 [Sections 21.5.4.1, 21.5.4.2, 21.5.4.3]****21.5.4.1**

~~Protection of Group A plastics in cartons, expanded or nonexpanded, whether encapsulated or nonencapsulated and with a clearance to ceiling up to and including 10 ft (3.1 m), shall be permitted using control mode density/area sprinklers in accordance with 21.5.4. The protection criteria requirements for rack storage of Group A plastic commodities stored over 25 ft (7.6 m) in height protected by CMDA sprinklers shall be in accordance with Chapter 25.~~

21.5.4.2

~~Protection of Group A plastics that are exposed and nonexpanded, whether encapsulated or nonencapsulated racks and with a clearance to ceiling up to and including 10 ft (3.1 m), shall be permitted only using in-rack sprinkler arrangements that are specifically permitted to be used with exposed unexpanded plastics.~~

21.5.4.3* Ceiling Sprinkler Water Demand.

For Group A plastic commodities, encapsulated or nonencapsulated, ceiling sprinkler water demand in terms of density [gpm/ft² (mm/min)] and area of operation [ft² (m²)] shall be selected from Table 21.5.4.3 where in-rack sprinklers are installed per Chapter 25.

Table 21.5.4.3 Control Mode Density/Area Sprinkler Discharge Criteria for Single, Double, and Multiple Row Racks of Group A Plastic Commodities with Storage Over 25 ft (7.6 m) in Height

Commodity	Rack Type	Storage height above top level of in-rack sprinklers	In-Racks Requirements	Ceiling Sprinklers Density Clearance to Ceiling Up to 10 ft	Ceiling Sprinkler Operating Area
-	ft (m)	ft (m)		gpm/ft ² (mm/min)	ft ² (m ²)
Cartoned Unexpanded and Expanded Group A plastic	Single Row and Double Row Racks	up to 5 ft (1.5 m)	Figure 21.5.5.5(a) to (c) or Figure 21.5.5.7	0.30 gpm/ft ² (12.2 mm/min)	2000 ft ² (186 m ²)
	Single Row and Double Row Racks	>5 ft up to 10 ft (>1.5 m up to 3.1 m)	21.5.5.5(a) to (c) or Figure 21.5.5.7	0.45 gpm/ft ² (18.3 mm/min)	2000 ft ² (186 m ²)
	Multiple Row Racks	up to 5 ft (1.5 m)	Figure 21.5.5.8(a) to (f)	0.30 gpm/ft ² (12.2 mm/min)	2000 ft ² (186 m ²)
		up to and including 10 ft (3.1 m)		0.45 gpm/ft ² (18.3 mm/min)	2000 ft ² (186 m ²)
Exposed Unexpanded Group A Plastic	Single Row and Double Row Racks	up to and including 10 ft (3.1 m)	Figure 21.5.5.7	0.45 gpm/ft ² (18.3 mm/min)	2000 ft ² (186 m ²)
	Multiple Row Racks	up to 5 ft (1.5 m)	Figure 21.5.5.8(a) to (f)	0.30 gpm/ft ² (12.2 mm/min)	2000 ft ² (186 m ²)
		up to and including 10 ft (3.1 m)		0.45 gpm/ft ² (18.3 mm/min)	2000 ft ² (186 m ²)

A.21.5.4.3

In this application ordinary, intermediate, or high temperature sprinklers can be used. There are no data to support temperature rating restrictions for this section.

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: National Fire Protection Assoc

Street Address:

City:

State:

Zip:

Submittal Date: Sun Jul 30 20:12:01 EDT 2017

Committee Statement

Committee Statement: In-rack criteria has been relocated to Chapter 25.

Response Message:

**Second Revision No. 324-NFPA 13-2017 [Section No. 21.5.4.4]****21.5.4.4**

The minimum water supply requirements for a hydraulically designed occupancy hazard fire control sprinkler system shall be determined by adding the hose stream allowance from Table 21.5.4.4 to the water supply for sprinklers determined in Section 17.3.

Table 21.5.4.4 Hose Stream Allowance and Water Supply Duration Requirements for Rack Storage of Group A Plastic Commodities Stored Over 25 ft (7.6 m) in Height

Commodity Classification	Storage Height		Inside Hose		Total Combined Inside and Outside Hose		Duration (minutes)
	ft	m	gpm	L/min	gpm	L/min	
Plastic	>25	>7.6	0, 50, or 100	0, 190, or 380	500	1900	120

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Wed Jun 28 16:11:47 EDT 2017

Committee Statement

Committee Statement: Section 21.5.4.4 and Table 21.5.4.4 are redundant. They deal with hose stream and water supply issues that are addressed in Section 20.12.2.6 and Table 20.12.2.6. Therefore, this redundant information should be deleted.

Response Message:

Public Comment No. 219-NFPA 13-2017 [Section No. 21.5.4.4]



Second Revision No. 1005-NFPA 13-2017 [Section No. 21.6.1]



21.6.1 Ceiling Systems.

Protection of rubber tire storage by ceiling-only sprinkler arrangements shall be selected from Table 21.6.1(a) or Table 21.6.1(b), or per Chapter 25 using ceiling and in-rack sprinkler arrangements.

Table 21.6.1(a) Protection Criteria for Rubber Tire Storage Using Control Mode Density/Area Sprinklers

<u>Piling Method^d</u>	<u>Pile Height [ft (m)]</u>	<u>Sprinkler Discharge Density^a [gpm/ft² over ft² (mm/min over m²)] (see Note 1)</u>	<u>Areas of Application^a [ft²(m²)](see Note 1)</u>	
			<u>Ordinary Temperature</u>	<u>High Temperature^a (see Note 1)</u>
(1) On-floor storage	Up to 5 (1.5)	0.19 (0.72)	2000 (186)	2000 (186)
(a) Pyramid piles, on-side	Over 5 (1.5) to 12 (3.7)	0.30 (1.1)	2500 (232)	2500 (232)
(b) Other arrangements such that no horizontal channels are formed ^b (see Note 2)	Over 12 (3.7) to 18 (5.5)	0.60 (2.3)	Not allowed	2500 (232)
(2) On-floor storage	Up to 5 (1.5)	0.19 (0.72)	2000 (186)	2000 (186)
Tires, on-tread	Over 5 (1.5) to 12 (3.7)	0.30 (1.1)	2500 (232)	2500 (232)
(3) Palletized portable rack storage	Up to 5 (1.5)	0.19 (0.72)	2000 (186)	2000 (186)
On-side or on-tread	Over 5 (1.5) to 20 (6.1)	See Table 18.4(b)	—	—
	Over 20 (6.1) to 30 (9.1)	0.30 (1.1) plus high- expansion foam	3000 (280)	3000 (280)
(4) Palletized portable rack storage, on-side	Up to 5 (1.5)	0.19 (0.72)	2000 (186)	2000 (186)
	Over 5 (1.5) to 20 (6.1)	See Table 18.4(b)	—	—
		0.60 (2.2) and	Not allowed	5000 (465)
	Over 20 (6.1) to 25 (7.6)	0.90 (3.4) ^c (see Note 3) or 0.75 (2.8) with 1-hour fire-resistive rating of roof and ceiling assembly	Not allowed	3000 (280) 4000 (370)
(5) Open portable rack storage, on-side or on-tread	Up to 5 (1.5)	0.19 (0.72)	2000 (186)	2000 (186)
	Over 5 (1.5) to 12 (3.7)	0.60 (2.2)	5000 (465)	3000 (280)
	Over 12 (3.7) to 20 (6.1)	0.60 (2.2) and	Not allowed	5000 (465)
		0.90 (3.4) ^c (see Note 3) ^c or	Not allowed	3000 (280)

<u>Piling Method^d</u>	<u>Pile Height [ft (m)]</u>	<u>Sprinkler Discharge</u>	<u>Areas of Application^a</u>	
		<u>Density^a [gpm/ft² over ft² (mm/min over m²)] (see Note 1)</u>	<u>Ordinary Temperature</u>	<u>High Temperature^a (see Note 1)</u>
		0.30 (1.1) plus high-expansion foam	3000 (280)	3000 (280)
(6) Open portable rack storage, laced	Over 12	0.60 (2.2) and	Not allowed	5000 (465)
	(3.7) to 20	0.90 (3.4) (see Notes 3 and 5) ^{c,d}	Not allowed	3000 (280)
	(6.1)			
	Up to 5	0.19 (0.72)	2000 (186)	2000 (186)
(7) Single-, double-, and multiple-row fixed rack storage on pallets, on-side, or on-tread without shelves	Over 5	See Table 18.4(b) or 0.40 (1.5) plus one level in-rack sprinklers or	3000 (280)	3000 (280)
	(1.5) to 20	0.30 (1.1) plus high-expansion foam	3000 (280)	3000 (280)
	(6.1)			
	Over 20	0.30 (1.1) plus high-expansion foam	Not allowed	3000 (280)
	(6.1) to 30			
	(9.1)			
	Up to 5	0.19 (0.72)	2000 (186)	2000 (186)
	(1.5)			
	Over 5	0.60 (2.2)	5000 (465)	3000 (280)
	(1.5) to 12			
	(3.7)			
(8) Single-, double-, and multiple-row fixed rack storage without pallets or shelves, on-side or on-tread	Over 12	0.40 (1.5) plus one level in-rack sprinklers	3000 (280)	3000 (280)
	(3.7) to 20	0.60 (2.2) and	Not allowed	5000 (465)
	(6.1)	0.90 (3.4) (see Note 3) ^c or	Not allowed	3000 (280)
	Over 12	0.40 (1.5) plus one level in-rack sprinklers or	3000 (280)	3000 (280)
	(3.7) to 20			
	(6.1)			
	Over 20	0.30 (1.1) plus high-expansion foam	3000 (280)	3000 (280)
	(6.1) to 30	0.30 (1.1) plus high-expansion foam	Not allowed	3000 (280)
	(9.1)			

Notes: : Shelf storage of rubber tires shall be protected as solid rack shelving.

(1)- ^a Sprinkler discharge densities and areas of application are based on a maximum clearance to ceiling of 10 ft (3.0 m) with the maximum height of storage anticipated.

(2)- ^b Laced tires on-floor, vertical stacking on-side (typical truck tires), and off-road tires. Laced tires are not stored to a significant height by this method due to the damage inflicted on the tire (i.e., bead).

(3)- ^c Water supply shall fulfill both requirements.

(4)- ^d Shelf storage of rubber tires shall be protected as solid rack shelving.

(5)- ^e This protection scheme is for use with K-16.8 (240) or larger control mode sprinklers only. Maximum clearance to ceiling can be increased to 14 ft (4.3 m) with this scheme.

Table 21.6.1(b) Control Mode Density/Area Sprinklers System Density (gpm/ft² over ft²) for Palletized Portable Rack Storage and Fixed Rack Storage of Rubber Tires with Pallets Over 5 ft (1.5 m) to 20 ft (3.7 m) in Height

<u>Storage Height [ft (m)]</u>	<u>Sprinkler Temperature</u>	
	<u>High Temperature</u>	<u>Ordinary Temperature</u>
>5 to 10 (1.5 to 3.0)	0.32/2000 (1.2/186)	0.32/2000 (1.2/186)
>10 to 12 (3.0 to 3.7)	0.39/2000 (1.5/186)	0.39/2600 (1.5/241)
>12 to 14 (3.7 to 4.3)	0.45/2000 (1.7/186)	0.45/3200 (1.7/300)
>14 to 16 (4.3 to 4.9)	0.5/2300 (1.9/214)	0.5/3700 (1.9/345)
>16 to 18 (4.9 to 5.5)	0.55/2600 (2.1/241)	0.55/4400 (2.1/410)
>18 to 20 (5.5 to 6.1)	0.6/3000 (2.3/280)	0.6/5000 (2.3/465)

Supplemental Information

<u>File Name</u>	<u>Description</u>	<u>Approved</u>
13_Table_21.6.1_a_With_Mark-Ups_.docx	Revised Table 21.6.1(a). For staff use.	

Submitter Information Verification

Submitter Full Name: AUT-SSD
Organization: National Fire Protection Assoc
Street Address:
City:
State:
Zip:
Submittal Date: Sun Jul 30 18:03:33 EDT 2017

Committee Statement

Committee Statement: Table 21.6.1(a) has been revised representing ceiling only protection, for in-rack design see Chapter 25.
Response Message:

**Second Revision No. 325-NFPA 13-2017 [Section No. 21.8.1.2]****21.8.1.2**

A wet pipe system that is designed to provide a minimum of 0.6 gpm/ft² (24.4 mm/min) density over a minimum area of 2000 ft² (186 m²) shall be permitted to protect single-row and double-row racks with slatted rack shelving where all of the following conditions are met:

- (1) Sprinklers shall be K-11.2 (160), K-14.0 (200), or K-16.8 (240) orifice spray sprinklers with a temperature rating of ordinary, intermediate, or high and shall be listed for storage occupancies.
- (2) The protected commodities shall be limited to Class I through Class IV, Group B plastics, Group C plastics, cartoned (expanded and nonexpanded) Group A plastics, and exposed (nonexpanded) Group A plastics.
- (3) Slats in slatted rack shelving shall be a minimum nominal 2 in. (50 mm) thick by maximum nominal 6 in. (150 mm) wide, with the slats held in place by spacers that maintain a minimum 2 in. (50 mm) opening between each slat.
- (4) Where K-11.2 (160), K-14.0 (200), or K-16.8 (240) orifice sprinklers are used, there shall be no slatted shelf levels in the rack above 12 ft (3.7 m). Open rack shelving using wire mesh shall be permitted for shelf levels above 12 ft (3.7 m).
- (5) Transverse flue spaces at least 3 in. (75 mm) wide shall be provided at least every 10 ft (3.0 m) horizontally.
- (6) Longitudinal flue spaces at least 6 in. (150 mm) wide shall be provided for double-row racks.
- (7) The aisle widths shall be at least 7½ ft (2.3 m).
- (8) The maximum roof height shall be 27 ft (8.2 m).
- (9) The maximum storage height shall be 20 ft (6.1 m).
- (10) Solid plywood or similar materials shall not be placed on the slatted shelves so that they block the 2 in. (50 mm) spaces between slats, nor shall they be placed on wire mesh shelves.

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Wed Jun 28 16:28:57 EDT 2017

Committee Statement

Committee Statement: For slatted shelves in Section 21.8.1.2 the requirement for 6" longitudinal flues was deleted without and substantiation. Without any technical justification for the deletion, this requirement must be re-inserted.

Response Message:

Public Comment No. 220-NFPA 13-2017 [Section No. 21.8.1.2]

**Second Revision No. 326-NFPA 13-2017 [Section No. 21.8.1.3]****21.8.1.3 Reduced-Discharge-Density.**

~~Where high-expansion foam systems are installed in accordance with NFPA 11, a reduction in sprinkler discharge density to one-half the density specified in Table 21.6.1(a) or 0.24 gpm/ft² (9.8 mm/min), whichever is higher, shall be permitted.~~

Submitter Information Verification**Submitter Full Name:** AUT-SSD**Organization:** [Not Specified]**Street Address:****City:****State:****Zip:****Submittal Date:** Wed Jun 28 16:30:24 EDT 2017**Committee Statement**

Committee Statement: Section 21.8.1.3 about reduced density with the use of Hi-X foam should be moved to 21.6.2 to go with the applicable subject of tire storage.

Response Message:

[Public Comment No. 222-NFPA 13-2017 \[Section No. 21.8.1.3\]](#)

**Second Revision No. 1014-NFPA 13-2017 [Section No. 21.10]****21.10*** Control Mode Density/Area Sprinkler Protection Criteria for Baled Cotton Storage.**A.21.10**

For protection of baled cotton, fire tests and actual fire experience indicate an initial low heat release; thus, sprinklers in the ordinary-temperature range should offer some advantage by opening faster than those of intermediate- or high-temperature classifications under similar conditions.

21.10.1

For tiered or rack storage up to a nominal 15 ft (4.6 m) in height, sprinkler discharge densities and areas of application shall be in accordance with Table 21.10.1.

Table 21.10.1 Baled Cotton Storage Up to and Including 15 ft (4.6 m)

<u>System Type</u>	<u>Discharge Density per Area [gpm/ft² over { ft² (mm/min over m²)]</u>		
	<u>Tiered Storage</u>	<u>Rack Storage</u>	<u>Untiered Storage</u>
Wet	0.25/3000 (0.95/280)	0.33/3000 (1.2/280)	0.15/3000 (0.57/280)
Dry	0.25/3900 (0.95/360)	0.33/3900 (1.2/360)	0.15/3900 (0.57/360)

21.10.2

Where roof or ceiling heights would prohibit storage above a nominal 10 ft (3 m), the sprinkler discharge density shall be permitted to be reduced by 20 percent of that indicated in Table 21.10.1 but shall not be reduced to less than 0.15 gpm/ft² (6.1 mm/min).

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: National Fire Protection Assoc

Street Address:

City:

State:

Zip:

Submittal Date: Tue Aug 01 08:23:17 EDT 2017

Committee Statement

Committee Statement: This comment proposes to move the the exiting annex not A.9.4.2.1 to the Annex of section 21.10. This note is in reference to Baled Cotton and is more appropriate in this section then in section 9.4.2.1 which deals with temperature rating of sprinklers.

Response Message:

Public Comment No. 99-NFPA 13-2017 [New Section after A.21.8.1.1]

**Second Revision No. 327-NFPA 13-2017 [Section No. 21.11.6.2.1]****21.11.6.2.1**

Ceiling sprinklers spaced to cover a maximum of 100 ft² (9.3 m²) shall be standard-response spray sprinklers with K-factors ~~per~~ in accordance with Section ~~12.6~~ 21.1 .

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Wed Jun 28 16:31:47 EDT 2017

Committee Statement

Committee Statement: In Section 21.11.6.2.1 the reference to Section 20.6 is from the 2016 edition of the NFPA 13. This matter needs to be revised to match the new chapter structure for the standard.

Response Message:

[Public Comment No. 223-NFPA 13-2017 \[Section No. 21.11.6.2.1\]](#)

**Second Revision No. 1012-NFPA 13-2017 [Sections 22.1.6, 22.1.7]****22.1.6***

The ceiling design criteria for single-, double-, and multiple-row racks in Chapter 46 22 shall be based on open rack configurations as defined in 3.3.141.

22.1.7

CMSA sprinklers shall not be permitted to protect storage on solid shelf racks unless the solid shelf racks are protected with in-rack sprinklers in accordance with 46.1.6 Chapter 25 .

22.1.7.1

~~Where solid shelves are used, in-rack sprinklers shall be installed in every level below the highest solid shelf.~~

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: National Fire Protection Assoc

Street Address:

City:

State:

Zip:

Submittal Date: Sun Jul 30 20:20:26 EDT 2017

Committee Statement

Committee Statement: Editorial revision.

Response Message:



Second Revision No. 390-NFPA 13-2017 [Section No. 22.2]



22.2 Palletized and Solid-Piled Storage of Class I Through Class IV Commodities.

Protection of palletized and solid-piled storage of Class I through Class IV commodities shall be in accordance with Table 22.2.

Table 22.2 CMSA Sprinkler Design Criteria for Palletized and Solid-Piled Storage of Class I Through Class IV Commodities (Encapsulated and Nonencapsulated)

<u>Configuration</u>	<u>Commodity Class</u>	<u>Maximum Storage Height</u>		<u>Maximum Ceiling/Roof Height</u>		<u>K-Factor/ Orientation</u>	<u>Type of System</u>	<u>Number of Design Sprinklers</u>	<u>Minimum Operating Pressure</u>	
		<u>ft</u>	<u>m</u>	<u>ft</u>	<u>m</u>				<u>psi</u>	<u>bar</u>
Palletized	Class I or II	20	6.1	30	9.1	25.2 (360) Pendent	Wet	15	10	0.7
				40	12.1	25.2 (360) Pendent	Wet	15	23	1.6
		25	7.6	30	9.1	11.2 (160) Upright	Wet	15	25	1.7
							Dry	25	25	1.7
						16.8 (240) Upright	Wet	15	10	0.7
							Dry	25	15	1.0
						19.6 (280) Pendent	Wet	15	16	1.1
						25.2 (360) Pendent	Wet	15	10	0.7
				35	11	11.2 (160) Upright	Wet	15	25	1.7
							Dry	25	25	1.7
						16.8 (240) Upright	Wet	15	15	1.0
							Dry	25	15	1.0
				40	12.1	25.2 (360) Pendent	Wet	15	23	1.6
		30	9.1	35	11	19.6 (280) Pendent	Wet	15	25	1.7
				40	12.1	25.2 (360) Pendent	Wet	15	23	1.6
		35	11	40	12	19.6 (280) Pendent	Wet	15	30	2.1
						25.2 (360) Pendent	Wet	15	23	1.6
	Class III	20	6.1	30	9.1	25.2 (360) Pendent	Wet	15	10	0.7
				40	12	25.2 (360) Pendent	Wet	15	23	1.6
		25	7.6	30	9.1	11.2 (160) Upright	Wet	15	25	1.7
							Dry	25	25	1.7
						16.8 (240) Upright	Wet	15	15	1.0
							Dry	25	15	1.0
						19.6 (280) Pendent	Wet	15	16	1.1
						25.2 (360) Pendent	Wet	15	16 10	1.1 0.7
				35	11	11.2 (160) Upright	Wet	15	25	1.7
							Dry	25	25	1.7

Configuration	Commodity Class	Maximum Storage Height		Maximum Ceiling/Roof Height		K-Factor/ Orientation	Type of System	Number of Design Sprinklers	Minimum Operating Pressure	
		ft	m	ft	m				psi	bar
	Class IV	30	9.1	40	12	16.8 (240) Upright	Wet	15	15	1.0
						Dry	25	15	1.0	
						25.2 (360) Pendent	Wet	15	23	1.6
						19.6 (280) Pendent	Wet	15	25	1.7
				40	12	25.2 (360) Pendent	Wet	15	23	1.6
				40	12	19.6 (280) Pendent	Wet	15	30	2.1
				40	12	25.2 (360) Pendent	Wet	15	23	1.6
				35	11	11.2 (160) Upright	Wet	20	25	1.7
		15	50			3.4				
		16.8 (240) Upright	Wet			20	15	1.0		
		15	22			1.5				
		19.6 (280) Pendent	Wet			15	16	1.1		
		25.2 (360) Pendent	Wet			15	10	0.7		
		20	6.1	40	12	25.2 (360) Pendent	Wet	15	23	1.6
						16.8 (240) Upright	Wet	15	22	1.5
						19.6 (280) Pendent	Wet	15	16	1.1
						25.2 (360) Pendent	Wet	15	10	0.7
				40	12	25.2 (360) Pendent	Wet	15	23	1.6
				30	9.1	19.6 (280) Pendent	Wet	15	16	1.1
				25.2 (360) Pendent	Wet	15	10	0.7		
				40	12	25.2 (360) Pendent	Wet	15	23	1.6
		30	9.1	35	11	19.6 (280) Pendent	Wet	15	25	1.7
40	12			25.2 (360) Pendent	Wet	15	23	1.6		
35	11			19.6 (280) Pendent	Wet	15	30	2.1		
				25.2 (360) Pendent	Wet	15	23	1.6		
Solid piled	Class I or II	20	6.1	30	9.1	19.6 (280) Pendent	Wet	15	30	2.1
						25.2 (360) Pendent	Wet	15	23	1.6
						11.2 (160) Upright	Wet	15	25	1.7
						Dry	25	25	1.7	
						16.8 (240) Upright	Wet	15	10	0.7
						Dry	25	15	1.0	
						19.6 (280) Pendent	Wet	15	16	1.1
						25.2 (360) Pendent	Wet	15	10	0.7

<u>Configuration</u>	<u>Commodity Class</u>	<u>Maximum Storage Height</u>		<u>Maximum Ceiling/Roof Height</u>		<u>K-Factor/ Orientation</u>	<u>Type of System</u>	<u>Number of Design Sprinklers</u>	<u>Minimum Operating Pressure</u>	
		<u>ft</u>	<u>m</u>	<u>ft</u>	<u>m</u>				<u>psi</u>	<u>bar</u>
				40	12	25.2 (360) Pendent	Wet	15	23	1.6
						16.8 (240) Upright	Wet	15	10	0.7
				30	9.1	19.6 (280) Pendent	Wet	15	16	1.1
		25	7.6			25.2 (360) Pendent	Wet	15	10	0.7
				40	12	25.2 (360) Pendent	Wet	15	23	1.6
				35	11	19.6 (280) Pendent	Wet	15	25	1.7
		30	9.1	40	12	25.2 (360) Pendent	Wet	15	23	1.6
						19.6 (280) Pendent	Wet	15	30	2.1
		35	11	40	12	25.2 (360) Pendent	Wet	15	23	1.6
	Class III					11.2 (160) Upright	Wet	15	25	1.7
							Dry	25	25	1.7
						16.8 (240) Upright	Wet	15	15	1.0
				30	9.1		Dry	25	15	1.0
		20	6.1			19.6 (280) Pendent	Wet	15	16	1.1
						25.2 (360) Pendent	Wet	15	10	0.7
				40	12	25.2 (360) Pendent	Wet	15	23	1.6
						16.8 (240) Upright	Wet	15	22	1.5
				30	9.1	19.6 (280) Pendent	Wet	15	16	1.1
		25	7.6			25.2 (360) Pendent	Wet	15	10	0.7
				40	12	25.2 (360) Pendent	Wet	15	23	1.6
				35	11	19.6 (280) Pendent	Wet	15	25	1.7
		30	9.1	40	12	25.2 (360) Pendent	Wet	15	23	1.6
						19.6 (280) Pendent	Wet	15	30	2.1
		35	11	40	12	25.2 (360) Pendent	Wet	15	23	1.6
	Class IV	20	6.1	30	9.1	11.2 (160) Upright	Wet	15	50	3.4

<u>Configuration</u>	<u>Commodity Class</u>	<u>Maximum Storage Height</u>		<u>Maximum Ceiling/Roof Height</u>		<u>K-Factor/ Orientation</u>	<u>Type of System</u>	<u>Number of Design Sprinklers</u>	<u>Minimum Operating Pressure</u>	
		<u>ft</u>	<u>m</u>	<u>ft</u>	<u>m</u>				<u>psi</u>	<u>bar</u>
						16.8 (240) Upright	Wet	15	22	1.5
						19.6 (280) Pendent	Wet	15	16	1.1
						25.2 (360) Pendent	Wet	15	10	0.7
				40	12	25.2 (360) Pendent	Wet	15	23	1.6
						16.8 (240) Upright	Wet	15	22	1.5
				30	9.1	19.6 (280) Pendent	Wet	15	16	1.1
	25	7.6				25.2 (360) Pendent	Wet	15	10	0.7
				40	12	25.2 (360) Pendent	Wet	15	23	1.6
				35	11	19.6 (280) Pendent	Wet	15	25	1.7
	30	9.1		40	12	25.2 (360) Pendent	Wet	15	23	1.6
						19.6 (280) Pendent	Wet	15	30	2.1
	35	11		40	12	25.2 (360) Pendent	Wet	15	23	1.6

Supplemental Information

<u>File Name</u>	<u>Description</u>	<u>Approved</u>
Table_22.2.docx	Revised Table 22.2. For staff use.	

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Fri Jul 14 11:22:12 EDT 2017

Committee Statement

Committee Statement: Editorial revisions.

Response Message:



Second Revision No. 1022-NFPA 13-2017 [Section No. 22.3]



22.3 Palletized and Solid-Piled Storage of Nonexpanded and Expanded Group A Plastic Commodities.

Protection of palletized and solid-piled storage of nonexpanded and expanded Group A plastic commodities shall be in accordance with Table 22.3.

Table 22.3 CMSA Sprinkler Design Criteria for Palletized and Solid-Piled Storage of Group A Plastic Commodities

<u>Storage Arrangement</u>	<u>Commodity Class</u>	<u>Maximum Storage Height</u>		<u>Maximum Ceiling/Roof Height</u>		<u>K-Factor/Orientation</u>	<u>Type of System</u>	<u>Number of Design Sprinklers</u>	<u>Minimum Operating Pressure</u>	
		<u>ft</u>	<u>m</u>	<u>ft</u>	<u>m</u>				<u>psi</u>	<u>b</u>
Palletized	Cartoned nonexpanded plastics	20	6.1	30	9.1	11.2 (160) Upright	Wet	25	25	1
						16.8 (240) Upright	Wet	15	22	1
						19.6 (280) Pendent	Wet	15	16	1
						25.2 (360) Pendent	Wet	15	10	0
		25	7.6	30	9.1	25.2 (360) Pendent	Wet	15	23	1
						16.8 (240) Upright	Wet	15	22	1
						19.6 (280) Pendent	Wet	15	16	1
						25.2 (360) Pendent	Wet	15	10	0
		30	9.1	35	11	25.2 (360) Pendent	Wet	15	23	1
						19.6 (280) Pendent	Wet	15	25	1
		35	11	40	12	25.2 (360) Pendent	Wet	15	23	1
						19.6 (280) Pendent	Wet	15	30	2
Solid piled	Cartoned nonexpanded plastics	20	6.1	30	9.1	11.2 (160) Upright	Wet	15	50	3
						16.8 (240) Upright	Wet	15	22	1
						19.6 (280) Pendent	Wet	15	16	1
						25.2 (360) Pendent	Wet	15	10	0
		25	7.6	30	9.1	25.2 (360) Pendent	Wet	15	23	1
						16.8 (240) Upright	Wet	15	22	1
						19.6 (280) Pendent	Wet	15	16	1
						25.2 (360) Pendent	Wet	15	10	0
		30	9.1	35	11	25.2 (360) Pendent	Wet	15	23	1
						19.6 (280) Pendent	Wet	15	25	1
		35	11	40	12	25.2 (360) Pendent	Wet	15	23	1
						19.6 (280) Pendent	Wet	15	30	2
Palletized	Exposed nonexpanded plastics	20	6.1	30	9.1	11.2 (160) Upright	Wet	25	25	1
		25	7.6	30	9.1	16.8 (240) Upright	Wet	15	22	1
	Cartoned or exposed expanded plastics	18	5.5	26	7.9	11.2 (160) Upright	Wet	15	50	3
						16.8 (240) Upright	Wet	15	22	1
Solid piled	Cartoned or exposed nonexpanded plastics	20	6.1	30	9.1	11.2 (160) Upright	Wet	15	50	3
		25	7.6	30	9.1	16.8 (240) Upright	Wet	15	22	1

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: National Fire Protection Assoc

Street Address:

City:

State:

Zip:

Submittal Date: Sat Aug 12 16:47:39 EDT 2017

Committee Statement

Committee Statement: Editorial revision.

Response Message:



Second Revision No. 1006-NFPA 13-2017 [Section No. 22.4]



22.4 Single-, Double-, and Multiple-Row Rack Storage for Class I Through Class IV Commodities.

Protection of single-, double-, and multiple-row rack storage for Class I through Class IV commodities shall be in accordance with Table 22.4.

Table 22.4 CMSA Sprinkler Design Criteria for Rack Storage of Class I Through Class IV Commodities (Encapsulated and Nonencapsulated)

<u>Storage Arrangement</u>	<u>Commodity Class</u>	<u>Maximum Storage Height</u>		<u>Maximum Ceiling/Roof Height</u>		<u>K-Factor/Orientation</u>	<u>Type of System</u>	<u>Number of Design Sprinklers</u>	<u>Minimum Operating Pressure</u>	
		<u>ft</u>	<u>m</u>	<u>ft</u>	<u>m</u>				<u>psi</u>	<u>bar</u>
Single-, double-, and multiple-row racks (no open-top containers)	Class I or II	20	6.1	30	9.1	11.2 (160) Upright	Wet	15	25	1.7
							Dry	25	25	1.7
						16.8 (240) Upright	Wet	15	10	0.7
							Dry	25	15	1.0
						19.6 (280) Pendent	Wet	15	16	1.1
						25.2 (360) Pendent	Wet	15	10	0.7
				40	12.1	25.2 (360) Pendent	Wet	15	23	1.6
		25	7.6	30	9.1	11.2 (160) Upright	Wet	20	25	1.7
							Dry	30	25	1.7
						16.8 (240) Upright	Wet	15	10	0.7
							Dry	30	15	1.0
						19.6 (280) Pendent	Wet	15	16	1.1
						25.2 (360) Pendent	Wet	15	10	0.7
				40	12.1	25.2 (360) Pendent	Wet	15	23	1.6
	Class III	20	6.1	30	9.1	11.2 (160) Upright	Wet	15	25	1.7
							Dry	25	25	1.7
						16.8 (240) Upright	Wet	15	15	1.0
							Dry	25	15	1.0
						19.6 (280) Pendent	Wet	15	16	1.1
						25.2 (360) Pendent	Wet	15	10	0.7
				40	12.1	25.2 (360) Pendent	Wet	15	23	1.6
		25	7.6	30	9.1	11.2 (160) Upright	Wet	15 + 1 level of in-rack *	25 NA	1.7 NA
							Dry	25 + 1 level of in-rack *	25 NA	1.7 NA
						16.8 (240) Upright	Wet	15	22	1.5
							Dry	25 + 1 level of in-rack *	15 NA	1.0 NA

<u>Storage Arrangement</u>	<u>Commodity Class</u>	<u>Maximum Storage Height</u>		<u>Maximum Ceiling/Roof Height</u>		<u>K-Factor/Orientation</u>	<u>Type of System</u>	<u>Number of Design Sprinklers</u>	<u>Minimum Operating Pressure</u>	
		<u>ft</u>	<u>m</u>	<u>ft</u>	<u>m</u>				<u>psi</u>	<u>bar</u>
						19.6 (280) Pendent	Wet	15	16	1.1
						25.2 (360) Pendent	Wet	15	10	0.7
							Wet	15 + 1 level of in-rack *	25 NA	1.7 NA
						11.2 (160) Upright	Dry	25 + 1 level of in-rack *	25 NA	1.7 NA
				35	10.7		Wet	15 + 1 level of in-rack *	15 NA	1.0 NA
						16.8 (240) Upright	Dry	25 + 1 level of in-rack *	15 NA	1.0 NA
						19.6 (280) Pendent	Wet	15	25	1.7
				40	12.2	19.6 (280) Pendent	Wet	15	30	2.1
						25.2 (360) Pendent	Wet	15	23	1.6
						11.2 (160) Upright	Wet	15	50	3.4
				25	7.6	16.8 (240) Upright	Wet	15	22	1.5
						19.6 (280) Pendent	Wet	15	16	1.1
						11.2 (160) Upright	Wet	20 15	50 75	3.4 5.2
				30	9.1	16.8 (240) Upright	Wet	15	22	1.5
						19.6 (280) Pendent	Wet	15	16	1.1
	Class IV	20	6.1			25.2 (360) Pendent	Wet	15	10	0.7
				40	12.1	25.2 (360) Pendent	Wet	15	23	1.6
						11.2 (160) Upright	Wet	15 + 1 level of in-rack *	50 NA	3.4 NA
				25	7.6	16.8 (240) Upright	Wet	15	22	1.5
						19.6 (280) Pendent	Wet	15	16	1.1
						25.2 (360) Pendent	Wet	15	10	0.7

<u>Storage Arrangement</u>	<u>Commodity Class</u>	<u>Maximum Storage Height</u>		<u>Maximum Ceiling/Roof Height</u>		<u>K-Factor/Orientation</u>	<u>Type of System</u>	<u>Number of Design Sprinklers</u>	<u>Minimum Operating Pressure</u>	
		<u>ft</u>	<u>m</u>	<u>ft</u>	<u>m</u>				<u>psi</u>	<u>bar</u>
						11.2 (160) Upright	Wet	20 + 1 level of in-rack *	50 NA	3.4 NA
								15 + 1 level of in-rack *	75 NA	5.2 NA
				35	10.7	16.8 (240) Upright	Wet	20 + 1 level of in-rack *	22 NA	1.5 NA
								15 + 1 level of in-rack *	35 NA	2.4 NA
						19.6 (280) Pendent	Wet	15	25	1.7
						19.6 (280) Pendent	Wet	15	30	2.1
				40	12.2	25.2 (360) Pendent	Wet	15	23	1.6

NA: Not applicable

*In-rack sprinklers required. See Chapter 25.

Supplemental Information

<u>File Name</u>	<u>Description</u>	<u>Approved</u>
13_Table_22.4_With_Mark-Ups_.docx	Revised Table 22.4. For staff use.	

Submitter Information Verification

Submitter Full Name: AUT-SSD
Organization: National Fire Protection Assoc
Street Address:
City:
State:
Zip:
Submission Date: Sun Jul 30 19:16:11 EDT 2017

Committee Statement

Committee Statement: Table 22.4 has been revised to show ceiling only design, for in-rack design see Chapter 25.
Response Message:



Second Revision No. 391-NFPA 13-2017 [Section No. 22.5]



22.5 Single-, Double-, and Multiple-Row Racks of Group A Plastic Commodities.

Protection of single-, double-, and multiple-row rack storage for nonexpanded Group A plastic commodities shall be in accordance with Table 22.5.

Table 22.5 CMSA Sprinkler Design Criteria for Single-, Double-, and Multiple-Row Racks of Group A Plastic Commodities Stored Up and Including 25 ft (7.6 m) in Height

<u>Storage Arrangement</u>	<u>Commodity Class</u>	<u>Maximum Storage Height</u>		<u>Maximum Ceiling/Roof Height</u>		<u>K-Factor/Orientation</u>	<u>Type of System</u>	<u>Number of Design Sprinklers</u>	<u>Minimum Operating Pressure</u>	
		<u>ft</u>	<u>m</u>	<u>ft</u>	<u>m</u>				<u>psi</u>	<u>bar</u>
Single-, double-, and multiple-row racks (no open-top containers)	Cartoned nonexpanded plastics	20	6.1	25	7.6	11.2 (160) Upright	Wet	15	50	3.4
						16.8 (240) Upright	Wet	15	22	1.5
						19.6 (280) Pendent	Wet	15	16	1.1
				30	9.1	11.2 (160) Upright	Wet Wet	30 20	50 75	3.4 5.2
						16.8 (240) Upright	Wet	15* ±	22	1.5
						19.6 (280) Pendent	Wet	15	16	1.1
		25	7.6	30	9.1	11.2 (160) Upright	Wet	15 + 4 level of in-rack *	50 NA	3.4 NA
						16.8 (240) Upright	Wet	15* ±	22	1.5
						19.6 (280) Pendent	Wet	15	16	1.1
						25.2 (360) Pendent	Wet	15	10	0.7
		25	7.6	35	11	11.2 (160) Upright	Wet	30 + 4 level of in-rack *	50 NA	3.4 NA
							Wet	20 + 4 level of in-rack *	75 NA	5.2 NA
						16.8 (240) Upright	Wet	30 + 4 level of in-rack *	22 NA	1.5 NA
							Wet	20 + 4 level of in-rack *	35 NA	2.4 NA
						19.6 (280) Pendent	Wet	15	25	1.7
		35	10.6	40	12.1	25.2 (360) Pendent	Wet	15	10	0.7
	Exposed nonexpanded plastics	20	6.1	25	7.6	11.2 (160) Upright	Wet	15	50	3.4
						16.8 (240) Upright	Wet	15	22	1.5
		20	6.1	30	9.1	11.2 (160) Upright	Wet	30	50	3.4
							Wet	20	75	5.2

<u>Storage Arrangement</u>	<u>Commodity Class</u>	<u>Maximum Storage Height</u>		<u>Maximum Ceiling/Roof Height</u>		<u>K-Factor/Orientation</u>	<u>Type of System</u>	<u>Number of Design Sprinklers</u>	<u>Minimum Operating Pressure</u>	
		<u>ft</u>	<u>m</u>	<u>ft</u>	<u>m</u>				<u>psi</u>	<u>bar</u>
						16.8 (240) Upright	Wet	15* ±	22	1.5
		25	7.6	30	9.1	11.2 (160) Upright	Wet	15 + 1 level of in-rack *	50 NA	3.4 NA
						16.8 (240) Upright	Wet	15* ±	22	1.5
							Wet	30 + 1 level of in-rack *	50 NA	3.4 NA
						11.2 (160) Upright	Wet	20 + 1 level of in-rack *	75 NA	5.2 NA
		25	7.6	35	11		Wet	30 + 1 level of in-rack *	22 NA	1.5 NA
						16.8 (240) Upright	Wet	20 + 1 level of in-rack *	35 NA	2.4 NA

NA: Not applicable

*In-rack sprinklers required. See Chapter 25.

* ± Minimum 8 ft (2.4 m) aisle.

Supplemental Information

<u>File Name</u>	<u>Description</u>	<u>Approved</u>
13_Table_22.5_With_Mark-Ups_.docx	Revised Table 22.5. For staff use.	

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Fri Jul 14 11:36:24 EDT 2017

Committee Statement

Committee Statement: Table 22.5 has been revised to show ceiling only design, for in-rack design see Chapter 25.

Response Message:

**Second Revision No. 1053-NFPA 13-2017 [Section No. 22.6]****22.6 Rubber Tires.**

Protection of rubber tires with CMSA sprinklers shall be in accordance with [Table 22.6](#).

[Table 22.6 Control Mode Specific Application \(CMSA\) Protection for Rubber Tires](#)

<u>Piling Method</u>	<u>Maximum Storage Height</u>		<u>Maximum Ceiling/Roof Height</u>		<u>K-Factor</u>	<u>Type of System</u>	<u>Number of Sprinklers</u>	<u>Operating Pressure</u>
	<u>ft</u>	<u>m</u>	<u>ft</u>	<u>m</u>				
Rubber tire storage, on-side or on-tread, in palletized portable racks, or open portable racks, or fixed racks without solid shelves	<u>25</u>	<u>7.6</u>	<u>32</u>	<u>10</u>	<u>11.2 (160)</u>	<u>Wet</u>	<u>15</u>	<u>75 psi (5.2 bar)</u>
	<u>25</u>	<u>7.6</u>	<u>32</u>	<u>10</u>	<u>16.8 (240)</u>	<u>Wet</u>	<u>15</u>	<u>35 psi (2.4 bar)</u>

Supplemental Information

<u>File Name</u>	<u>Description</u>	<u>Approved</u>
13_SSD_Table_22.6.docx	Table 22.6--for staff use	

Submitter Information Verification

Submitter Full Name: AUT-SSD
Organization: National Fire Protection Assoc
Street Address:
City:
State:
Zip:
Submittal Date: Mon Oct 16 15:14:14 EDT 2017

Committee Statement

Committee Statement: The section references a table that was not originally inserted. This is former Table 18.4(c) from the 2016 edition.
Response Message:

**Second Revision No. 328-NFPA 13-2017 [Section No. 23.1.2.3]****23.1.2.3 Temperature Ratings.**

~~Sprinkler temperature ratings for ESFR sprinklers shall be ordinary unless 8.3.2 requires intermediate or high temperature ratings.~~

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Wed Jun 28 16:37:55 EDT 2017

Committee Statement

Committee Statement: In Section 23.1.2.3 the references are from the 2016 edition of the NFPA 13. These matters need to be revised to match the new chapter structure for the standard.

Response Message:

[Public Comment No. 225-NFPA 13-2017 \[Section No. 23.1.2.3\]](#)

**Second Revision No. 329-NFPA 13-2017 [Section No. 23.1.4]****23.1.4**

The ceiling design criteria for single-, double-, and multiple-row racks in Chapter 23 shall be based on open rack configurations as defined in ~~3.9.3.7.4~~ 3.3.141.

23.1.4.1

ESFR sprinklers shall not be permitted to protect storage on solid shelf racks unless the solid shelf racks are protected with in-rack sprinklers in accordance with Chapter 25.

23.1.4.2

ESFR sprinklers shall not be permitted to protect ~~storage on solid shelf racks unless the solid shelf racks are protected with in-rack sprinklers in accordance with 16.1.6.~~ storage with open-top containers.

23.1.4.2.1

~~Where solid shelves are used, in-rack sprinklers shall be installed in every level below the highest solid shelf.~~

23.1.4.3

ESFR sprinklers shall ~~not be permitted to protect storage with open top containers.~~ be designed such that the minimum operating pressure is not less than that indicated in Table 23.5.1 for type of storage, commodity, storage height, and building height involved.

23.1.4.4

ESFR sprinkler systems shall be designed such that the minimum operating pressure is not less than that indicated in Table 23.5.1 for type of storage, commodity, storage height, and building height involved.

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submission Date: Wed Jun 28 16:40:40 EDT 2017

Committee Statement

Committee Statement: Revised to update the reference to the definition for open racks and to delete a duplicate line.

Response Message:

Public Comment No. 226-NFPA 13-2017 [Section No. 23.1.4]



Second Revision No. 1007-NFPA 13-2017 [Section No. 23.5.1]



23.5.1

Protection of single-, double-, and multiple-row rack storage of Class I through Class IV commodities shall be in accordance with Table 23.5.1.

Table 23.5.1 ESFR Sprinkler Protection of Rack Storage of Class I Through Class IV Commodities

<u>Storage Arrangement</u>	<u>Commodity</u>	<u>Maximum Storage Height</u>		<u>Maximum Ceiling/Roof Height</u>		<u>Nominal K-Factor</u>	<u>Orientation</u>	<u>Minimum Operating Pressure</u>		<u>In-Rack Sprinkler Requirement</u>
		<u>ft</u>	<u>m</u>	<u>ft</u>	<u>m</u>			<u>psi</u>	<u>bar</u>	
Single-row, double-row, and multiple-row racks (no open-top containers)	Class I, II, III, or IV, encapsulated or nonencapsulated	20	6.1	25	7.6	14 (200)	Upright/pendent	50	3.4	NA
						16.8 (240)	Upright/pendent	35	2.4	NA
						22.4 (320)	Pendent	25	1.7	NA
						25.2 (360)	Pendent	15	1	NA
				30	9.1	14 (200)	Upright/pendent	50	3.4	NA
						16.8 (240)	Upright/pendent	35	2.4	NA
						22.4 (320)	Pendent	25	1.7	NA
						25.2 (360)	Pendent	15	1	NA
				35	10.7	14 (200)	Upright/pendent	75	5.2	NA
						16.8 (240)	Upright/pendent	52	3.6	NA
						22.4 (320)	Pendent	35	2.4	NA
						25.2 (360)	Pendent	20	1.4	NA
				40	12.2	16.8 (240)	Pendent	52	3.6	NA
						22.4 (320)	Pendent	40	2.8	NA
						25.2 (360)	Pendent	25	1.7	NA
				45	13.7	14 (200)	Pendent*	90 NA	6.2 NA	Y
						16.8 (240)	Pendent*	63 NA	4.4 NA	Y
						22.4 (320)	Pendent	40	2.8	NA
						25.2 (360)	Pendent	40	2.8	NA
		25	7.6	30	9.1	14 (200)	Upright/pendent	50	3.4	NA
						16.8 (240)	Upright/pendent	35	2.4	NA
						22.4 (320)	Pendent	25	1.7	NA

<u>Storage Arrangement</u>	<u>Commodity</u>	<u>Maximum Storage Height</u>		<u>Maximum Ceiling/Roof Height</u>		<u>Nominal K-Factor</u>	<u>Orientation</u>	<u>Minimum Operating Pressure</u>		<u>In-Spr Requirement</u>
		<u>ft</u>	<u>m</u>	<u>ft</u>	<u>m</u>			<u>psi</u>	<u>bar</u>	
Single-, double-, and multiple-row rack (no open-top containers)	Class I, II, III, or IV, encapsulated or nonencapsulated	30	9.1	32	9.8	25.2 (360)	Pendent	15	1.0	P
						14 (200)	Upright/pendent	60	4.1	P
						16.8 (240)	Upright/pendent	42	2.9	P
						14 (200)	Upright/pendent	75	5.2	P
				35	10.7	16.8 (240)	Upright/pendent	52	3.6	P
						22.4 (320)	Pendent	35	2.4	P
						25.2 (360)	Pendent	20	1.4	P
						16.8 (240)	Pendent	52	3.6	P
				40	12.2	22.4 (320)	Pendent	40	2.8	P
						25.2 (360)	Pendent	25	1.7	P
						14 (200)	Pendent*	90 <u>NA</u>	6.2 <u>NA</u>	Y
						16.8 (240)	Pendent*	63 <u>NA</u>	4.3 <u>NA</u>	Y
				45	13.7	22.4 (320)	Pendent	40	2.8	P
						25.2 (360)	Pendent	40	2.8	P
						14 (200)	Upright/pendent	75	5.2	P
						16.8 (240)	Upright/pendent	52	3.6	P
				35	10.7	22.4 (320)	Pendent	35	2.4	P
						25.2 (360)	Pendent	20	1.4	P
						16.8 (240)	Pendent	52	3.6	P
				40	12.2	22.4 (320)	Pendent	40	2.8	P
						25.2 (360)	Pendent	25	1.7	P
						14 (200)	Pendent*	90 <u>NA</u>	6.2 <u>NA</u>	Y
						16.8 (240)	Pendent*	63 <u>NA</u>	4.3 <u>NA</u>	Y

<u>Storage Arrangement</u>	<u>Commodity</u>	<u>Maximum Storage Height</u>		<u>Maximum Ceiling/Roof Height</u>		<u>Nominal K-Factor</u>	<u>Orientation</u>	<u>Minimum Operating Pressure</u>		<u>In-Rack Sprinkler Required</u>
		<u>ft</u>	<u>m</u>	<u>ft</u>	<u>m</u>			<u>psi</u>	<u>bar</u>	
						22.4 (320)	Pendent	40	2.8	NA
						25.2 (360)	Pendent	40	2.8	NA
						16.8 (240)	Pendent	52	3.6	NA
				40	12.2	22.4 (320)	Pendent	40	2.8	NA
						25.2 (360)	Pendent	25	1.7	NA
		35	10.7			14 (200)	Pendent*	90 <u>NA</u>	6.2 <u>NA</u>	Y
						16.8 (240)	Pendent*	63 <u>NA</u>	4.3 <u>NA</u>	Y
				45	13.7	22.4 (320)	Pendent	40	2.8	NA
						25.2 (360)	Pendent	40	2.8	NA
						16.8 (240)	Pendent*	63 <u>NA</u>	4.3 <u>NA</u>	Y
		40	12	45	13.7	22.4 (320)	Pendent	40	2.8	NA
						25.2 (360)	Pendent	40	2.8	NA

*In-rack sprinklers required. See Chapter 25.

NA: Not applicable

Supplemental Information

<u>File Name</u>	<u>Description</u>	<u>Approved</u>
13_Table_23.5.1_With_Mark-Ups_.docx	Revised Table 23.5.1. For staff use.	

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: National Fire Protection Assoc

Street Address:

City:

State:

Zip:

Submittal Date: Sun Jul 30 19:39:07 EDT 2017

Committee Statement

Committee	Table 23.5.1 has been revised to show ceiling only design, for in-rack design see Chapter
Statement:	25.
Response Message:	



Second Revision No. 1008-NFPA 13-2017 [Section No. 23.6.1 [Excluding any Sub-Sections]]

Protection of single-, double-, and multiple-row rack storage of cartoned or exposed nonexpanded Group A plastic and cartoned expanded Group A plastic shall be in accordance with Table 23.6.1.

Table 23.6.1 ESFR Protection of Rack Storage of Group A Plastic Commodities

<u>Storage Arrangement</u>	<u>Commodity</u>	<u>Maximum Storage Height</u>		<u>Maximum Ceiling/Roof Height</u>		<u>Nominal K-Factor</u>	<u>Orientation</u>	<u>Minimum Operating Pressure</u>		<u>In-Rack Sprinkler Requirements</u>
		<u>ft</u>	<u>m</u>	<u>ft</u>	<u>m</u>			<u>psi</u>	<u>bar</u>	
Single-, double-, and multiple-row racks (no open-top containers)	Cartoned nonexpanded	20	6.1	25	7.6	14 (200)	Upright/pendent	50	3.4	No
						16.8 (240)	Upright/pendent	35	2.4	No
						22.4 (320)	Pendent	25	1.7	No
						25.2 (360)	Pendent	15	1	No
				30	9.1	14 (200)	Upright/pendent	50	3.4	No
						16.8 (240)	Upright/pendent	35	2.4	No
						22.4 (320)	Pendent	25	1.7	No
						25.2 (360)	Pendent	15	1	No
				35	11	14 (200)	Upright/pendent	75	5.2	No
						16.8 (240)	Upright/pendent	52	3.6	No
						22.4 (320)	Pendent	35	2.4	No
						25.2 (360)	Pendent	20	1.4	No
				40	12	16.8 (240)	Pendent	52	3.6	No
						22.4 (320)	Pendent	40	2.7	No
						25.2 (360)	Pendent	25	1.7	No
				45	14	14 (200)	Pendent	90	6.2	Yes
						16.8 (240)	Pendent	63	4.3	Yes
						22.4 (320)	Pendent	40	2.7	No
						25.2 (360)	Pendent	40	2.7	No
		25	7.6	30	9.1	14 (200)	Upright/	50	3.4	No

<u>Storage Arrangement</u>	<u>Commodity</u>	<u>Maximum Storage Height</u>		<u>Maximum Ceiling/Roof Height</u>		<u>Nominal K-Factor</u>	<u>Orientation</u>	<u>Minimum Operating Pressure</u>		<u>In-Rack Sprinkler Requirements</u>
		<u>ft</u>	<u>m</u>	<u>ft</u>	<u>m</u>			<u>psi</u>	<u>bar</u>	
							pendent			
						16.8 (240)	Upright/ pendent	35	2.4	No
						22.4 (320)	Pendent	25	1.7	No
						25.2 (360)	Pendent	15	1	No
				32	10	14 (200)	Upright/ pendent	60	4.1	No
						16.8 (240)	Upright/ pendent	42	2.9	No
						14 (200)	Upright/ pendent	75	5.2	No
				35	11	16.8 (240)	Upright/ pendent	52	3.6	No
						22.4 (320)	Pendent	35	2.4	No
						25.2 (360)	Pendent	20	1.4	No
						16.8 (240)	Pendent	52	3.6	No
				40	12	22.4 (320)	Pendent	40	2.7	No
						25.2 (360)	Pendent	25	1.7	No
						14 (200)	Pendent*	90	6.2	Yes
				45	14	16.8 (240)	Pendent*	63	4.3	Yes
						22.4 (320)	Pendent	40	2.7	No
						25.2 (360)	Pendent	40	2.7	No
						14 (200)	Upright/ pendent	75	5.2	No
		30	9.1	35	11	16.8 (240)	Upright/ pendent	52	3.6	No
						22.4 (320)	Pendent	35	2.4	No
						25.2	Pendent	20	1.4	No

<u>Storage Arrangement</u>	<u>Commodity</u>	<u>Maximum Storage Height</u>		<u>Maximum Ceiling/Roof Height</u>		<u>Nominal K-Factor</u>	<u>Orientation</u>	<u>Minimum Operating Pressure</u>		<u>In-Rack Sprinkler Requirements</u>
		<u>ft</u>	<u>m</u>	<u>ft</u>	<u>m</u>			<u>psi</u>	<u>bar</u>	
						(360)				
						16.8 (240)	Pendent	52	3.6	No
				40	12	22.4 (320)	Pendent	40	2.7	No
						25.2 (360)	Pendent	25	1.7	No
						14 (200)	Pendent*	90	6.2	Yes
				45	14	16.8 (240)	Pendent*	63	4.3	Yes
						22.4 (320)	Pendent	40	2.7	No
						25.2 (360)	Pendent	40	2.7	No
				40	12	16.8 (240)	Pendent	52	3.6	No
						25.2 (360)	Pendent	25	1.7	No
						14 (200)	Pendent*	90	6.2	Yes
		35	11			16.8 (240)	Pendent*	63	4.3	Yes
				45	14	22.4 (320)	Pendent	40	2.7	No
						25.2 (360)	Pendent	40	2.7	No
						14 (200)	Pendent*	90	6.2	Yes
				40	12	16.8 (240)	Pendent*	63	4.3	Yes
						22.4 (320)	Pendent	40	2.7	No
						25.2 (360)	Pendent	40	2.7	No
						14 (200)	Upright/ pendent	50	3.4	No
	Cartoned Expanded	20	6.1	25	7.6	16.8 (240)	Upright/ pendent	35	2.4	No
				30	9.1	14 (200)	Upright/ pendent	50	3.4	No

<u>Storage Arrangement</u>	<u>Commodity</u>	<u>Maximum Storage Height</u>		<u>Maximum Ceiling/Roof Height</u>		<u>Nominal K-Factor</u>	<u>Orientation</u>	<u>Minimum Operating Pressure</u>		<u>In-Rack Sprinkler Requirements</u>
		<u>ft</u>	<u>m</u>	<u>ft</u>	<u>m</u>			<u>psi</u>	<u>bar</u>	
						16.8 (240)	Upright/ pendent	35	2.4	No
						14 (200)	Upright/ pendent	50	3.4	No
				30	9.1	16.8 (240)	Upright/ pendent	35	2.4	No
		25	7.6			14 (200)	Pendent	60	4.1	No
				32	10	16.8 (240)	Upright/ pendent	42	2.9	No
						14 (200)	Pendent	50	3.4	No
				25	7.6	16.8 (240)	Pendent	35	2.4	No
						14 (200)	Pendent	50	3.4	No
				30	9.1	16.8 (240)	Pendent	35	2.4	No
		20	6.1			14 (200)	Pendent	75	5.2	No
				35	11	16.8 (240)	Pendent	52	3.6	No
						16.8 (240)	Pendent	52	3.6	No
	Exposed nonexpanded					14 (200)	Pendent*	90	6.2	Yes
				45	14	16.8 (240)	Pendent*	63	4.3	Yes
						14 (200)	Pendent	50	3.4	No
				30	9.1	16.8 (240)	Pendent	35	2.4	No
						14 (200)	Pendent	60	4.1	No
		25	7.6	32	10	16.8 (240)	Pendent	42	2.9	No
						14 (200)	Pendent	75	5.2	No
				35	11	16.8 (240)	Pendent	52	3.6	No
				40	12	16.8	Pendent	52	3.6	No

<u>Storage Arrangement</u>	<u>Commodity</u>	<u>Maximum Storage Height</u>		<u>Maximum Ceiling/Roof Height</u>		<u>Nominal K-Factor</u>	<u>Orientation</u>	<u>Minimum Operating Pressure</u>		<u>In-Rack Sprinkler Requirements</u>
		<u>ft</u>	<u>m</u>	<u>ft</u>	<u>m</u>			<u>psi</u>	<u>bar</u>	
						(240)				
						22.4 (320)	Pendent	50	3.4	No
						25.2 (360)	Pendent	50	3.4	No
				45	14	14 (200)	Pendent*	90	6.2	Yes
						16.8 (240)	Pendent*	63	4.3	Yes
				35	10.7	14 (200)	Pendent	75	5.2	No
						16.8 (240)	Pendent	52	3.6	No
						16.8 (240)	Pendent	52	3.6	No
		30	9.1	40	11	22.4 (320)	Pendent	50	3.4	No
						25.2 (360)	Pendent	50	3.4	No
				45	12	14 (200)	Pendent*	90	6.2	Yes
						16.8 (240)	Pendent*	63	4.3	Yes
						16.8 (240)	Pendent	52	3.6	No
				40	12	22.4 (320)	Pendent	50	3.4	No
		35	11			25.2 (360)	Pendent	50	3.4	No
				45	14	14 (200)	Pendent	90	6.2	Yes
						16.8 (240)	Pendent	63	4.3	Yes
		40	12	45	14	14 (200)	Pendent	90	6.2	Yes
						16.8 (240)	Pendent	63	4.3	Yes

*In-rack sprinklers required. See Chapter 25.

NA: Not applicable

Supplemental Information

<u>File Name</u>	<u>Description</u>	<u>Approved</u>
13_Table_23.6.1_With_Mark-Ups_.docx	Revised Table 23.6.1. For staff use.	

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: National Fire Protection Assoc

Street Address:

City:

State:

Zip:

Submittal Date: Sun Jul 30 19:43:09 EDT 2017

Committee Statement

Committee Statement: Table 23.6.1 has been revised to ceiling only design, for in-rack design see Chapter 25.

Response Message:



Second Revision No. 805-NFPA 13-2017 [Section No. 23.6.1.2 [Excluding any Sub-Sections]]

ESFR sprinklers shall not be permitted to protect storage on solid shelf racks unless the solid shelf racks are protected with in-rack sprinklers in accordance with 47.4.5 Section 25.6 .

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Tue Jul 18 08:48:34 EDT 2017

Committee Statement

Committee Statement: Editorial revision.

Response Message:

**Second Revision No. 806-NFPA 13-2017 [Section No. 23.6.1.2.1]****23.6.1.2.1**

~~Where solid shelves are used, in-rack sprinklers shall be installed in every level below the highest solid shelf.~~

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Tue Jul 18 08:51:51 EDT 2017

Committee Statement

Committee Statement: This is redundant text that is covered by Chapter 25, 25.6.

Response Message:

**Second Revision No. 808-NFPA 13-2017 [Section No. 23.6.4]****23.6.4 In-Rack Sprinkler Requirements Where ESFR Sprinklers Are Used at Ceiling.****23.6.4.1**

~~Where required by Table 23.6.1, in-rack sprinklers shall be installed at the first tier level at or above one-half of the storage height.~~

23.6.4.2

~~In-rack sprinklers shall be K-8.0 (115) or K-11.2 (160) quick-response, ordinary-temperature sprinklers.~~

23.6.4.3

~~The minimum of 6 in. (150 mm) vertical clear space shall be maintained between the sprinkler deflectors and the top of a tier of storage.~~

(A)

~~Sprinkler discharge shall not be obstructed by horizontal rack members.~~

23.6.4.4

~~The maximum horizontal distance between in-rack sprinklers shall be 5 ft (1.5 m).~~

23.6.4.5

~~In-rack sprinklers shall be located at an intersection of transverse and longitudinal flues while not exceeding the maximum spacing rules.~~

23.6.4.6

~~Where distances between transverse flues exceed the maximum allowable distances, sprinklers shall be installed at the intersection of the transverse and longitudinal flues, and additional sprinklers shall be installed between transverse flues to meet the maximum distance rules.~~

23.6.4.7

~~Where no transverse flues exist, in-rack sprinklers shall not exceed the maximum spacing rules.~~

23.6.4.8

~~The water demand for sprinklers installed in racks shall be based on simultaneous operation of the most hydraulically remote eight sprinklers.~~

23.6.4.9

~~Each of the in-rack sprinklers described in 23.6.4.8 shall discharge at a minimum of 60 gpm (227 L/min).~~

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Tue Jul 18 09:11:55 EDT 2017

Committee Statement

Committee Statement: This is redundant text that can be found in Chapter 25.

Response Message:

**Second Revision No. 330-NFPA 13-2017 [Section No. 23.13]****23.13** Slatted Shelves.**23.13.1***

Slatted rack shelves shall be considered equivalent to solid rack shelves where the shelving is not considered open rack shelving or where the requirements of 23.13.1 are not met. (See Section C.20.)

A.23.13.1

Slating of decks or walkways or the use of open grating as a substitute for automatic sprinkler thereunder is not acceptable.

In addition, where shelving of any type is employed, it is for the basic purpose of providing an intermediate support between the structural members of the rack. As a result, it becomes almost impossible to define and maintain transverse flue spaces across the rack as required.

23.13.2

A wet pipe system that is designed to provide K-14.0 (200) ESFR sprinklers operating at a minimum of 50 psi (3.4 bar), K-16.8 (240) sprinklers operating at a minimum of 32 psi (2.2 bar), or K-25.2 (360) ESFR sprinklers operating at a minimum of 15 psi (1.0 bar) shall be permitted to protect single- and double-row racks with slatted rack shelving racks where all of the following conditions are met:

- (1) Sprinklers shall be K-14.0 (200), K-16.8 (240), or K-25.2 (360) ESFR.
- (2) The protected commodities shall be limited to Class I through Class IV, Group B plastics, Group C plastics, cartoned (expanded and nonexpanded) Group A plastics, and exposed (nonexpanded) Group A plastics.
- (3) Slats in slatted rack shelving shall be a minimum nominal 2 in. (50 mm) thick by maximum nominal 6 in. (150 mm) wide with the slats held in place by spacers that maintain a minimum 2 in. (50 mm) opening between each slat.
- (4) Longitudinal flue spaces shall not be required.
- (5) Transverse flue spaces at least 3 in. (75 mm) wide shall be provided at least every 10 ft (3.0 m) horizontally.
- (6) The aisle widths shall be at least 7 1/2 ft (2.3 m).
- (7) The maximum roof height shall be 30 ft (9.1 m).
- (8) The maximum storage height shall be 20 ft (6.1 m).
- (9) Solid plywood or similar materials shall not be placed on the slatted shelves so that they block the 2 in. (50 mm) spaces between slats, nor shall they be placed on the wire mesh shelves.

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Wed Jun 28 17:08:06 EDT 2017

Committee Statement

Committee Statement: In the First Draft Report, Chapter 23, Section 23.13 for Slatted Shelves consists of just a title line. ESFR protection of slatted shelves is covered in 16.2.4.1 and 17.2.4.1 of NFPA 13-2016, so that information needs to be brought forward into this new ESFR chapter.

Response Message:

[Public Comment No. 224-NFPA 13-2017 \[Section No. 23.13\]](#)

[Public Comment No. 179-NFPA 13-2017 \[New Section after 23.13\]](#)

**Second Revision No. 331-NFPA 13-2017 [Sections 24.1.2, 24.1.3]****24.1.2**

The requirements of Chapters ~~12 through 20~~through 23 and 25 shall apply unless modified by this chapter.

24.1.2.1

Sprinklers having standard coverage areas that require up to 20 sprinklers to be included in the hydraulic calculation shall be installed in accordance with 14.2.3, 14.2.4, 14.2.4.1 and ~~21.42.6~~ 20.6.5.

24.1.2.1.1

Quick-response sprinklers shall also be installed in accordance with 14.2.5.1 and 14.2.5.2.

24.1.2.2

Sprinklers having extended coverage areas that require up to 10 sprinklers to be included in the hydraulic calculation shall be installed in accordance with 14.2.3, 14.2.4, 14.2.4.1 and ~~21.42.6~~ 20.6.5.

24.1.2.2.1

Quick-response sprinklers shall also be installed in accordance with 14.2.5.1 and 14.2.5.2.

24.1.3

The in-rack protection requirements of Chapters ~~12 through 20~~ Chapter 25 shall apply when storage racks are equipped with solid shelves, and in-rack sprinklers are required per the applicable chapter.

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submission Date: Wed Jun 28 17:13:24 EDT 2017

Committee Statement

Committee Statement: In Sections 24.1.2 and 24.1.3, the references are from the 2016 edition of the NFPA 13. These matters need to be revised to match the new chapter structure for the standard.

Response Message:

Public Comment No. 217-NFPA 13-2017 [Sections 24.1.2, 24.1.3]


Second Revision No. 393-NFPA 13-2017 [Sections 24.3.2, 24.3.3]
24.3.2

Protection of Class I through Class IV and cartoned nonexpanded plastic commodities stored on single-, double-, or multiple-row racks without solid shelves or solid-piled, palletized, shelf, or bin-box storage arrangements shall be permitted to be protected in accordance with Table 24.3.2(a) or Table 24.3.2(b) .

Table 24.3.2(a) CMSA K-25.2 Pendant Upright Standard Coverage Sprinkler Design Criteria for Single-, Double-, and Multiple-Row Racks Without Solid Shelves and Solid-Piled, Palletized Storage Arrangement of Class I Through IV and Cartoned Nonexpanded Plastic Commodities

<u>Storage Arrangement</u>	<u>Commodity Class</u>	<u>Maximum Storage Height</u>		<u>Maximum Ceiling/Roof Height</u>		<u>K-Factor Orientation</u>	<u>System Type</u>	<u>Number of Design Sprinklers</u>	<u>Minimum Operating Pressure</u>
		<u>ft</u>	<u>m</u>	<u>ft</u>	<u>m</u>				
Solid-piled, palletized, and single-, double-, and multiple-row racks without solid shelves (no open-top containers)	Class I–IV encapsulated and nonencapsulated, and cartoned nonexpanded plastics	25	7.6	30	9.1	25.2 (360) <u>Pendant Upright</u>	Wet	12	20 psi (1.4 bar)

Table 24.3.2(b) CMSA K-25.2 Pendant Pendant Standard Coverage Sprinkler Design Criteria for Single-, Double-, and Multiple-Row Racks Without Solid Shelves and Solid-Piled, Palletized Storage Arrangement of Class I Through IV and Cartoned Nonexpanded Plastic Commodities

<u>Storage Arrangement</u>	<u>Commodity Class</u>	<u>Maximum Storage Height</u>		<u>Maximum Ceiling/Roof Height</u>		<u>K-Factor Orientation</u>	<u>System Type</u>	<u>Number of Design Sprinklers</u>	<u>Minimum Operating Pressure</u>
		<u>ft</u>	<u>m</u>	<u>ft</u>	<u>m</u>				
Solid-piled, palletized, and single-, double-, and multiple-row racks without solid shelves (no open-top containers)	Class I–IV encapsulated and nonencapsulated, and cartoned nonexpanded plastics	25	7.6	30	9.1	25.2 (360) <u>Pendant Pendant</u>	Wet	12	15 psi (1 bar)

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submission Date: Fri Jul 14 12:19:10 EDT 2017

Committee Statement

Committee Statement: Editorial revision.

Response Message:



Second Revision No. 392-NFPA 13-2017 [New Section after 24.3.3]

24.3.3

Protection of Class I through Class IV and cartoned nonexpanded plastic commodities stored on single-, double-, or multiple-row racks without solid shelves or solid-piled, palletized, shelf, or bin-box storage arrangements shall be permitted to be protected in accordance with Table 24.3.2(b) Protection of open rack storage of Class I through Class III commodities with dry pipe systems using standard response upright sprinkler design criteria using high-temperature-rated sprinklers shall be in accordance with Table 24.3.3.

Table 24.3.3 Standard Response Upright Sprinkler Design Criteria for Open Rack Storage of Class I Through Class III Commodities (Using High-Temperature-Rated Sprinklers)

Storage Arrangement	Commodity Class	Maximum Storage Height		Maximum Ceiling/Roof Height		K-Factor/Orientation	Type of System	Number of Design Sprinklers	Minimum Operating Pressure
		ft	m	ft	m				psi
Rack storage without solid shelves (no open-top containers)	Class I, II, or III	35	10.6	40	12.1	25.2 (360)/Upright	Dry	24	15*
		40	12.1	45	13.6	25.2 (360)/Upright	Dry	12	50†

*25 second water delivery time maximum

†20 second water delivery time maximum

24.3.3.1

For protection criteria using a minimum operating pressure of 15 psi (1 bar), a maximum water delivery time of 25 seconds shall be used.

24.3.3.2

For protection criteria using a minimum operating pressure of 50 psi (3.4 bar), a maximum water delivery time of 20 seconds shall be used.

24.3.4

Protection of solid-piled, palletized, shelf, bin box, or open frame rack storage of Class I through Class IV and cartoned nonexpanded plastic commodities with standard response upright sprinkler design criteria using ordinary-temperature-rated sprinklers shall be in accordance with [Table 24.3.4](#).

Table 24.3.4 Standard Response Upright Sprinkler Design Criteria for Solid-Piled, Palletized, Shelf, Bin Box, or Open Frame Rack Storage of Class I Through Class IV and Cartoned Nonexpanded Plastic Commodities (Using Ordinary-Temperature-Rated Sprinklers)

<u>Storage Arrangement</u>	<u>Commodity Class</u>	<u>Maximum Storage Height</u>		<u>Maximum Ceiling/Roof Height</u>		<u>K-Factor/Orientation</u>	<u>Type of System</u>	<u>Number of Design Sprinklers</u>	<u>Minimum Operating Pressure</u>	
		<u>ft</u>	<u>m</u>	<u>ft</u>	<u>m</u>				<u>psi</u>	<u>kPa</u>
<u>Solid-piled, palletized, shelf, bin box, and rack storage without solid shelves (no open-top containers)</u>	<u>Class I through Class IV and cartoned nonexpanded plastic</u>	<u>25</u>	<u>7.6</u>	<u>30</u>	<u>9.1</u>	<u>25.2 (360)/Upright</u>	<u>Wet</u>	<u>12</u>	<u>20</u>	<u>138</u>

Supplemental Information

<u>File Name</u>	<u>Description</u>	<u>Approved</u>
New_Tables_24.3.3_and_24.3.4_-_Kevin_Kelly.xlsx	New Tables 24.3.3 and 24.3.4. For staff use.	

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Fri Jul 14 11:53:15 EDT 2017

Committee Statement

Committee Statement: These tables represent successful fire test results at FM.

Response Message:

**Second Revision No. 807-NFPA 13-2017 [Section No. 24.6]**

24.6 ~~In-Rack Sprinkler Protection Criteria for Open-Frame Rack Storage of Class I Through Class IV and Plastic Commodities.~~

24.6.1

~~Protection of closed-top Class I through Class IV and plastic commodities stored on single-, double-, or multiple-row racks without solid shelves shall be permitted to be protected in accordance with this section.~~

24.6.2

~~In-rack sprinkler systems shall be wet-pipe only.~~

24.6.3

~~In-rack sprinklers shall be standard-coverage, quick-response, pendent, and 160°F (70°C) nominally rated.~~

24.6.3.1

~~Minimum K-14.0 (K-200) sprinklers shall be installed where the minimum required flow is 100 gpm (380 L/min) or less.~~

24.6.3.2

~~Minimum K-22.4 (K-320) sprinklers shall be installed where the minimum required flow exceeds 100 gpm (380 L/min).~~

24.6.4

Depending on the type of storage rack being protected, in-rack sprinklers shall be positioned horizontally in accordance with Figure 24.6.4(a) through Figure 24.6.4(f) and the following:

The minimum horizontal distance between in-rack sprinklers shall be 27 in. (700 mm), with the maximum horizontal distance being 4.5 ft (1.4 m), unless shown otherwise in the applicable figures.

Except as shown in Figure 24.6.4(c), all in-rack sprinklers shall be located within the footprint of the rack structure.

All face sprinklers shall be positioned so that the horizontal distance between the face of the storage rack and the outer edge of storage, if it protrudes into the storage aisle, does not exceed 18 in. (450 mm).

Figure 24.6.4(a) Plan View of In-Rack Sprinkler Arrangement for Open-Frame Single-Row Racks Up to 3 ft (0.9 m) Deep.

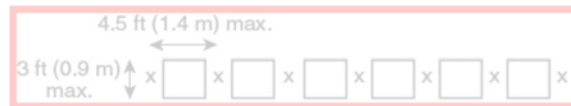


Figure 24.6.4(b) Plan View of In-Rack Sprinkler Arrangement for Open-Frame Single-Row Racks Up to 6 ft (1.8 m) Deep.



Figure 24.6.4(c) Plan View of In-Rack Sprinkler Arrangement for Open-Frame Single-Row Racks Up to 6 ft (1.8 m) Deep Located Against a Wall.

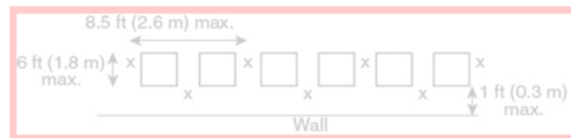


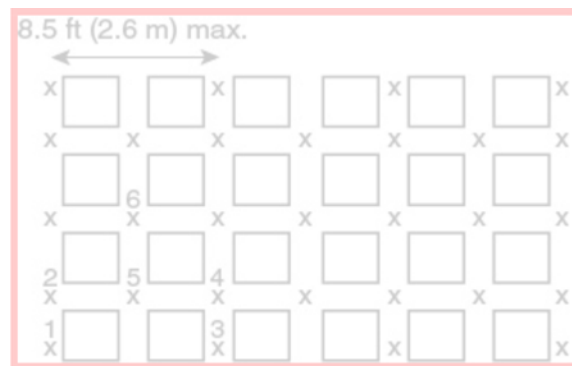
Figure 24.6.4(d) Plan View of In-Rack Sprinkler Arrangement for Open-Frame Double-Row Racks Up to 9 ft (2.7 m) Deep.



Figure 24.6.4(e) Plan View of In-Rack Sprinkler Arrangement for Open-Frame Double-Row Racks Up to 12 ft (3.7 m) Deep.



Figure 24.6.4(f) Plan View of In-Rack Sprinkler Arrangement for Open-Frame Multiple-Row Racks.



24.6.5

The maximum allowable vertical distance between in-rack sprinklers for cartoned expanded plastics, exposed nonexpanded plastics, and exposed expanded plastics shall be 30 ft (9.1 m).

24.6.5.1

The maximum allowable vertical distance between in-rack sprinklers for Class I through Class IV and cartoned nonexpanded plastics shall be 40 ft (12.2 m).

24.6.5.2

A minimum 6 in. (150 mm) vertical distance between the top of storage and the in-rack sprinkler deflector shall be maintained.

24.6.6

Regardless of the number of in-rack sprinkler levels installed, the number of sprinkler levels for the in-rack sprinkler system design shall be based on the single most hydraulically remote in-rack sprinkler level and the minimum number of in-rack sprinklers for this level in accordance with Table 24.6.6.

Table 24.6.6 Number of Sprinklers in the In-Rack Sprinkler Design

IRAS Installation Arrangement; Figure	Number of Sprinklers in the In-Rack Design	
	Class I through IV and Cartoned Plastics	Exposed Plastics
Single-row racks up to 3 ft (0.9 m) Deep; Figure 21.6.4(a)	4	4
Single-row racks up to 6 ft (1.8 m) deep; Figures 21.6.4(b) and 21.6.4(c)	5	5
Double- and multiple-row racks; Figures 21.6.4(e) and 21.6.4(f)	6	6 and 6*

*This represents 6 sprinklers in the most remote rack as well as 6 sprinklers in the nearest adjacent rack. See Figures 21.6.4(d), 21.6.4(e) and 21.6.4(f) to determine which 6 sprinklers to account for in the in-rack sprinkler design for double- and multiple-row racks.

24.6.7

The minimum flow required in the system design shall be from the most remote in-rack sprinkler in accordance with Table 24.6.7.

Table 24.6.7 Minimum Flow in the In-Rack Sprinkler Design

Maximum Vertical IRAS Installation Increment, ft (m)	Commodity Hazard	Min. K-Factor	Minimum Flow from Most Remote IRAS, gpm (L/min)
30 (9.1)	Class I through IV and cartoned nonexpanded plastic	14.0 (200)	65 (250)
	Cartoned expanded plastic	14.0 (200)	100 (380)
	Exposed plastic	22.4 (320)	120 (455)
40 (12.2)	Class I through IV and cartoned nonexpanded plastic	22.4 (320)	121 (455)

24.6.8

A hose stream allowance of 250 gpm (950 L/min) shall be included as part of the in-rack sprinkler system design obtained from Section 24.6.

24.6.9

The water supply requirements obtained from Section 24.6 shall be available for a minimum of 60 minutes.

24.6.10*

The water supply for the in-rack sprinkler system shall be capable of providing the required in-rack sprinkler system design obtained from Section 24.6 independent of the design requirements of the ceiling sprinkler system protecting this same area.

A.24.6.10

Hydraulically balancing the in-rack system with the ceiling sprinkler system or accounting for them flowing simultaneously, is not required.

24.6.11

The ceiling sprinkler system shall be designed and installed in accordance with the guidelines outlined in Chapters 16 or 17, depending on the commodity hazard, except as modified in Section 24.6.

24.6.11.1

Where the in-rack sprinkler system is designed and installed in accordance with Section 24.6, the top level of in-rack sprinklers shall be considered to be a floor for design purposes of the ceiling sprinkler system.

24.6.11.2

As a result, the storage height above the top level of in-rack sprinklers shall be permitted to be in excess of 10 ft (3.0 m).

24.6.12*

The water supply for the ceiling system shall be capable of providing the required ceiling sprinkler system design obtained from either Chapter 16 or Chapter 17 independent of the design requirements of the in-rack sprinkler system obtained from Section 24.6 and protecting this same area.

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]
Street Address:
City:
State:
Zip:
Submittal Date: Tue Jul 18 08:55:02 EDT 2017

Committee Statement

Committee Statement: This is redundant text that can be found in Chapter 25, 25.8.3.

Response Message:

[Public Comment No. 325-NFPA 13-2017 \[Section No. 24.6.3\]](#)



Second Revision No. 809-NFPA 13-2017 [Chapter 25]

Chapter 25 Protection of Rack Storage Using In-Rack Sprinklers

25.1 General Requirements of In-Rack Sprinklers.

25.1.1 Scope.

This chapter shall apply where rack storage of Class I through Class IV commodities, Group A plastic commodities, or rubber tires will be protected with in-rack sprinklers. Applicable sections shall include the following:

- (1) See Section 25.2 for the ceiling-level sprinkler design criteria applicable to designs with in-rack sprinklers.
- (2) See Section 25.3 for in-rack sprinkler characteristics.
- (3) See Section 25.4 for vertical spacing and location of in-rack sprinklers.
- (4) See Section 25.5 for horizontal location and spacing of in-rack sprinklers.
- (5) See Section 25.6 for protection of racks with solid shelves.
- (6) See Section 25.7 for horizontal barriers in combination with in-rack sprinklers.
- (7) See Section 25.8 for in-rack sprinkler arrangements and designs independent of ceiling-level sprinklers.
- (8) See Section 25.9 for in-rack sprinkler arrangements in combination with CMDA sprinklers at ceiling level.
- (9) See Section 25.10 for in-rack sprinkler arrangements in combination with CMSA sprinklers at ceiling level.
- (10) See Section 25.11 for in-rack sprinkler arrangements in combination with ESFR sprinklers at ceiling level.
- (11) See Section 25.12 for design criteria for in-rack sprinklers in combination with ceiling-level sprinklers.

25.1.2 Open Rack Storage.

25.1.2.1

The in-rack sprinkler arrangements as well as the ceiling and in-rack sprinkler design criteria for rack storage in this chapter shall be based on open rack configurations as defined in 3.3.141 unless indicated otherwise.

25.1.3 In-Rack Sprinkler System.

25.1.3.1 In-Rack Sprinkler System Size.

The area protected by a single in-rack sprinkler system shall not exceed 40,000 ft² (3720 m²) of floor area occupied by the racks, including aisles, regardless of the number of in-rack sprinkler levels.

25.1.3.2* In-Rack Sprinkler System Control Valves.

A.25.1.3.2

In-rack sprinklers and ceiling sprinklers selected for protection should be controlled by at least two separate indicating valves and drains. In higher rack arrangements, consideration should be given to providing more than one in-rack control valve to limit the extent of any single impairment.

25.1.3.2.1

Unless the requirements of 25.1.3.2.2 or 25.1.3.2.3 are met, separate indicating control valves and drains shall be provided and arranged so that ceiling and in-rack sprinkler systems can be controlled independently.

25.1.3.2.2

A separate indicating control valve shall not be required where 20 or fewer in-rack sprinklers are supplied by any one ceiling sprinkler system.

25.1.3.2.3

The separate indicating valves shall be permitted to be arranged as sectional control valves supplied from the ceiling sprinkler system where in-rack sprinklers are required and the racks, including the adjacent aisles, occupy 8000 ft^2 (740 m^2) or less of the area protected by the ceiling sprinklers.

25.1.3.3* Sprinkler Waterflow Alarm for In-Rack Sprinklers.

See Section C.4 .

A.25.1.3.3

See A.16.11.2 .

25.1.4 Building Steel Protection.

Where in-rack sprinklers are installed in accordance with this chapter, building steel shall not require special protection.

25.2 Ceiling-Level Sprinkler Design Criteria in Combination with In-Rack Sprinklers.**25.2.1** General.**25.2.1.1**

This section shall apply to storage of Class I through Class IV and Group A plastic commodities as well as rubber tires, representing the broad range of combustibles stored in racks that are being protected by in-rack sprinklers. The requirements of Chapter 20 shall apply unless modified by this chapter. (See Section C.9 .)

25.2.1.2*

Ceiling-level sprinkler design criteria for single-, double-, and multiple-row racks in Section 25.2 shall be based on open rack configurations as defined in 3.3.141 .

A.25.2.1.2

Solid shelf racks as defined in 3.3.199 or obstructions resulting in solid shelf requirements could require additional in-rack sprinklers that could affect the ceiling design requirements.

25.2.1.3*

Ceiling-level sprinkler design criteria for Group A plastic commodities in this chapter shall be permitted for the protection of the same storage height and configuration of Class I, II, III, and IV commodities.

A.25.2.1.3

Information for the protection of Classes I, II, III, and IV commodities was extrapolated from full-scale fire tests that were performed at different times than the tests that were used to develop the protection for Group A plastic commodities. It is possible that, by selecting certain points from the tables (and after applying the appropriate modifications), the protection specified by 25.2.3.2.4 for Class I through Class IV commodities exceeds the requirements for Group A plastic commodities. In such situations, the protection specified for plastics, although less than that required by the tables, can adequately protect Class I, II, III, and IV commodities. This section also allows storage areas that are designed to protect Group A plastic commodities to store Class I, II, III, and IV commodities without a re-evaluation of fire protection systems.

25.2.1.4

Ceiling-level sprinkler design criteria for single- and double-row rack storage of Group A plastic commodities shall be applicable where aisles are 3.5 ft (1.1 m) or greater in width.

25.2.1.5

Ceiling-level sprinkler design criteria for rack storage of Group A plastic commodities shall be protected as multiple-row racks where aisles are less than 3.5 ft (1.1 m) in width.

25.2.1.6

The minimum water supply requirements for a hydraulically designed occupancy hazard ceiling-level sprinkler system shall be determined by adding the hose stream allowance from Table 20.12.2.6 to the water supply for in-rack sprinklers determined in Section 25.12, unless indicated otherwise.

25.2.2 Miscellaneous and Low-Piled Storage.**25.2.2.1 Miscellaneous Storage.****25.2.2.1.1**

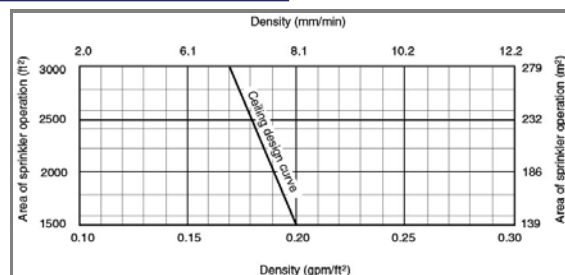
This section shall apply to any of the following situations:

- (1) Miscellaneous rack storage of Class I through Class IV commodities up to and including 12 ft (3.7 m) in height
- (2) Miscellaneous rack storage of Group A plastic commodities up to and including 12 ft (3.7 m) in height
- (3) Miscellaneous rack storage of rubber tires up to and including 12 ft (3.7 m) in height

25.2.2.1.2

Where in-rack sprinklers are installed in accordance with Section 25.4 through Section 25.7 to protect miscellaneous rack storage of Class I through Class IV and Group A plastic commodities, as well as miscellaneous rack storage of rubber tires, up to and including 12 ft (3.7 m) in height under a maximum 32 ft (10.0 m) high ceiling, the ceiling-level sprinkler design criteria shall be in accordance with Figure 25.2.2.1.2.

Figure 25.2.2.1.2 CMDA Ceiling-Level Sprinkler Design Criteria for Miscellaneous Storage Protected with One Level of In-Rack Sprinklers.

**25.2.2.1.3**

Installation criteria as permitted by NFPA 13 and design criteria and modifiers as permitted by the density/area method of Section 19.2 for ordinary hazard Group 2 occupancies shall be applicable.

25.2.2.1.4 Hose Connections.

Hose connections shall not be required for the protection of miscellaneous storage.

25.2.2.2 Low-Piled Rack Storage.**25.2.2.2.1**

This section shall apply to any of the following situations:

- (1) Rack storage of Class I through Class IV commodities up to and including 12 ft (3.7 m) in height
- (2)* Rack storage of Group A plastic commodities up to and including 5 ft (1.5 m) in height

A.25.2.2.2.1(2)

All rack fire tests of Group A plastic commodities were run with an approximate 10 ft (3.0 m) maximum clearance to ceiling.

25.2.2.2.2

Where in-rack sprinklers are installed in accordance with Sections 25.4 through 25.7 to protect low-piled rack storage that does not meet the definition of miscellaneous storage, of Class I through Class IV and Group A plastic commodities, the ceiling-level design shall be in accordance with Figure 25.2.2.1.2 .

25.2.2.2.3

For low-piled rack storage that does not meet the definition of miscellaneous storage, with solid shelves of Class I through Class IV commodities up to and including 12 ft (3.7 m) in height, in-rack sprinklers shall be provided in accordance with Section 25.6 , and the ceiling-level sprinkler design shall be in accordance with Figure 25.2.2.1.2 .

25.2.2.2.4

For low-piled rack storage that does not meet the definition of miscellaneous storage, with solid shelves of Group A plastic commodities up to and including 5 ft (1.5 m) in height, in-rack sprinklers shall be provided in accordance with Section 25.6 , and the ceiling-level sprinkler design shall be in accordance with Figure 25.2.2.1.2 .

25.2.3 CMDA Ceiling-Level Sprinkler Design Criteria in Combination with In-Rack Sprinklers.**25.2.3.1** General.**25.2.3.1.1**

Ceiling-level sprinkler design criteria in combination with in-rack sprinklers for the rack storage of Class I through Class IV commodities shall be in accordance with 25.2.3.2 for storage over 12 ft (3.7 m) and up to and including 25 ft (7.6 m) in height and 25.2.3.3 for storage over 25 ft (7.6 m) in height.

25.2.3.1.2

Ceiling-level sprinkler design criteria in combination with in-rack sprinklers for the rack storage of Group A plastic commodities shall be in accordance with 25.2.3.4 for storage over 5 ft (1.5 m) and up to and including 25 ft (7.6 m) in height and 25.2.3.5 for storage over 25 ft (7.6 m) in height.

25.2.3.2 Rack Storage of Class I Through Class IV Commodities Stored Over 12 ft (3.7 m) and Up to and Including 25 ft (7.6 m) in Height.**25.2.3.2.1*** Single- and Double-Row Racks.

For single- or double-row rack storage of Class I through Class IV commodities, encapsulated or nonencapsulated, stored over 12 ft (3.7 m) and up to and including 25 ft (7.6 m) in height, Table 25.2.3.2.1 shall be used to determine the appropriate figure for determining ceiling-level sprinkler design criteria with the provision of one level of in-rack sprinklers.

Table 25.2.3.2.1 Determining Appropriate Ceiling-Level Protection Criteria Figure for Single- or Double-Row Racks of Class I Through Class IV Commodities — Storage Height Over 12 ft (3.7 m) Up to and Including 25 ft (7.6 m)

<u>Storage Height</u>	<u>Commodity Class</u>	<u>Encapsulated</u>	<u>Aisle Width*</u>		<u>No. of In-Rack Sprinkler Levels</u>	<u>Appropriate Figure and Curves</u>		
			<u>ft</u>	<u>m</u>		<u>Figure</u>	<u>Curves</u>	<u>Apply Figure 25.2.3.2.4.1</u>
<u>Over 12 ft (3.7 m) and up to and including 20 ft (6.1 m)</u>	<u>I</u>	<u>No</u>	<u>4</u>	<u>1.2</u>	<u>1 Level</u>	<u>25.2.3.2.3.1(a)</u>	<u>C and D</u>	<u>Yes</u>
			<u>8</u>	<u>2.4</u>			<u>A and B</u>	
		<u>Yes</u>	<u>4</u>	<u>1.2</u>		<u>25.2.3.2.3.1(e)</u>	<u>C and D</u>	
			<u>8</u>	<u>2.4</u>			<u>A and B</u>	
	<u>II</u>	<u>No</u>	<u>4</u>	<u>1.2</u>		<u>25.2.3.2.3.1(b)</u>	<u>C and D</u>	
			<u>8</u>	<u>2.4</u>			<u>A and B</u>	
		<u>Yes</u>	<u>4</u>	<u>1.2</u>		<u>25.2.3.2.3.1(e)</u>	<u>C and D</u>	
			<u>8</u>	<u>2.4</u>			<u>A and B</u>	
	<u>III</u>	<u>No</u>	<u>4</u>	<u>1.2</u>		<u>25.2.3.2.3.1(c)</u>	<u>C and D</u>	
			<u>8</u>	<u>2.4</u>			<u>A and B</u>	
		<u>Yes</u>	<u>4</u>	<u>1.2</u>		<u>25.2.3.2.3.1(f)</u>	<u>C and D</u>	
			<u>8</u>	<u>2.4</u>			<u>A and B</u>	
	<u>IV</u>	<u>No</u>	<u>4</u>	<u>1.2</u>		<u>25.2.3.2.3.1(d)</u>	<u>C and D</u>	
			<u>8</u>	<u>2.4</u>			<u>A and B</u>	
		<u>Yes</u>	<u>4</u>	<u>1.2</u>		<u>25.2.3.2.3.1(g)</u>	<u>C and D</u>	
			<u>8</u>	<u>2.4</u>			<u>A and B</u>	
<u>Over 20 ft (6.1 m) and up to and including 22 ft (6.7 m)</u>	<u>I</u>	<u>No</u>	<u>4</u>	<u>1.2</u>	<u>1 Level</u>	<u>25.2.3.2.3.1(a)</u>	<u>C and D</u>	<u>No</u>
			<u>8</u>	<u>2.4</u>		-	<u>A and B</u>	
		<u>Yes</u>	<u>4</u>	<u>1.2</u>		<u>25.2.3.2.3.1(e)</u>	<u>C and D</u>	
			<u>8</u>	<u>2.4</u>		-	<u>A and B</u>	
	<u>II</u>	<u>No</u>	<u>4</u>	<u>1.2</u>		<u>25.2.3.2.3.1(b)</u>	<u>C and D</u>	
			<u>8</u>	<u>2.4</u>		-	<u>A and B</u>	
		<u>Yes</u>	<u>4</u>	<u>1.2</u>		<u>25.2.3.2.3.1(e)</u>	<u>C and D</u>	
			<u>8</u>	<u>2.4</u>		-	<u>A and B</u>	
	<u>III</u>	<u>No</u>	<u>4</u>	<u>1.2</u>		<u>25.2.3.2.3.1(c)</u>	<u>C and D</u>	
			<u>8</u>	<u>2.4</u>		-	<u>A and B</u>	
		<u>Yes</u>	<u>4</u>	<u>1.2</u>		<u>25.2.3.2.3.1(f)</u>	<u>C and D</u>	
			<u>8</u>	<u>2.4</u>		-	<u>A and B</u>	
	<u>IV</u>	<u>No</u>	<u>4</u>	<u>1.2</u>		<u>25.2.3.2.3.1(d)</u>	<u>C and D</u>	
			<u>8</u>	<u>2.4</u>		-	<u>A and B</u>	
		<u>Yes</u>	<u>4</u>	<u>1.2</u>		<u>25.2.3.2.3.1(g)</u>	<u>C and D</u>	
			<u>8</u>	<u>2.4</u>		-	<u>A and B</u>	
<u>Over 22 ft (6.7 m)</u>	<u>I</u>	<u>No</u>	<u>4</u>	<u>1.2</u>	<u>1 Level</u>	<u>25.2.3.2.3.1(a)</u>	<u>C and D</u>	<u>No</u>
			<u>8</u>	<u>2.4</u>		-	<u>A and B</u>	

<u>Storage Height</u>	<u>Commodity Class</u>	<u>Encapsulated</u>	<u>Aisle Width*</u>		<u>No. of In-Rack Sprinkler Levels</u>	<u>Appropriate Figure and Curves</u>		
			<u>ft</u>	<u>m</u>		<u>Figure</u>	<u>Curves</u>	<u>Apply Figure 25.2.3.2.4.1</u>
and up to and including 25 ft (7.6 m)	II	Yes	4	1.2		25.2.3.2.3.1(e)	C and D	
			8	2.4		-	A and B	
		No	4	1.2		25.2.3.2.3.1(b)	C and D	
			8	2.4		-	A and B	
		Yes	4	1.2		25.2.3.2.3.1(e)	C and D	
			8	2.4		-	A and B	
	III	No	4	1.2		25.2.3.2.3.1(c)	C and D	
			8	2.4		-	A and B	
		Yes	4	1.2		25.2.3.2.3.1(f)	C and D	
			8	2.4		-	A and B	
		No	4	1.2		25.2.3.2.3.1(d)	C and D	
			8	2.4		-	A and B	
	IV	Yes	4	1.2		25.2.3.2.3.1(g)	C and D	
			8	2.4		-	A and B	

*See 25.2.3.2.1.1 for interpolation of aisle widths.

A.25.2.3.2.1

Bulkheads are not a substitute for sprinklers in racks. Their installation does not justify reduction in sprinkler densities or design operating areas as specified in the design curves.

25.2.3.2.1.1*

Design densities for single- and double-row racks shall be selected to correspond to aisle width. (See Section C.15.)

A.25.2.3.2.1.1

The aisle width and the depth of racks are determined by material-handling methods. The widths of aisles should be considered in the design of the protection system. Storage in aisles can render protection ineffective and should be discouraged.

(A)

For aisle widths between 4 ft (1.2 m) and 8 ft (2.4 m), the rules for 4 ft (1.2 m) wide aisles shall be used or direct linear interpolation between the densities shall be permitted.

(B)

The density given for 8 ft (2.4 m) wide aisles shall be applied to aisles wider than 8 ft (2.4 m).

(C)

The density given for 4 ft (1.2 m) wide aisles shall be applied to aisles more narrow than 4 ft (1.2 m) down to 3 1/2 ft (1.1 m).

(D)

Where aisles are more narrow than 3 1/2 ft (1.1 m), racks shall be considered multiple-row racks.

25.2.3.2.2 Multiple-Row Racks.

25.2.3.2.2.1

For multiple-row racks, having a rack depth up to and including 16 ft (4.9 m) with aisles 8 ft (2.4 m) or wider, storing Class I through Class IV commodities, encapsulated or nonencapsulated, over 12 ft (3.7 m) and up to and including 25 ft (7.6 m) in height, Table 25.2.3.2.2.1 shall be used to determine the appropriate figure for determining ceiling-level sprinkler design criteria with the provision of in-rack sprinklers.

Table 25.2.3.2.2.1 Determining Appropriate Ceiling-Level Protection Criteria Figure for Multiple-Row Racks of Class I Through Class IV Commodities — Rack Depth Up to and Including 16 ft (4.9 m), Aisles 8 ft (2.4 m) or Wider, and Storage Height Over 12 ft (3.7 m) Up to 25 ft (7.6 m)

<u>Storage Height</u>	<u>Commodity Class</u>	<u>Encapsulated</u>	<u>No. of In-Rack Sprinkler Levels</u>	<u>Appropriate Figure and Curves</u>		
				<u>Figure</u>	<u>Apply Figure 25.2.3.2.4.1</u>	<u>Density Multiplier</u>
<u>Over 12 ft (3.7 m) and up to and including 15 ft (4.6 m)</u>	<u>I</u>	<u>No</u>	<u>1 Level</u>	<u>25.2.3.2.3.1(a)</u>	<u>Yes</u>	<u>1.0</u>
		<u>Yes</u>				<u>1.25</u>
	<u>II</u>	<u>No</u>		<u>25.2.3.2.3.1(b)</u>		<u>1.0</u>
		<u>Yes</u>				<u>1.25</u>
	<u>III</u>	<u>No</u>		<u>25.2.3.2.3.1(c)</u>		<u>1.0</u>
		<u>Yes</u>				<u>1.25</u>
	<u>IV</u>	<u>No</u>		<u>25.2.3.2.3.1(d)</u>		<u>1.0</u>
		<u>Yes</u>				<u>1.5</u>
<u>Over 15 ft (4.6 m) and up to and including 20 ft (6.1 m)</u>	<u>I</u>	<u>No</u>	<u>1 Level</u>	<u>25.2.3.2.3.1(a)</u>	<u>Yes</u>	<u>1.0</u>
		<u>Yes</u>				<u>1.25</u>
	<u>II</u>	<u>No</u>		<u>25.2.3.2.3.1(b)</u>		<u>1.0</u>
		<u>Yes</u>				<u>1.25</u>
	<u>III</u>	<u>No</u>		<u>25.2.3.2.3.1(c)</u>		<u>1.0</u>
		<u>Yes</u>				<u>1.25</u>
	<u>IV</u>	<u>No</u>		<u>25.2.3.2.3.1(d)</u>		<u>1.0</u>
		<u>Yes</u>				<u>1.5</u>
<u>Over 20 ft (6.1 m) and up to and including 25 ft (7.6 m)</u>	<u>I</u>	<u>No</u>	<u>1 Level</u>	<u>25.2.3.2.3.1(a)</u>	<u>No</u>	<u>1.0</u>
		<u>Yes</u>				<u>1.25</u>
	<u>II</u>	<u>No</u>		<u>25.2.3.2.3.1(b)</u>		<u>1.0</u>
		<u>Yes</u>				<u>1.25</u>
	<u>III</u>	<u>No</u>		<u>25.2.3.2.3.1(c)</u>		<u>1.0</u>
		<u>Yes</u>				<u>1.25</u>
	<u>IV</u>	<u>No</u>	<u>2 Levels</u>	<u>25.2.3.2.3.1(d)</u>		<u>1.0</u>
		<u>Yes</u>	<u>2 Levels</u>			<u>1.5</u>

25.2.3.2.2.2

For multiple-row racks, having a rack depth over 16 ft (4.9 m) or aisles less than 8 ft (2.4 m) wide, storing Class I through Class IV commodities, encapsulated or nonencapsulated, over 12 ft (3.7 m) and up to and including 25 ft (7.6 m) in height, Table 25.2.3.2.2.2 shall be used to determine the appropriate figure for determining ceiling-level sprinkler design criteria with the provision of in-rack sprinklers.

Table 25.2.3.2.2.2 Determining Appropriate Ceiling-Level Protection Criteria Figure for Multiple-Row Racks of Class I Through Class IV Commodities — Rack Depth Over 16 ft (4.9 m) or Aisles Narrower than 8 ft (2.4 m), Storage Height Over 12 ft (3.7 m) Up to and Including 25 ft (7.6 m)

Storage Height	Commodity Class	Encapsulated	No. of In-Rack Sprinkler Levels	Appropriate Figure and Curves			
				Figure	Curves	Apply Figure 25.2.3.2.4.1	Density Multiplier
Over 12 ft (3.7 m) and up to and including 15 ft (4.6 m)	I	No	1 Level	25.2.3.2.3.1(a)	C and D	Yes	1.0
		Yes					1.25
	II	No		25.2.3.2.3.1(b)			1.0
		Yes					1.25
	III	No		25.2.3.2.3.1(c)			1.0
		Yes					1.25
	IV	No		25.2.3.2.3.1(d)			1.0
		Yes					1.5
Over 15 ft (4.6 m) and up to and including 20 ft (6.1 m)	I	No	1 Level	25.2.3.2.3.1(a)	C and D	Yes	1.0
		Yes					1.25
	II	No		25.2.3.2.3.1(b)			1.0
		Yes					1.25
	III	No		25.2.3.2.3.1(c)			1.0
		Yes					1.25
	IV	No		25.2.3.2.3.1(d)			1.0
		Yes					1.5
Over 20 ft (6.1 m) and up to and including 25 ft (7.6 m)	I	No	1 Level	25.2.3.2.3.1(a)	C and D	No	1.0
		Yes					1.25
	II	No		25.2.3.2.3.1(b)			1.0
		Yes					1.25
	III	No		25.2.3.2.3.1(c)			1.0
		Yes					1.25
	IV	No	2 Levels	25.2.3.2.3.1(d)			1.0
		Yes					1.5

25.2.3.2.3 Ceiling-Level Protection, Used in Combination with In-Rack Sprinklers, Criteria Figures.**25.2.3.2.3.1***

The ceiling-level sprinkler design criteria in terms of density [gpm/ft² (mm/min)] and area of sprinkler operation [ft² (m²)] of ceiling or roof sprinklers] obtained from the appropriate density/area curves of Figure 25.2.3.2.3.1(a) through Figure 25.2.3.2.3.1(g) shall be modified as appropriate by 25.2.3.2.4. These requirements shall apply to portable racks arranged in the same manner as single-, double-, or multiple-row racks. (See Section C.14.)

Figure 25.2.3.2.3.1(a) CMDA Sprinkler System Design Curves — 20 ft (6.1 m) High Rack Storage — Class I Nonencapsulated Commodities — Conventional Pallets.

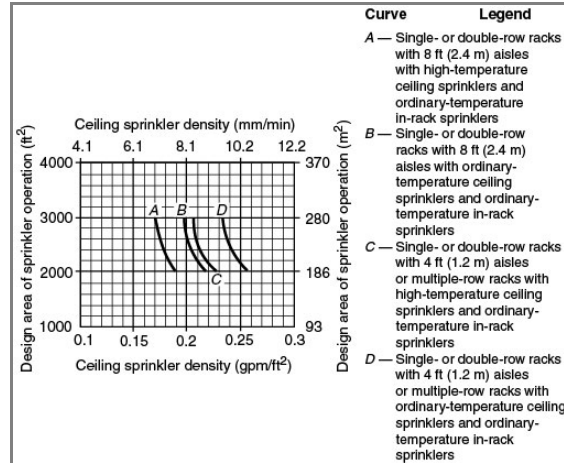


Figure 25.2.3.2.3.1(b) CMDA Sprinkler System Design Curves — 20 ft (6.1 m) High Rack Storage — Class II Nonencapsulated Commodities — Conventional Pallets.

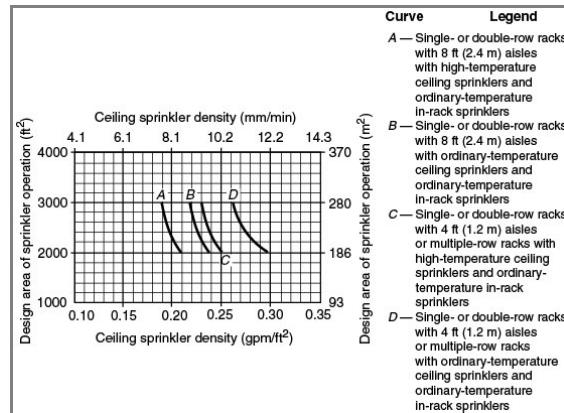


Figure 25.2.3.2.3.1(c) CMDA Sprinkler System Design Curves — 20 ft (6.1 m) High Rack Storage — Class III Nonencapsulated Commodities — Conventional Pallets.

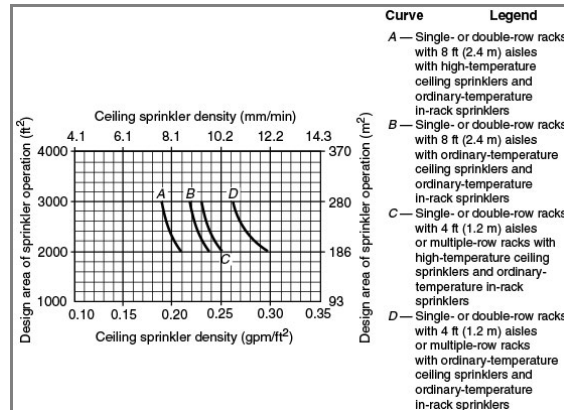


Figure 25.2.3.2.3.1(d) CMDA Sprinkler System Design Curves — 20 ft (6.1 m) High Rack Storage — Class IV Nonencapsulated Commodities — Conventional Pallets.

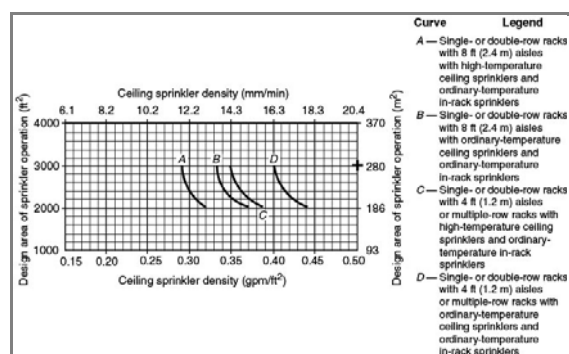


Figure 25.2.3.2.3.1(e) CMDA Sprinkler System Design Curves — Single- or Double-Row Racks — 20 ft (6.1 m) High Rack Storage — Class I and Class II Encapsulated Commodities — Conventional Pallets.

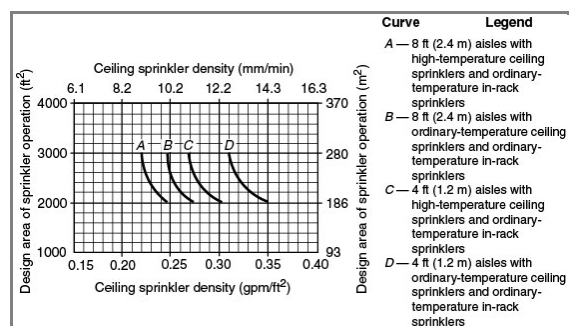


Figure 25.2.3.2.3.1(f) CMDA Sprinkler System Design Curves — Single- or Double-Row Racks — 20 ft (6.1 m) High Rack Storage — Class III Encapsulated Commodities — Conventional Pallets.

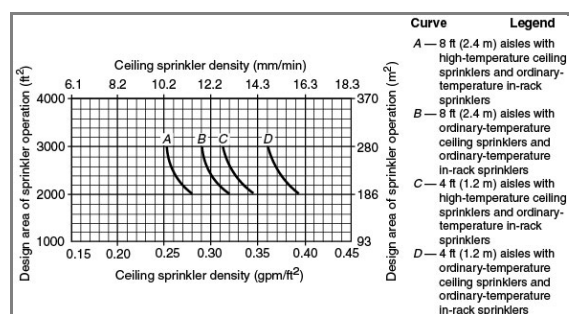
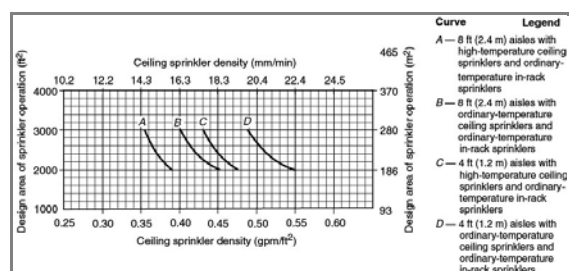


Figure 25.2.3.2.3.1(g) CMDA Sprinkler System Design Curves — Single- or Double-Row Racks — 20 ft (6.1 m) High Rack Storage — Class IV Encapsulated Commodities — Conventional Pallets.



A.25.2.3.2.3.1

Data indicate that the sprinkler protection criteria in Figure 25.2.3.2.3.1(a) through Figure 25.2.3.2.3.1(g) are ineffective, by themselves, for rack storage with solid shelves, if the required flue spaces are not maintained. Use of Figure 25.2.3.2.3.1(a) through Figure 25.2.3.2.3.1(g), along with the additional provisions that are required by this standard, can provide acceptable protection.

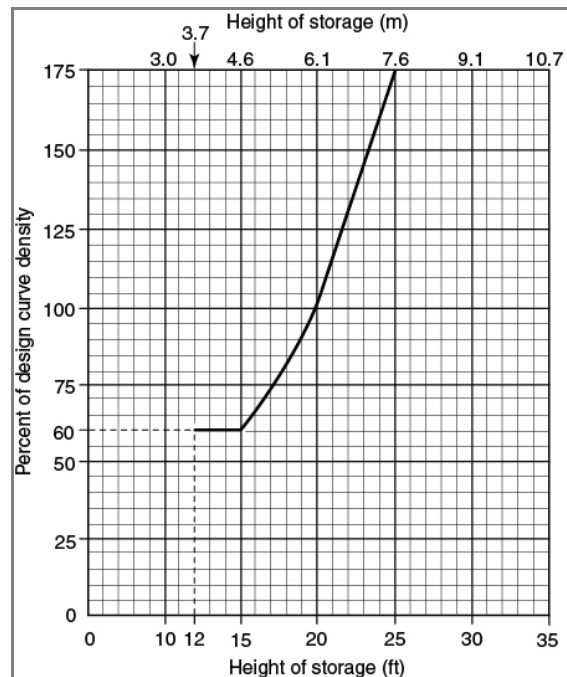
25.2.3.2.4* Ceiling Sprinkler Density Adjustments.**A.25.2.3.2.4**

The adjustments in [25.2.3.2.4](#) apply to solid shelves where the minimum required level of in-rack sprinklers from an open rack option is exceeded.

25.2.3.2.4.1

Where in-rack sprinklers are being installed within racks of Class I through Class IV commodities stored over 12 ft (3.7 m) up to and including 20 ft (6.1 m) protected with CMDA sprinklers at ceiling level along with the minimum number of required in-rack sprinkler levels, densities obtained from design curves shall be adjusted in accordance with [Figure 25.2.3.2.4.1](#).

Figure 25.2.3.2.4.1 Adjustment to Ceiling-Level Sprinkler Density Due to Storage Height.



25.2.3.2.4.2

Where in-rack sprinklers are being installed within racks of Class I through Class IV commodities stored over 12 ft (3.7 m) and up to and including 20 ft (6.1 m) in height protected with CMDA sprinklers at ceiling level along with more than one level of in-rack sprinklers, but not in every tier, densities obtained from design curves and adjusted in accordance with [Figure 25.2.3.2.4.1](#) shall be permitted to be reduced an additional 20 percent, as indicated in [Table 25.2.3.2.4.2](#) .

[Table 25.2.3.2.4.2 Adjustment to Ceiling-Level Sprinkler Density Due to Storage Height and In-Rack Sprinklers](#)

Storage Height	In-Rack Sprinklers	Apply Figure 25.2.3.2.4.1	Permitted Ceiling-Level Sprinkler Density Adjustment Due to In-Rack Sprinklers
Over 12 ft (3.7 m) and up to and including 20 ft (6.1 m)	Minimum required	Yes	None
	More than required but not in every tier	Yes	Reduce density 20% from that for minimum in-rack sprinklers
	Every tier level	Yes	Reduce density 40% from that for minimum in-rack sprinklers
Over 20 ft (6.1 m) and up to and including 25 ft (7.6 m)	Minimum required	No	None
	More than required but not in every tier	No	Reduce density 20% from that for minimum in-rack sprinklers
	Every tier level	No	Reduce density 40% from that for minimum in-rack sprinklers

25.2.3.2.4.3*

Where in-rack sprinklers are being installed within racks of Class I through Class IV commodities stored over 12 ft (3.7 m) and up to and including 20 ft (6.1 m) in height protected with CMDA sprinklers at ceiling level along with in-rack sprinklers at each tier level, densities obtained from design curves and adjusted in accordance with [Figure 25.2.3.2.4.1](#) shall be permitted to be reduced an additional 40 percent, as indicated in [Table 25.2.3.2.4.2](#) .

A.25.2.3.2.4.3

It is not the intent that an in-rack sprinkler be installed above the top-tier of storage when utilizing “in-rack sprinklers at each tier level.”

25.2.3.2.4.4

Where in-rack sprinklers are being installed within racks of Class I through Class IV commodities stored over 20 ft (6.1 m) and up to and including 25 ft (7.6 m) in height protected with CMDA sprinklers at ceiling level along with the minimum number of required in-rack sprinkler levels, densities obtained from design curves shall be used. Densities shall not be adjusted in accordance with [Figure 25.2.3.2.4.1](#) .

25.2.3.2.4.5

Where in-rack sprinklers are being installed within racks of Class I through Class IV commodities stored over 20 ft (6.1 m) and up to and including 25 ft (7.6 m) in height protected with CMDA sprinklers at ceiling level along with more than the minimum required level of in-rack sprinklers, but not in every tier, densities obtained from design curves shall be permitted to be reduced 20 percent, as indicated in [Table 25.2.3.2.4.2](#) . Densities shall not be adjusted in accordance with [Figure 25.2.3.2.4.1](#) for storage height.

25.2.3.2.4.6

Where in-rack sprinklers are being installed within racks of Class I through Class IV commodities stored over 20 ft (6.1 m) and up to and including 25 ft (7.6 m) in height protected with CMDA sprinklers at ceiling level along with in-rack sprinklers at each tier level, except above the top tier, densities obtained from design curves shall be permitted to be reduced 40 percent, as indicated in Table 25.2.3.2.4.2. Densities shall not be adjusted in accordance with Figure 25.2.3.2.4.1 for storage height.

25.2.3.3 Rack Storage of Class I Through Class IV Commodities Over 25 ft (7.6 m) in Height.**25.2.3.3.1* Single- and Double-Row Racks.**

Where in-rack sprinklers are being installed within single- and double-row racks separated by aisles at least 4 ft (1.2 m) wide and with a clearance to ceiling up to and including 10 ft (3.0 m) of Class I through Class IV commodities stored over 25 ft (7.6 m) in height protected by CMDA sprinklers at ceiling level, the ceiling sprinkler designs shall be in accordance with Table 25.2.3.3.1.

Table 25.2.3.3.1 CMDA Ceiling-Level Sprinkler Design Criteria for Single- or Double-Row Racks of Class I Through Class IV Commodities Stored Over 25 ft (7.6 m) in Height with Aisles 4 ft (1.2 m) or More in Width, Clearance to Ceiling Up to and Including 10 ft (3.0 m) Supplemented with In-Rack Sprinklers

Commodity Class	Applicable In-Rack Sprinkler Installation Figures	Encapsulated	Ceiling Sprinkler Density, Clearance to Ceiling Up to 10 ft (3.0 m)				Ceiling Sprinkler Operating Area	
			Ordinary Temperature		High Temperature		ft ²	m ²
			gpm/ft ²	mm/min	gpm/ft ²	mm/min		
I	25.9.2.2.1(a)–(b)	No	0.25	10.2	0.35	14.3	2000	186
		Yes	0.31	12.8	0.44	17.9		
I, II, III	25.9.2.2.1(c)–(g)	No	0.3	12.2	0.4	16.3		
		Yes	0.37	15.3	0.5	20.4		
I, II, III, IV	25.9.2.2.1(h)–(j)	No	0.35	14.2	0.45	18.3		
		Yes	0.44	17.8	0.56	22.8		

A.25.2.3.3.1

Water demand for storage height over 25 ft (7.6 m) on racks separated by aisles at least 4 ft (1.2 m) wide and with more than 10 ft (3.0 m) between the top of storage and the sprinklers should be based on sprinklers in a 2000 ft² (186 m²) operating area for double-row racks and a 3000 ft² (279 m²) operating area for multiple-row racks discharging a minimum of 0.18 gpm/ft² (7.3 mm/min) for Class I commodities, 0.21 gpm/ft² (8.5 mm/min) for Class II and Class III commodities, and 0.25 gpm/ft² (10.2 mm/min) for Class IV commodities for ordinary temperature-rated sprinklers or a minimum of 0.25 gpm/ft² (10.2 mm/min) for Class I commodities, 0.28 gpm/ft² (11.4 mm/min) for Class II and Class III commodities, and 0.32 gpm/ft² (13 mm/min) for Class IV commodities for high temperature-rated sprinklers. (See A.25.9.2.3.1.) Where such storage is encapsulated, ceiling sprinkler density should be 25 percent greater than for nonencapsulated storage. Data indicate that the sprinkler protection criteria in 25.2.3.3.1.1 are ineffective, by themselves, for rack storage with solid shelves if the required flue spaces are not maintained. Use of 25.2.3.3.1.1, along with the additional provisions that are required by this standard, can provide acceptable protection.

25.2.3.3.2 Multiple-Row Racks.

Where in-rack sprinklers are being installed within multiple-row racks separated by aisles at least 4 ft (1.2 m) wide and with a clearance to ceiling up to and including 10 ft (3.0 m) of Class I through Class IV commodities stored over 25 ft (7.6 m) in height protected by CMDA sprinklers at ceiling level, the ceiling sprinkler designs shall be in accordance with [Table 25.2.3.3.2](#).

Table 25.2.3.3.2 CMDA Ceiling-Level Sprinkler Design Criteria for Multiple-Row Racks of Class I Through Class IV Commodities Stored Over 25 ft (7.6 m) in Height, Clearance to Ceiling Up to and Including 10 ft (3.0 m) Supplemented with In-Rack Sprinklers

Commodity Class	Encapsulated	Maximum Allowable Storage Height Above Top In-Rack Sprinkler Level		Ceiling Sprinkler Density, Clearance to Ceiling Up to 10 ft (3.0 m)				Ceiling Sprinkler Operating Area	
				Ordinary Temperature		High Temperature			
		ft	m	gpm/ft²	mm/min	gpm/ft²	mm/min	ft²	m²
I	No	10	3.0	0.25	10.2	0.35	14.3	2000	186
	Yes			0.31	12.6	0.44	17.9		
I, II, III	No	10	3.0	0.3	12.2	0.4	16.3		
	Yes			0.37	15.1	0.5	20.4		
I, II, III, IV	No	5	1.5	0.35	14.2	0.45	18.3		
	Yes			0.44	17.9	0.56	22.8		

25.2.3.4 Rack Storage of Group A Plastic Commodities Stored Over 5 ft (1.5 m) and Up to and Including 25 ft (7.6 m) in Height.

25.2.3.4.1 Cartoned Group A Plastic Commodities.**25.2.3.4.1.1**

Where rack storage of cartoned Group A plastic commodities, encapsulated or nonencapsulated, having a clearance to ceiling up to and including 10 ft (3.0 m) is protected by in-rack sprinklers, ceiling-level sprinkler designs in terms of density [gpm/ft² (mm/min)] and area of operation [ft² (m²)] shall be selected from [Figure 25.9.3.1\(a\)](#) through [Figure 25.9.3.1\(e\)](#).

25.2.3.4.1.2

Linear interpolation of design densities and areas of application shall be permitted between storage heights with the same clearance to ceiling.

25.2.3.4.1.3

No interpolation between clearance to ceiling shall be permitted.

25.2.3.4.2 2 Exposed Nonexpanded Group A Plastic Commodities.

Where in-rack sprinkler protection is installed to protect rack storage of exposed nonexpanded Group A plastic commodities, encapsulated or nonencapsulated, stored over 5 ft (1.5 m) and up to and including 25 ft (7.6 m) in height protected by CMDA sprinklers at ceiling level, the ceiling sprinkler design shall be in accordance with one of the following:

- (1) Where in-rack sprinklers are installed in accordance with Figure 25.9.3.3(a) for storage up to 10 ft (3.0 m) high in a building up to 20 ft (6.1 m) high, the ceiling-level sprinkler design shall be a minimum 0.45 gpm/ft² (18.3 mm/min) density over a 2000 ft² (186 m²) demand area.
- (2) Where in-rack sprinklers are installed in accordance with Figure 25.9.3.3(b) for storage up to 10 ft (3.0 m) high in a building up to 20 ft (6.1 m) high, the ceiling-level sprinkler design shall be a minimum 0.30 gpm/ft² (12.2 mm/min) density over a 2000 ft² (186 m²) demand area.
- (3) Where in-rack sprinklers are installed in accordance with Figure 25.9.3.3(c) for storage up to 15 ft (4.6 m) high in a building up to 25 ft (7.6 m) high, the ceiling-level sprinkler design shall be a minimum 0.45 gpm/ft² (18.3 mm/min) density over a 2000 ft² (186 m²) demand area.
- (4) Where in-rack sprinklers are installed in accordance with Figure 25.9.3.3(d) for storage up to 15 ft (4.6 m) high in a building up to 25 ft (7.6 m) high, the ceiling-level sprinkler design shall be a minimum 0.30 gpm/ft² (12.2 mm/min) density over a 2000 ft² (186 m²) demand area.
- (5) Where in-rack sprinklers are installed in accordance with Figure 25.9.3.3(e) for storage up to 20 ft (6.1 m) high in a building up to 25 ft (7.6 m) high, the ceiling-level sprinkler design shall be a minimum 0.6 gpm/ft² (24.4 mm/min) density over a 2000 ft² (186 m²) demand area.
- (6) Where in-rack sprinklers are installed in accordance with Figure 25.9.3.3(f) for storage up to 20 ft (6.1 m) high in a building up to 25 ft (7.6 m) high, the ceiling-level sprinkler design shall be a minimum 0.45 gpm/ft² (18.3 mm/min) density over a 2000 ft² (186 m²) demand area.
- (7) Where in-rack sprinklers are installed in accordance with Figure 25.9.3.3(g) for storage up to 20 ft (6.1 m) high in a building up to 30 ft (9.1 m) high, the ceiling-level sprinkler design shall be a minimum 0.8 gpm/ft² (32.6 mm/min) density over a 1500 ft² (139 m²) demand area.
- (8) Where in-rack sprinklers are installed in accordance with Figure 25.9.3.3(h) for storage up to 20 ft (6.1 m) high in a building up to 30 ft (9.1 m) high, the ceiling-level sprinkler design shall be a minimum 0.6 gpm/ft² (24.4 mm/min) density over a 1500 ft² (139 m²) demand area.
- (9) Where in-rack sprinklers are installed in accordance with Figure 25.9.3.3(i) for storage up to 20 ft (6.1 m) high in a building up to 30 ft (9.1 m) high, the ceiling-level sprinkler design shall be a minimum 0.30 gpm/ft² (12.2 mm/min) density over a 2000 ft² (186 m²) demand area.
- (10) Where in-rack sprinklers are installed in accordance with Figure 25.9.3.3(j) for storage up to 25 ft (7.6 m) high in a building up to 35 ft (10.7 m) high, the ceiling-level sprinkler design shall be a minimum 0.8 gpm/ft² (32.6 mm/min) density over a 1500 ft² (139 m²) demand area.
- (11) Where in-rack sprinklers are installed in accordance with Figure 25.9.3.3(k) for storage up to 25 ft (7.6 m) high in a building up to 35 ft (10.7 m) high, the ceiling-level sprinkler design shall be a minimum 0.30 gpm/ft² (12.2 mm/min) density over a 2000 ft² (186 m²) demand area.

25.2.3.5* Rack Storage of Group A Plastic Commodities Stored Over 25 ft (7.6 m) in Height.

Where rack storage of Group A plastic commodities, encapsulated or nonencapsulated, over 25 ft (7.6 m) in height are protected by in-rack sprinklers in accordance with 25.9.4, ceiling-level sprinkler designs, in terms of density $[gpm/ft^2 \text{ (mm/min)}]$ and area of operation $[ft^2 \text{ (m}^2\text{)}]$, shall be selected from Table 25.2.3.5 based on the storage height of commodity above the top level of in-rack sprinklers.

Table 25.2.3.5 CMDA Ceiling-Level Sprinkler Design Criteria for Rack Storage of Group A Plastic Commodities with Storage Over 25 ft (7.6 m) in Height, Clearance to Ceiling Up to and Including 10 ft (3.0 m) Supplemented with In-Rack Sprinklers

Storage Height Above Top Level of In-Rack Sprinklers		Ceiling-Level Sprinkler Design Criteria	
ft	m	$\frac{gpm}{ft^2} \text{ over } \frac{ft^2}{ft^2}$	$\frac{mm/min \text{ over } m^2}{m^2}$
Up to and including 5 ft	Up to and including 1.5 m	0.30/2000	12.2/186
Over 5 ft and up to and including 10 ft	Over 1.5 m and up to and including 3.0 m	0.45/2000	18.3/186

A.25.2.3.5

In this application ordinary-, intermediate-, or high-temperature ceiling-level sprinklers can be used. There are no data to support temperature rating restrictions for this section.

25.2.3.6 Rack Storage of Rubber Tires Stored Over 12 ft (3.7 m) in Height.

25.2.3.6.1 General.

The requirements of Chapter 20 shall apply unless modified in this section.

25.2.3.6.2 Ceiling Systems.

Where rack storage of rubber tires on pallets, either on-side or on-tread, over 5 ft (1.5 m) and up to and including 20 ft (6.1 m) in height protected by CMDA sprinklers at ceiling level with a maximum clearance to ceiling of 10 ft (3.0 m) along with one level of in-rack sprinklers, the ceiling-level sprinkler system design density and area of application shall be a minimum $0.40 \text{ gpm/ft}^2 \text{ (16.3 mm/min)}$ density over a $3000 \text{ ft}^2 \text{ (279 m}^2\text{)}$ demand area. (See A.21.6.)

25.2.3.6.3 Reduced-Discharge Density.

Where high-expansion foam systems are installed in accordance with NFPA 11 to protect rack storage of rubber tires, either on-side or on-tread, over 5 ft (1.5 m) and up to and including 20 ft (6.1 m) in height protected by CMDA sprinklers at ceiling level with a maximum clearance to ceiling of 10 ft (3.0 m) and one level of in-rack sprinklers, the ceiling-level sprinkler system design density shall be permitted to be reduced from $0.40 \text{ gpm/ft}^2 \text{ (16.3 mm/min)}$ to $0.24 \text{ gpm/ft}^2 \text{ (9.8 mm/min)}$.

25.2.3.6.4 Water Supplies.

Total water supplies shall be capable of providing flow for automatic sprinklers, hose streams, and foam systems (if provided) for the duration required in Table 20.12.2.6.

25.2.4 CMSA Ceiling-Level Sprinkler Design Criteria in Combination with In-Rack Sprinklers.

25.2.4.1 General.

25.2.4.1.1 Open Wood Joist Construction with CMSA Sprinklers at Ceiling Level.

25.2.4.1.1.1

Where CMSA sprinklers are installed under open wood joist construction, firestopping in accordance with 25.2.4.1.1.2 shall be provided or the minimum operating pressure of the sprinklers shall be 50 psi (3.4 bar) for a K-11.2 (160) sprinkler or 22 psi (1.5 bar) for a K-16.8 (240) sprinkler.

25.2.4.1.1.2

Where each joist channel of open wood joist construction is fully firestopped to its full depth at intervals not exceeding 20 ft (6.1 m), the lower pressures specified in Table 25.2.4.2.1 shall be permitted to be used.

25.2.4.1.2 Preaction Systems for CMSA Sprinklers.

For the purpose of using [Table 25.2.4.2.1](#), preaction systems shall be classified as dry pipe systems.

25.2.4.2 Rack Storage of Class I Through Class IV Commodities.**25.2.4.2.1**

Where rack storage of Class I through Class IV commodities is protected by CMSA sprinklers at ceiling level along with one level of in-rack sprinklers, the ceiling-level sprinkler design criteria shall be in accordance with [Table 25.2.4.2.1](#).

[Table 25.2.4.2.1](#) CMSA Ceiling-Level Sprinkler Design Criteria for Rack Storage of Class I Through Class IV Commodities (Encapsulated and Nonencapsulated) Supplemented with In-Rack Sprinklers

Storage Arrangement	Commodity Class	Maximum Storage Height		Maximum Ceiling/Roof Height		K-Factor/Orientation	Type of System	No. of Ceiling Sprinklers in the Design	No. of Required Levels In-Rack Sprinklers
		ft	m	ft	m				
Single-, double-, and multiple-row racks (no open-top containers)	I or II	30	9.1	35	10.7	11.2 (160) Upright	Wet	20	One level
							Dry	30	One level
						16.8 (240) Upright	Wet	20	One level
							Dry	30	One level
	III	25	7.6	30	9.1	11.2 (160) Upright	Wet	15	One level
						16.8 (240) Upright	Dry	25	One level
				35	10.7	11.2 (160) Upright	Wet	15	One level
							Dry	25	One level
						16.8 (240) Upright	Wet	15	One level
							Dry	25	One level
	IV	25	7.6	30	9.1	11.2 (160) Upright	Wet	15	One level
						11.2 (160) Upright	Wet	20	One level
				35	10.7			15	One level
						16.8 (240) Upright	Wet	20	One level
								15	One level
						16.8 (240) Upright	Wet	15	One level

25.2.4.2.2

Protection shall be provided as specified in [Table 25.2.4.2.1](#) or appropriate NFPA standards in terms of minimum operating pressure and the number of ceiling-level sprinklers to be included in the design area.

25.2.4.3 Rack Storage of Group A Plastic Commodities.

25.2.4.3.1

Where rack storage of nonexpanded, cartoned and exposed, Group A plastic commodities is protected by CMSA sprinklers at ceiling level along with one level of in-rack sprinklers, the ceiling-level sprinkler system design criteria shall be in accordance with [Table 25.2.4.3.1](#).

Table 25.2.4.3.1 CMSA Ceiling-Level Sprinkler Design Criteria for Rack Storage of Group A Plastic Commodities Stored Up to and Including 25 ft (7.6 m) in Height Supplemented with In-Rack Sprinklers

<u>Storage Arrangement</u>	<u>Commodity Class</u>	<u>Maximum Storage Height</u>		<u>Maximum Ceiling/Roof Height</u>		<u>K-Factor/Orientation</u>	<u>Type of System</u>	<u>No. of Ceiling Sprinklers in the Design</u>	<u>No. of Required Levels of In-Rack Sprinklers</u>
		<u>ft</u>	<u>m</u>	<u>ft</u>	<u>m</u>				
<u>Single-, double-, and multiple-row racks (no open-top containers)</u>	<u>Cartoned nonexpanded plastics and exposed nonexpanded plastics</u>	<u>25</u>	<u>7.6</u>	<u>30</u>	<u>9.1</u>	<u>11.2 (160) upright</u>	<u>Wet</u>	<u>15</u>	<u>One level</u>
				<u>35</u>	<u>10.7</u>	<u>11.2 (160) upright</u>	<u>Wet</u>	<u>30</u>	<u>One level</u>
							<u>Wet</u>	<u>20</u>	<u>One level</u>
						<u>16.8 (240) upright</u>	<u>Wet</u>	<u>30</u>	<u>One level</u>
							<u>Wet</u>	<u>20</u>	<u>One level</u>

25.2.4.3.2

Protection shall be provided as specified in [Table 25.2.4.3.1](#) or appropriate NFPA standards in terms of minimum operating pressure and the number of ceiling-level sprinklers to be included in the design area.

25.2.5 ESFR Ceiling-Level Sprinkler Design Criteria in Combination with In-Rack Sprinklers.**25.2.5.1 Rack Storage of Class I Through Class IV and Group A Plastic Commodities.****25.2.5.1.1**

Where rack storage of Class I through Class IV and Group A plastic commodities is protected by ESFR sprinklers at ceiling level along with one level of in-rack sprinklers, the ceiling-level sprinkler design criteria shall be in accordance with [Table 25.2.5.1.1](#).

Table 25.2.5.1.1 ESFR Ceiling-Level Sprinkler Design Criteria for Rack Storage of Class I Through Class IV and Group A Plastic Commodities (Encapsulated and Nonencapsulated) Supplemented with In-Rack Sprinklers

<u>Storage Arrangement</u>	<u>Commodity Class</u>	<u>Maximum Storage Height</u>		<u>Maximum Ceiling/Roof Height</u>		<u>K-Factor</u>	<u>Orientation</u>	<u>No. of Ceiling Sprinklers in the Design</u>	<u>No. of Required Levels of In-Rack Sprinklers</u>
		<u>ft</u>	<u>m</u>	<u>ft</u>	<u>m</u>				
<u>Single-, double-, and multiple-row racks (no open-top containers)</u>	<u>Class I, II, III or IV, encapsulated or nonencapsulated, cartoned nonexpanded and exposed nonexpanded plastics</u>	<u>25</u>	<u>7.6</u>	<u>45</u>	<u>13.7</u>	<u>14.0 (200)</u>	<u>Pendent</u>	<u>12</u>	<u>One level</u>
						<u>16.8 (240)</u>	<u>Pendent</u>	<u>12</u>	<u>One level</u>

25.2.5.1.2

ESFR sprinkler systems, when supplemented with in-rack sprinklers, shall be designed such that the minimum operating pressure is not less than that indicated in [Table 25.2.5.1.1](#) for type of storage, commodity, storage height, and building height involved.

25.2.5.1.3

The design area applicable to the ceiling-level design options listed in Table 25.2.5.1.1 shall consist of the most hydraulically demanding area of 12 sprinklers, consisting of 4 sprinklers on each of three branch lines.

25.3 In-Rack Sprinkler Characteristics.

25.3.1

In-rack sprinklers shall be pendent or upright, standard- or quick-response, ordinary-temperature-rated and have a nominal K-factor of K-5.6 (80), K-8.0 (115), or K-11.2 (160).

25.3.2

In-rack sprinklers protecting open rack storage where ESFR sprinklers are installed at ceiling level shall be quick-response, ordinary-temperature-rated, and either K-8.0 (115) or K-11.2 (160).

25.3.3

In-rack sprinklers with intermediate- and high-temperature ratings shall be used near heat sources as required by 9.4.2 .

25.3.4

In-rack sprinklers shall be permitted to have a different RTI rating from the ceiling sprinklers under which they are installed.

25.3.5 In-Rack Sprinkler Water Shields.

25.3.5.1 In-Rack Sprinkler Water Shields for Storage of Class I Through Class IV Commodities.

Water shields shall be provided directly above in-rack sprinklers, or listed intermediate level/rack storage sprinklers shall be used where there is more than one level, if not shielded by horizontal barriers. (See Section C.3 .)

25.3.5.2 In-Rack Sprinkler Water Shields for Group A Plastic Storage.

Where in-rack sprinklers are not shielded by horizontal barriers, water shields shall be provided above the sprinklers, or listed intermediate level/rack storage sprinklers shall be used.

25.4 Vertical Spacing and Location of In-Rack Sprinklers.

25.4.1

In-rack sprinklers shall not be required to meet the obstruction criteria and clearance from storage requirements of Section 9.5 .

25.4.2

A minimum 6 in. (150 mm) vertical clear space shall be maintained between in-rack sprinkler deflectors and the top of storage located below them.

25.4.2.1*

Where in-rack sprinklers are being installed within single- and double-row racks of Class I through Class IV commodities up to and including 20 ft (6.1 m) in height, the vertical clear space of in-rack sprinkler deflectors with respect to the top of storage located below them shall be permitted to be less than 6 in. (150 mm). (See Section C.16 .)

A.25.4.2.1

Where possible, it is recommended that in-rack sprinkler deflectors be located at least 6 in. (150 mm) vertically above the top of storage located below them.

25.4.3

In-rack sprinkler discharge shall not be obstructed by horizontal rack members

25.4.4*

Where one level of in-rack sprinklers are required by the guidelines of this chapter and the vertical location of the in-rack sprinklers is not indicated in an applicable figure, in-rack sprinklers shall be installed at the first tier level at or above one-half of the highest expected storage height.

A.25.4.4

Where one level of in-rack sprinklers are required by the guidelines in Chapter 25, in-rack sprinklers for multiple-row rack storage up to and including 25 ft (7.6 m) of Class I through Class IV commodities should be installed at the first tier level nearest one-half to two-thirds of the highest expected storage height.

25.4.5

Where two levels of in-rack sprinklers are required by the guidelines of this chapter and the vertical location of the in-rack sprinklers is not indicated in an applicable figure, in-rack sprinklers shall be installed at the first tier level at or above one-third and two-thirds of the highest expected storage height.

25.4.6 Maximum Storage Height Above Top In-Rack Sprinkler Level.

25.4.6.1

Where in-rack sprinklers are required for single- and double-row rack storage of Class I through Class IV commodities over 25 ft (7.6 m) in height and protected by CMDA sprinklers at ceiling level, storage above the top level of in-rack sprinklers shall not exceed 10 ft (3.0 m).

25.4.6.2

Where in-rack sprinklers are required for multiple-row rack storage of Class I through Class IV commodities over 25 ft (7.6 m) in height and protected by CMDA sprinklers at ceiling level, storage above the top level of in-rack sprinklers shall not exceed 10 ft (3.0 m) for Class I, Class II, or Class III commodities or 5 ft (1.5 m) for Class IV commodities.

25.4.6.3

Where in-rack sprinklers are required for rack storage of Group A plastic commodities over 25 ft (7.6 m) in height and protected by CMDA sprinklers at ceiling level, storage above the top level of in-rack sprinklers shall not exceed 10 ft (3.0 m).

25.4.7 Staggering of In-Rack Sprinklers for Class I Through Class IV Commodities Over 25 ft (7.6 m) in Height.

25.4.7.1

Where single-, double-, and multiple-row rack storage of Class I through Class IV commodities is over 25 ft (7.6 m) in height and protected by CMDA sprinklers at ceiling level, in-rack sprinklers shall be staggered vertically where installed in accordance with Table 25.9.2.1.1, Figure 25.9.2.2.1(a) through Figure 25.9.2.2.1(j), and Figure 25.9.2.1.1(a) through Figure 25.9.2.1.1(e).

25.5 Horizontal Location and Spacing of In-Rack Sprinklers.

25.5.1 Horizontal Location of In-Rack Sprinklers.

25.5.1.1

In-rack sprinklers shall not be required to meet the obstruction criteria and clearance from storage requirements of Section 9.5.

25.5.1.2*

Where in-rack sprinklers are installed in longitudinal flues, they shall be located at an intersection of transverse and longitudinal flues while not exceeding the maximum horizontal spacing rules.

A.25.5.1.2

In-rack sprinklers have proven to be the most effective way to fight fires in rack storage. To accomplish this, however, in-rack sprinklers must be located where they will operate early in a fire as well as direct water where it will do the most good. Simply maintaining a minimum horizontal spacing between sprinklers does not achieve this goal. This is because fires in rack storage develop and grow in transverse and longitudinal flues, and in-rack sprinklers do not operate until flames actually impinge on them. To ensure early operation and effective discharge, in-rack sprinklers in the longitudinal flue of open racks must be located at transverse flue intersections.

25.5.1.3

Where horizontal distances between transverse flues exceed the maximum allowable horizontal linear spacing for in-rack sprinklers, in-rack sprinklers shall be installed at the intersection of the transverse and longitudinal flues, and additional in-rack sprinklers shall be installed between transverse flues to meet the maximum allowable horizontal linear spacing rules for in-rack sprinklers.

25.5.1.4

Where no transverse flues exist, horizontal spacing of in-rack sprinklers shall not exceed the maximum allowable spacing rules.

25.5.1.5

Where in-rack sprinklers are installed to protect a higher-hazard commodity that occupies only a portion of the length of a rack, in-rack sprinklers shall be extended a minimum of 8 ft (2.4 m) or one bay, whichever is greater, in each direction along the rack on either side of the higher hazard. The in-rack sprinklers protecting the higher hazard shall not be required to extend across the aisle.

25.5.1.6*

Where rack storage is over 25 ft (7.6 m) in height, in-rack sprinklers shall be a minimum 3 in. (75 mm) radially from the side of rack uprights.

A.25.5.1.6

Where rack storage is up to and including 25 ft (7.6 m) in height, in-rack sprinklers should be a minimum 3 in. (75 mm) radially from the side of rack uprights.

25.5.1.6.1

Where rack storage of Class I through Class IV commodities is up to and including 25 ft (7.6 m), in-rack sprinklers shall be permitted to be installed horizontally without regard to rack uprights. (See Section C.17.)

25.5.1.7

Where rack storage is over 25 ft (7.6 m) in height and requires face sprinklers, the face sprinklers shall be located within the rack a minimum 3 in. (75 mm) from rack uprights and no more than 18 in. (450 mm) from the aisle face of storage.

25.5.1.8

Where single- and double-row rack storage of Class I through Class IV commodities is over 25 ft (7.6 m) in height and protected by CMDA sprinklers at ceiling level, in-rack sprinklers shall be staggered horizontally where installed in accordance with Table 25.9.2.1.1 and Figure 25.9.2.1.1(a) through Figure 25.9.2.1.1(e) for single-row racks or Table 25.9.2.2.1 and Figure 25.9.2.2.1(a) through Figure 25.9.2.2.1(j) for double-row racks.

25.5.1.9

Where multiple-row rack storage of Class I through Class IV commodities is over 25 ft (7.6 m) in height and protected by CMDA sprinklers at ceiling level, in-rack sprinklers shall be staggered horizontally where installed in accordance with Table 25.9.2.3.1 and Figure 25.9.2.3.1(a) through Figure 25.9.2.3.1(c).

25.5.1.10

Where rack storage of Group A plastic commodities is over 25 ft (7.6 m) in height, in-rack sprinklers in longitudinal flues shall be installed with the deflector located at or below the bottom of horizontal load beams or above or below other adjacent horizontal rack members.

25.5.2 Horizontal Spacing of In-Rack Sprinklers.**25.5.2.1 General.****25.5.2.1.1**

Unless specified elsewhere in this standard, the maximum allowable horizontal spacing of in-rack sprinklers shall be in accordance with 25.5.2.1.2 through 25.5.2.1.4.

25.5.2.1.2

In-rack sprinklers shall be permitted to be installed horizontally less than 6 ft (1.8 m) apart.

25.5.2.1.3

For rack storage of rubber tires, the maximum allowable horizontal spacing of in-rack sprinklers shall be 8 ft (2.4 m).

25.5.2.1.4

The maximum allowable horizontal spacing of in-rack sprinklers for Class IV and Group A plastic commodities in miscellaneous, low-piled, and rack storage shall be 10 ft (3.0 m).

25.5.2.2 CMDA Sprinklers Installed at Ceiling Level.**25.5.2.2.1***

Where single- and double-row rack storage of Class I through Class IV commodities is up to and including 25 ft (7.6 m) in height and protected by CMDA sprinklers at ceiling level, the maximum allowable horizontal spacing of in-rack sprinklers shall be in accordance with Table 25.5.2.2.1.

Table 25.5.2.2.1 In-Rack Sprinkler Horizontal Spacing for Class I, II, III, and IV Commodities Stored in Single- or Double-Row Racks Up to 25 ft (7.6 m) in Height Protected by CMDA Sprinklers at Ceiling Level

<u>Commodity Class</u>	<u>Aisle Width</u>		<u>Encapsulated</u>	<u>Maximum Allowable Linear Spacing</u>	
	<u>ft</u>	<u>m</u>		<u>ft</u>	<u>m</u>
<u>I, II</u>	<u>8</u>	<u>2.4</u>	<u>No</u>	<u>12</u>	<u>3.7</u>
			<u>Yes</u>	<u>8</u>	<u>2.4</u>
	<u>4</u>	<u>1.2</u>	<u>No</u>	<u>12</u>	<u>3.7</u>
			<u>Yes</u>	<u>8</u>	<u>2.4</u>
<u>III</u>	<u>8</u>	<u>2.4</u>	<u>No</u>	<u>12</u>	<u>3.7</u>
			<u>Yes</u>	<u>8</u>	<u>2.4</u>
	<u>4</u>	<u>1.2</u>	<u>No</u>	<u>10</u>	<u>3</u>
			<u>Yes</u>	<u>8</u>	<u>2.4</u>
<u>IV</u>	<u>8</u>	<u>2.4</u>	<u>No</u>	<u>10</u>	<u>3</u>
			<u>Yes</u>	<u>8</u>	<u>2.4</u>
	<u>4</u>	<u>1.2</u>	<u>No</u>	<u>10</u>	<u>3</u>
			<u>Yes</u>	<u>8</u>	<u>2.4</u>

A.25.5.2.2.1

Spacing of sprinklers on branch lines in racks in the various tests demonstrates that maximum spacing as specified is proper.

25.5.2.2.2

Where multiple-row rack storage of Class I through Class IV commodities is up to and including 25 ft (7.6 m) in height and protected by CMDA sprinklers at ceiling level, the maximum allowable horizontal spacing of in-rack sprinklers shall be in accordance with [Table 25.5.2.2.2](#).

Table 25.5.2.2.2 In-Rack Sprinkler Horizontal Spacing for Class I, II, III, and IV Commodities Stored in Multiple-Row Racks Up to 25 ft (7.6 m) in Height Protected by Control Mode Density/Area Sprinklers at Ceiling Level

<u>Commodity Class</u>	<u>Linear Spacing</u>		<u>Area Spacing</u>	
	<u>ft</u>	<u>m</u>	<u>ft²</u>	<u>m²</u>
<u>I, II, III</u>	<u>12</u>	<u>3.7</u>	<u>100</u>	<u>9.3</u>
<u>IV</u>	<u>8</u>	<u>2.4</u>	<u>80</u>	<u>7.4</u>

(A)

The rack plan view shall be considered in determining the area covered by each sprinkler.

(B)

The aisles shall not be included in area calculations.

25.5.2.2.3*

For horizontal spacing of in-rack sprinklers not addressed by [25.5.2.2.1](#) or [25.5.2.2.2](#), the maximum allowable horizontal spacing of in-rack sprinklers shall be in accordance with [Table 25.5.2.2.3](#).

Table 25.5.2.2.3 Horizontal Spacing for In-Rack Sprinklers in Combination with CMDA Ceiling Sprinklers That Are Represented by Figures

<u>Commodity Class</u>	<u>Storage Rack Type</u>	<u>Storage Height</u>		<u>Applicable Table and/or Figure for Horizontal Spacing of In-Rack Sprinklers</u>
		<u>ft</u>	<u>m</u>	
<u>Class I through IV</u>	<u>Single-row</u>	<u>Over 25</u>	<u>Over 7.6</u>	<u>Table 25.9.2.1.1 and Figures 25.9.2.1.1(a)–(e)</u>
	<u>Double-row</u>	<u>Over 25</u>	<u>Over 7.6</u>	<u>Table 25.9.2.2.1 and Figures 25.9.2.2.1(a)–(j)</u>
	<u>Multiple-row</u>	<u>Over 25</u>	<u>Over 7.6</u>	<u>Table 25.9.2.3.1 and Figures 25.9.2.3.1(a)–(c)</u>
<u>Group A plastics</u>	<u>Single-, double-, and multiple-row</u>	<u>Up to 25</u>	<u>Up to 7.6</u>	<u>Figures 25.9.3.1(a)–(e)</u>
<u>Group A plastics, cartoned</u>	<u>Single-row</u>	<u>Over 25</u>	<u>Over 7.6</u>	<u>Figures 25.9.4.1.1(a)–(d)</u>
	<u>Double-row</u>	<u>Over 25</u>	<u>Over 7.6</u>	<u>Figures 25.9.4.2.1(a)–(c)</u>
	<u>Multiple-row</u>	<u>Over 25</u>	<u>Over 7.6</u>	<u>Figures 25.9.4.3.1(a)–(f)</u>
<u>Group A plastics, exposed nonexpanded</u>	<u>Single-row, maximum 3 ft (0.9 m) deep</u>	<u>Over 25</u>	<u>Over 7.6</u>	<u>Figure 25.9.4.1.3</u>
	<u>Multiple-row</u>	<u>Over 25</u>	<u>Over 7.6</u>	<u>Figures 25.9.4.3.1(a)–(f)</u>

A.25.5.2.2.3

The protection area per sprinkler under barriers should be no greater than 80 ft² (7.4 m²) in [Figure 25.9.4.3.1\(a\)](#) and [Figure 25.9.4.3.1\(b\)](#). The protection area per sprinkler under barriers should be no greater than 50 ft² (4.6 m²) in [Figure 25.9.4.3.1\(c\)](#) through [Figure 25.9.4.3.1\(f\)](#).

25.5.2.3 CMSA Sprinklers Installed at Ceiling Level.

25.5.2.3.1

Where rack storage of Class I through Class IV commodities is up to and including 25 ft (7.6 m) in height and protected by CMSA sprinklers at ceiling level, the maximum allowable horizontal spacing of in-rack sprinklers shall be 8 ft (2.4 m).

25.5.2.3.2

Where rack storage of plastic commodities is up to and including 25 ft (7.6 m) in height and protected by CMSA sprinklers at ceiling level, the maximum allowable horizontal spacing of in-rack sprinklers shall be 5 ft (1.5 m).

25.5.2.3.3

Where rack storage of Class I through Class IV commodities is over 25 ft (7.6 m) in height and protected by CMSA sprinklers at ceiling level, the maximum allowable horizontal spacing of in-rack sprinklers shall be 5 ft (1.5 m).

25.5.2.4 ESFR Sprinklers Installed at Ceiling Level.

Where rack storage is protected by ESFR sprinklers at ceiling level, the maximum allowable horizontal spacing of in-rack sprinklers shall be 5 ft (1.5 m).

25.6 Protection of Racks with Solid Shelves.

25.6.1 General.

The requirements in this chapter for the installation of in-rack sprinklers shall apply to racks with solid shelves except as modified in this section.

25.6.2

Ceiling-level sprinkler design criteria for CMDA, CMSA, and ESFR sprinklers shall be an applicable option for open racks combined with in-rack sprinklers installed in accordance with the criteria for solid shelving.

25.6.3 Vertical Spacing and Location of In-Rack Sprinklers in Racks with Solid Shelves.

25.6.3.1

Where CMDA sprinklers are at ceiling level protecting racks with solid shelving that exceeds 20 ft $\frac{2}{3}$ (1.9 m $\frac{2}{3}$) in area but not 64 ft $\frac{2}{3}$ (5.9 m $\frac{2}{3}$), in-rack sprinklers shall not be required below every shelf but shall be installed below shelves at intermediate levels not more than 6 ft (1.8 m) apart vertically. (See Section C.11.)

25.6.3.2

Where CMDA sprinklers are at ceiling level protecting racks with solid shelving that exceeds 64 ft $\frac{2}{3}$ (5.9 m $\frac{2}{3}$) in area or where the levels of storage exceed 6 ft (1.8 m), in-rack sprinklers shall be installed below each level of shelving.

25.6.3.3

Where CMSA sprinklers are at ceiling level and protect racks with solid shelving, in-rack sprinklers shall be installed beneath all tiers under the highest solid shelf.

25.6.3.4

Where ESFR sprinklers are at ceiling level and protect racks with solid shelving, in-rack sprinklers shall be installed beneath all tiers under the highest solid shelf.

25.6.3.5

Where racks with solid shelves obstruct only a portion of an open rack, in-rack sprinklers shall be installed vertically as follows:

- (1) In accordance with 25.6.3.1 and 25.6.3.2 where CMDA sprinklers are installed at ceiling level
- (2) In accordance with 25.6.3.3 where CMSA sprinklers are installed at ceiling level
- (3) In accordance with 25.6.3.4 where ESFR sprinklers are installed at ceiling level

25.6.4 Horizontal Location and Spacing of In-Rack Sprinklers in Racks with Solid Shelves.

25.6.4.1

Where racks with solid shelves contain storage of Class I through Class IV commodities, the maximum allowable horizontal spacing of in-rack sprinklers shall be 10 ft (3.0 m).

25.6.4.2

Where racks with solid shelves contain storage of Group A plastic commodities, the maximum allowable horizontal spacing of in-rack sprinklers shall be 5 ft (1.5 m).

25.6.4.3

Where racks with solid shelves obstruct only a portion of an open rack, in-rack sprinklers shall be extended beyond the end of the solid shelf a minimum of 4 ft (1.2 m) to the nearest flue space intersection.

25.7 Horizontal Barriers in Combination with In-Rack Sprinklers.**25.7.1***

Where required by sections of this chapter, horizontal barriers used in combination with in-rack sprinklers to impede vertical fire development shall be constructed of sheet metal, wood, or similar material and shall extend the full length and depth of the rack.

A.25.7.1

Barriers should be of sufficient strength to avoid sagging that interferes with loading and unloading operations.

25.7.2

Barriers shall be fitted within 2 in. (50 mm) horizontally around rack uprights.

25.8 Alternative In-Rack Sprinkler Protection Options That Are Independent of the Ceiling Sprinkler Design.**25.8.1 In-Rack Sprinkler Protection for Class I Through Class IV and Group A Plastic Commodities That Are Independent of the Ceiling Sprinkler Design, Option 1.****25.8.1.1**

Where Class I, II, III, IV, and Group A plastic commodities are protected in accordance with the guidelines of this section, the in-rack sprinkler system shall not be required to be hydraulically balanced with the ceiling-level sprinkler system.

25.8.1.2

Where a storage rack will not be solely dedicated to the in-rack sprinkler system outlined in this section, either of the following shall apply:

- (1) Extend the protection outlined in this section horizontally one pallet load in all directions beyond the commodity storage area that is being protected by the alternative in-rack sprinkler arrangement.
- (2) Install a vertical barrier to segregate the commodities that are being protected by the alternative in-rack sprinkler arrangement.

25.8.1.3

Where a storage rack is partially protected by the in-rack sprinkler system outlined in this section, commodities that can be protected by the ceiling-level sprinkler system shall be permitted to be stored vertically above and horizontally adjacent to the portions of the storage rack protected in accordance with this section.

25.8.1.4 Horizontal Barriers for Alternative In-Rack Sprinkler Protection Option 1.**25.8.1.4.1**

The barrier shall be constructed of minimum 22 gauge (0.8 mm) sheet metal or of minimum $\frac{3}{8}$ in. (10 mm) plywood.

25.8.1.4.2

The barrier shall span horizontally to both aisle faces of the rack, covering up all flue spaces of the rack bays in which they are installed.

25.8.1.4.3

A maximum 3 in. (75 mm) wide horizontal gap shall be permitted at rack uprights or other equipment that would create an opening, such as vertical in-rack sprinkler pipe drops.

25.8.1.4.4

Where the dedicated storage is in open racks, horizontal barriers shall be installed at vertical increments not exceeding 12 ft (3.6 m).

25.8.1.4.5

Where the dedicated storage is in racks with solid shelves, horizontal barriers shall be installed at every tier level of the dedicated storage rack.

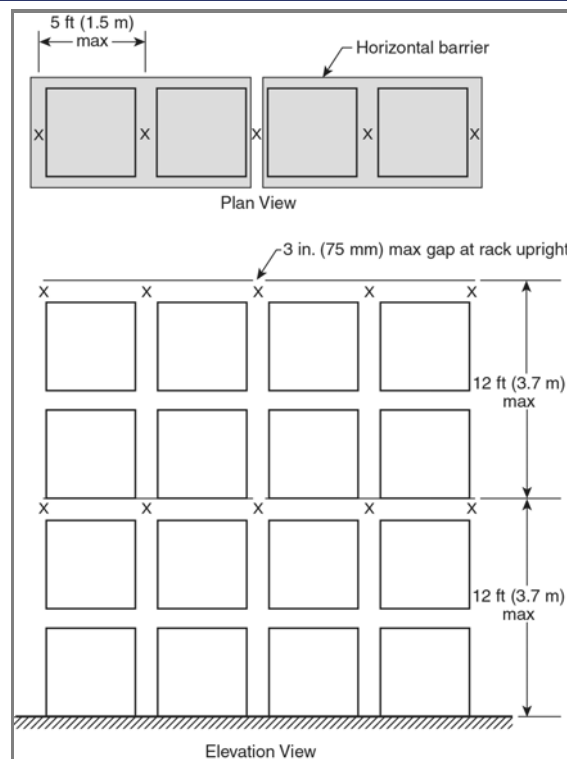
25.8.1.5

In-rack sprinklers shall be quick-response, minimum K-8.0 (K-115) installed as close to the underside of the horizontal barrier as possible.

25.8.1.6 Alternative In-Rack Sprinkler Protection Option 1 for Single-Row Racks.**25.8.1.6.1**

For single-row racks, in-rack sprinklers shall be installed beneath horizontal barriers at each rack upright and within the rack bay as shown in Figure 25.8.1.6.1.

Figure 25.8.1.6.1 Alternative In-Rack Sprinkler Protection Option 1 for Single-Row Racks.

**25.8.1.6.2**

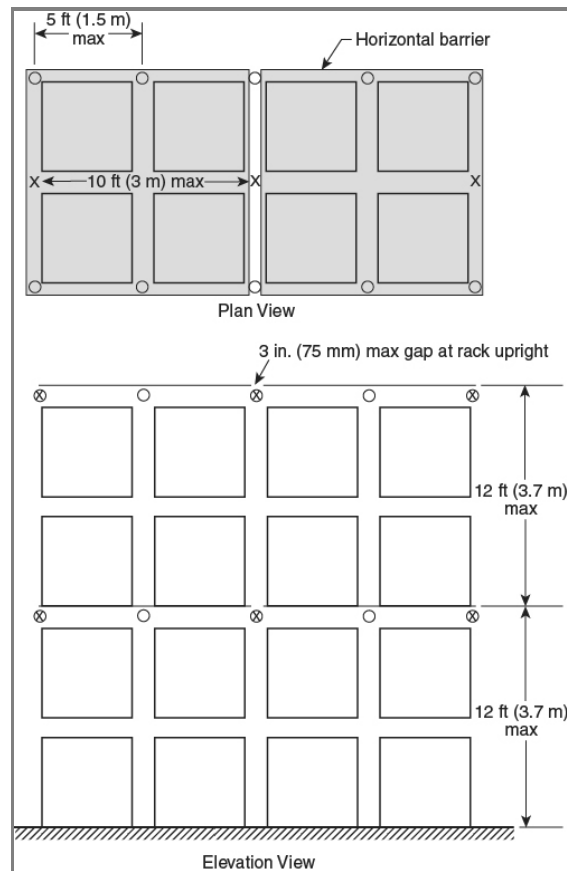
The maximum allowable horizontal spacing between in-rack sprinklers shall not exceed 5 ft (1.5 m).

25.8.1.7 Alternative In-Rack Sprinkler Protection Option 1 for Double-Row Racks.

25.8.1.7.1

For double-row racks, in-rack sprinklers shall be installed beneath horizontal barriers at each rack upright within the longitudinal flue space and at the face of the rack as well as at the face of each rack bay as shown in Figure 25.8.1.7.1.

Figure 25.8.1.7.1 Alternative In-Rack Sprinkler Protection Option 1 for Double-Row Racks.



25.8.1.7.2

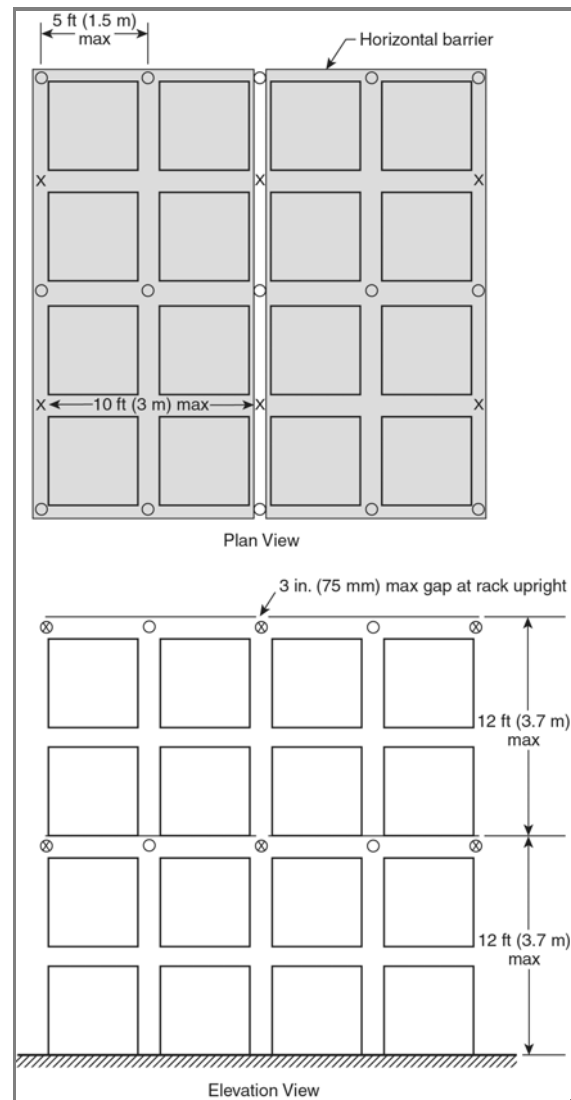
The maximum allowable horizontal spacing between in-rack sprinklers shall not exceed 5 ft (1.5 m) at the rack face and 10 ft (3.0 m) within the longitudinal flue space.

25.8.1.8 Alternative In-Rack Sprinkler Protection Option 1 for Multiple-Row Racks.

25.8.1.8.1

For multiple-row racks, an alternating in-rack sprinkler arrangement shall be installed within adjacent transverse flue spaces and with sprinklers at the face of each flue space as shown in Figure 25.8.1.8.1.

Figure 25.8.1.8.1 Alternative In-Rack Sprinkler Protection Option 1 for Multiple-Row Racks.

**25.8.1.8.2**

The maximum allowable horizontal spacing between in-rack sprinklers at the face and at each alternating rack bay shall not exceed 5 ft (1.5 m) and shall not exceed 10 ft (3.0 m) between in-rack sprinklers at every other rack bay.

25.8.1.9 In-Rack Sprinkler System Design.

The in-rack sprinkler system design outlined in this section shall be based on a minimum flow of 60 gpm (230 L/min) from the most remote six in-rack sprinklers for single-row racks or the most remote eight in-rack sprinklers for both double-row and multiple-row racks.

25.8.1.10 Ceiling-Level Sprinkler System Design.

The ceiling-level sprinkler system shall be designed based on the highest commodity hazard not protected by the in-rack sprinkler system outlined in this section.

25.8.2 In-Rack Sprinkler Protection for Class I Through Class IV and Group A Plastic Commodities That Are Independent of the Ceiling Sprinkler Design, Option 2.

25.8.2.1

Protection of closed-top Class I through Class IV and Group A plastic commodities (i.e., no open-top containers) stored on single-, double-, or multiple-row racks without solid shelves shall be permitted to be protected in accordance with this section.

25.8.2.2

In-rack sprinkler systems shall be wet-pipe only.

25.8.2.3

In-rack sprinklers shall be ESFR, pendent, and ordinary-temperature-rated.

25.8.2.3.1

Minimum K-14.0 (K-200) ESFR sprinklers shall be installed where the minimum required flow is 100 gpm (380 L/min) or less.

25.8.2.3.2

Minimum K-22.4 (K-320) ESFR sprinklers shall be installed where the minimum required flow exceeds 100 gpm (380 L/min).

25.8.2.4

Depending on the type of storage rack being protected, in-rack sprinklers shall be positioned horizontally in accordance with Figure 25.8.2.4(a) through Figure 25.8.2.4(f) and the following:

- (1) The minimum horizontal distance between in-rack sprinklers shall be 27 in. (700 mm), with the maximum horizontal distance being 4.5 ft (1.4 m), unless shown otherwise in the applicable figures.
- (2) Except as shown in Figure 25.8.2.4(c), all in-rack sprinklers shall be located within the footprint of the rack structure.
- (3) All face sprinklers shall be positioned so that the horizontal distance between the face of the storage rack and the outer edge of storage, if it protrudes into the storage aisle, does not exceed 18 in. (450 mm).

Figure 25.8.2.4(a) Plan View of In-Rack Sprinkler Arrangement for Open Single-Row Racks Up to 3 ft (0.9 m) Deep.

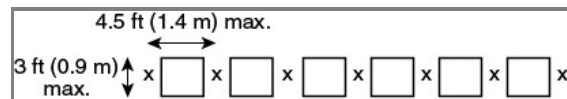


Figure 25.8.2.4(b) Plan View of In-Rack Sprinkler Arrangement for Open Single-Row Racks Up to 6 ft (1.8 m) Deep.

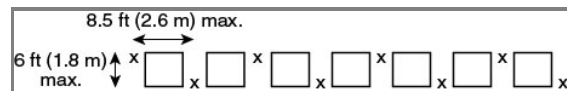


Figure 25.8.2.4(c) Plan View of In-Rack Sprinkler Arrangement for Open Single-Row Racks Up to 6 ft (1.8 m) Deep Located Against a Wall.

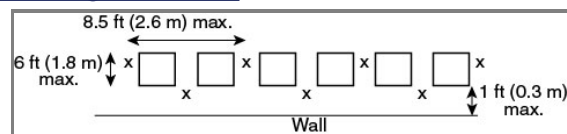


Figure 25.8.2.4(d) Plan View of In-Rack Sprinkler Arrangement for Open Double-Row Racks Up to 9 ft (2.7 m) Deep.

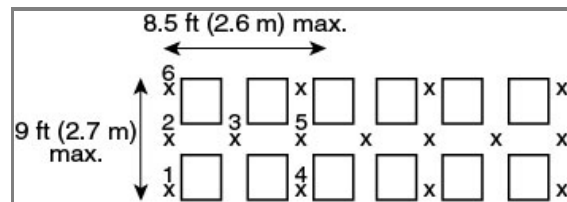


Figure 25.8.2.4(e) Plan View of In-Rack Sprinkler Arrangement for Open Double-Row Racks Up to 12 ft (3.7 m) Deep.

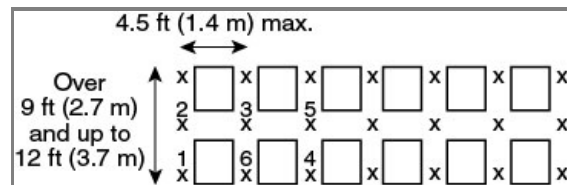
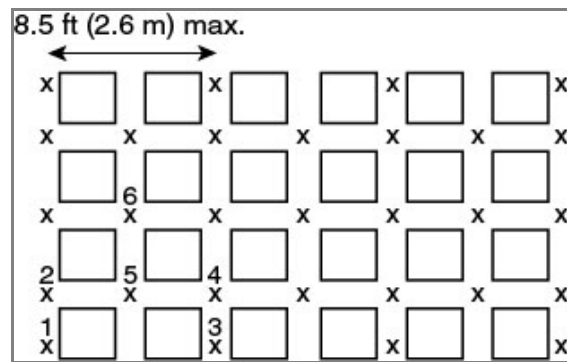


Figure 25.8.2.4(f) Plan View of In-Rack Sprinkler Arrangement for Open Multiple-Row Racks.



25.8.2.5

The maximum allowable vertical distance between in-rack sprinklers for cartoned expanded Group A plastics, exposed nonexpanded Group A plastics, and exposed expanded Group A plastics shall be 30 ft (9.1 m).

25.8.2.5.1

The maximum allowable vertical distance between in-rack sprinklers for Class I through Class IV and cartoned nonexpanded Group A plastics shall be 40 ft (12.2 m).

25.8.2.5.2

A minimum 6 in. (150 mm) vertical distance between the top of storage and the in-rack sprinkler deflector shall be maintained.

25.8.2.6

Regardless of the number of in-rack sprinkler levels installed, the number of sprinkler levels for the in-rack sprinkler system design shall be based on the single most hydraulically remote in-rack sprinkler level and the minimum number of in-rack sprinklers for this level in accordance with Table 25.8.2.6.

Table 25.8.2.6 Number of Sprinklers in the In-Rack Sprinkler Design

<u>IRAS Installation Arrangement; Figure</u>	<u>Number of Sprinklers in the In-Rack Design</u>	
	<u>Class I Through IV and Cartoned Group A Plastics</u>	<u>Exposed Group A Plastics</u>
Single-row racks up to 3 ft (0.9 m) deep; Figure 25.8.2.4(a)	<u>4</u>	<u>4</u>
Single-row racks up to 6 ft (1.8 m) deep; Figures 25.8.2.4(b) and 25.8.2.4(c)	<u>5</u>	<u>5</u>
Double- and multiple-row racks; Figures 25.8.2.4(d), 25.8.2.4(e) and 25.8.2.4(f)	<u>6</u>	<u>6 and 6*</u>

*This represents 6 sprinklers in the most remote rack as well as 6 sprinklers in the nearest adjacent rack. See Figures 25.8.2.4(d), 25.8.2.4(e), and 25.8.2.4(f) to determine which 6 sprinklers to account for in the in-rack sprinkler design for double- and multiple-row racks.

25.8.2.7

The minimum flow required in the system design shall be from the most remote in-rack sprinkler in accordance with [Table 25.8.2.7](#) .

Table 25.8.2.7 Minimum Flow in the In-Rack Sprinkler Design

<u>Maximum Vertical IRAS Installation Increment, ft (m)</u>	<u>Commodity Hazard</u>	<u>Min. K-Factor</u>	<u>Minimum Flow from Most Remote IRAS, gpm (L/min)</u>
<u>30 (9.1)</u>	<u>Class I through IV and cartoned nonexpanded Group A plastic</u>	<u>14.0 (200)</u>	<u>65 (250)</u>
	<u>Cartoned expanded Group A plastic</u>	<u>14.0 (200)</u>	<u>100 (380)</u>
	<u>Exposed Group A plastic</u>	<u>22.4 (320)</u>	<u>120 (455)</u>
<u>40 (12.2)</u>	<u>Class I through Class IV and cartoned nonexpanded Group A plastic</u>	<u>22.4 (320)</u>	<u>120 (455)</u>

25.8.2.8

A hose stream allowance per [Table 20.12.2.6](#) shall be included as part of the in-rack sprinkler system design.

25.8.2.9

The water supply requirements shall be available for a minimum duration as required in [Table 20.12.2.6](#) .

25.8.2.10

The water supply for the in-rack sprinkler system shall be capable of providing the required in-rack sprinkler system design obtained from [25.8.2](#) independent of the design requirements of the ceiling sprinkler system protecting this same area.

25.8.2.11

The ceiling sprinkler system shall be designed and installed in accordance with the guidelines outlined in [Chapters 21](#) , [22](#) , or [23](#) , depending on the commodity hazard and the ceiling-level sprinkler, except as modified in [25.8.2](#) .

25.8.2.11.1*

Where the in-rack sprinkler system is designed and installed in accordance with [25.8.2](#) , the top level of in-rack sprinklers shall be considered to be a floor for design purposes of the ceiling sprinkler system.

A.25.8.2.11.1

The design for the ceiling sprinkler system can treat the top level of in-rack sprinklers as a floor, thus allowing for storage heights above the top in-rack sprinkler level that exceed 10 ft (3.0 m). For example, if open rack storage of cartoned Group A plastics was stored to 70 ft (21.3 m) high under an 80 ft (24.4 m) ceiling and one level of in-rack sprinklers was installed per [25.8.2](#) at the 40 ft (12.2 m) level, then the ceiling sprinkler system could be designed based on 30 ft (9.1 m) high storage being maintained under a 40 ft (12.2 m) high ceiling.

25.8.2.12

The water supply for the ceiling system shall be capable of providing the required ceiling sprinkler system design obtained from [Chapters 21](#) , [22](#) , or [23](#) independent of the design requirements of the in-rack sprinkler system obtained from [25.8.2](#) and protecting this same area.

25.8.3 In-Rack Sprinkler Protection for Class I Through Class IV and Group A Plastic Commodities That Are Independent of the Ceiling Sprinkler Design, Option 3.

25.8.3.1

Class I through Class IV and Group A plastic commodities requiring a greater level of protection than is available from the overhead sprinkler system shall be permitted to be protected in accordance with this section.

25.8.3.1.1

Where the storage rack will not be solely dedicated to the storage of commodities requiring a greater level of protection than is available from the overhead sprinkler system, either of the following shall apply:

- (1) Extend the protection prescribed by this section horizontally one pallet load in all directions beyond the commodity storage area requiring the higher level of protection.
- (2) Install a vertical barrier to segregate the commodities requiring the higher level of protection from any adjacent commodities.

25.8.3.1.2

Commodities that can be protected by the ceiling-level sprinkler system shall be permitted to be stored vertically above and horizontally adjacent to the portions of the storage rack equipped as prescribed by this section.

25.8.3.2 Horizontal Barriers.

Horizontal barriers shall be installed at every tier level of the dedicated storage rack where the rack is equipped with solid shelves.

25.8.3.2.1

Where dedicated storage of Class I through IV and cartoned Group A plastic commodity is in open racks, horizontal barriers shall be installed at vertical increments not exceeding 30 ft (9.1 m).

25.8.3.2.2

Where dedicated storage of exposed Group A plastic commodity is in open racks, horizontal barriers shall be installed at vertical increments not exceeding 20 ft (6.1 m).

25.8.3.2.3

The barriers shall span horizontally so that all flue spaces within the rack bay are covered.

25.8.3.2.4

A maximum 3 in. (75 mm) wide gap shall be permitted at rack uprights.

25.8.3.2.5

The solid barrier shall be installed on a horizontal plane within a rack, beneath which in-rack sprinklers shall be installed, as follows:

- (1) The barrier shall be constructed of minimum 22 gauge (0.8 mm) sheet metal or of minimum $\frac{3}{8}$ in. (10 mm) plywood.
- (2) The barrier shall extend to both ends and both aisle faces of the racks covering up both the longitudinal and transverse flue spaces of the rack bays in which they are installed.
- (3) The barrier shall be fitted to within 3 in. (75 mm) of any vertical rack member or other equipment that would create an opening, such as vertical in-rack sprinkler pipe drops.

25.8.3.3 In-Rack Sprinklers.

Intermediate-temperature extended-coverage CMDA pendent storage sprinklers with a nominal K-factor of K-25.2 (360) shall be installed beneath each horizontal barrier. The deflector of the sprinkler shall be located as close to the underside of the horizontal barrier as possible with the deflector a minimum of 6 in. (150 mm) above the top of the commodity.

25.8.3.3.1 Single-Row Racks.

(A)

For single-row racks, sprinklers shall be installed at each rack mid-bay as shown in [Figure 25.8.3.3.1\(A\)\(a\)](#) for Class I through Class IV and cartoned Group A plastic commodity and [Figure 25.8.3.3.1\(A\)\(b\)](#) for exposed Group A plastic commodity.

Figure 25.8.3.3.1(A)(a) Alternative In-Rack Sprinkler Protection for Class I Through Class IV and Cartoned Group A Plastic Commodities in Single-Row Racks, Option 3.

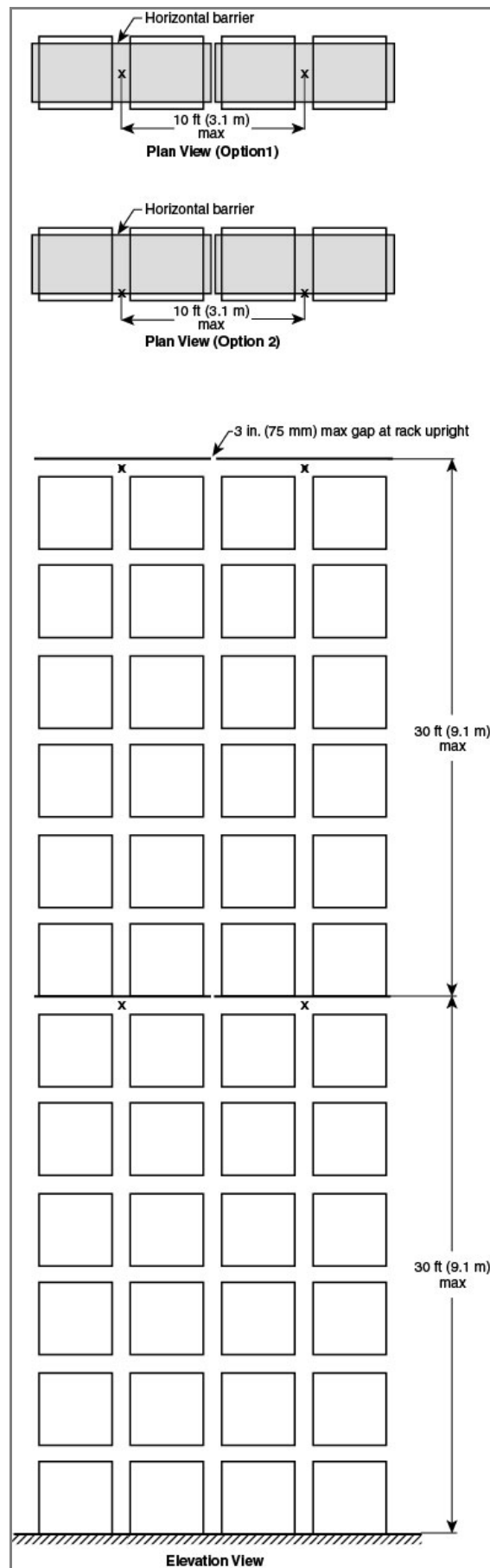
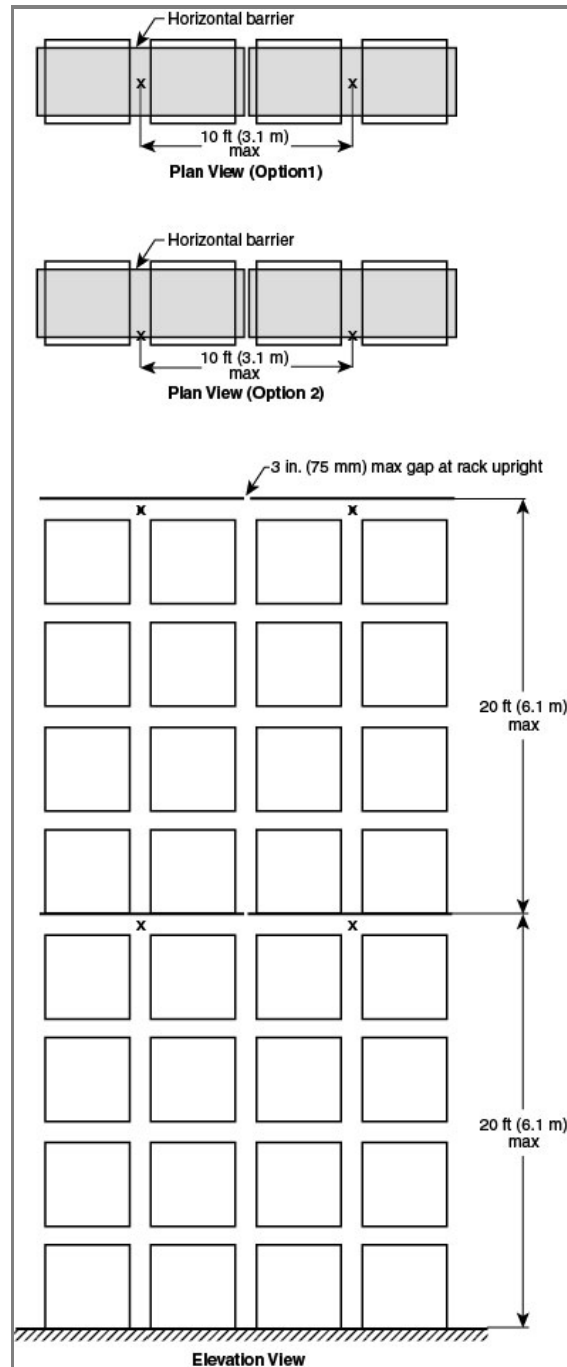


Figure 25.8.3.3.1(A)(b) Alternative In-Rack Sprinkler Protection for Exposed Group A Plastic Commodities in Single-Row Racks, Option 3.



(B)

The maximum linear spacing between sprinklers shall not exceed 10 ft (3.1 m).

25.8.3.3.2 Double-Row Racks.

(A)

For double-row racks, sprinklers shall be installed within the longitudinal flue space at each rack mid-bay as shown in [Figure 25.8.3.3.2\(A\)\(a\)](#) for Class I through Class IV and cartoned Group A plastic commodity and [Figure 25.8.3.3.2\(A\)\(b\)](#) for exposed Group A plastic commodity.

Figure 25.8.3.3.2(A)(a) Alternative In-Rack Sprinkler Protection for Class I Through Class IV and Cartoned Group A Plastic Commodities in Double-Row Racks, Option 3.

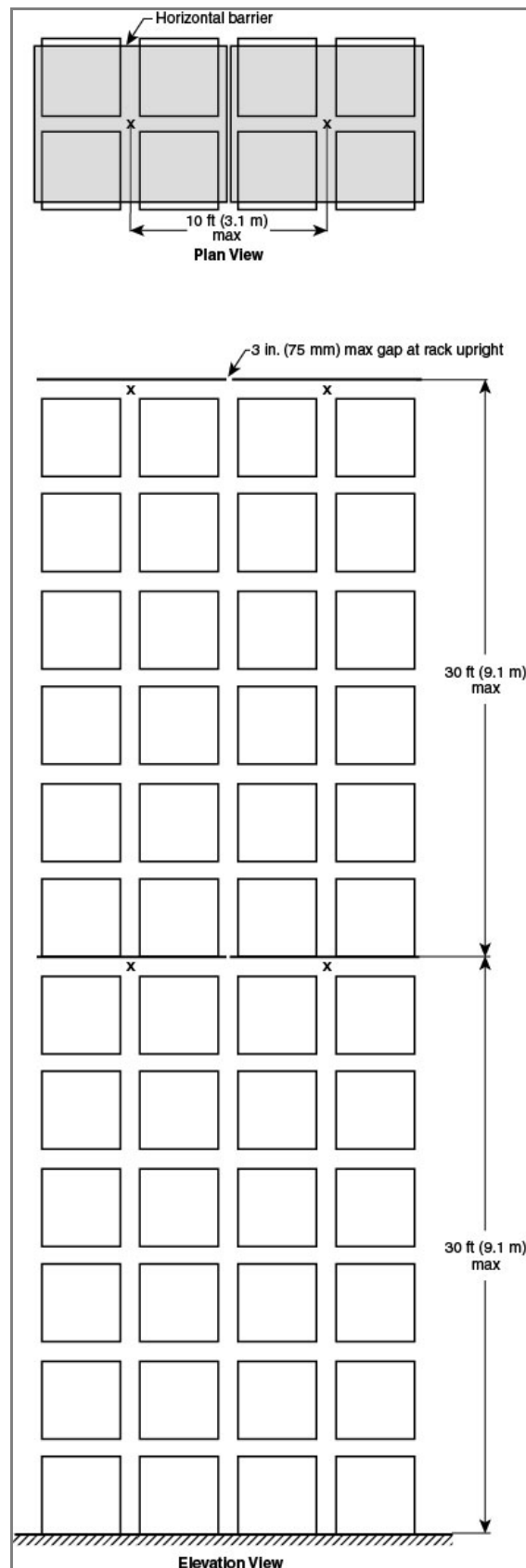
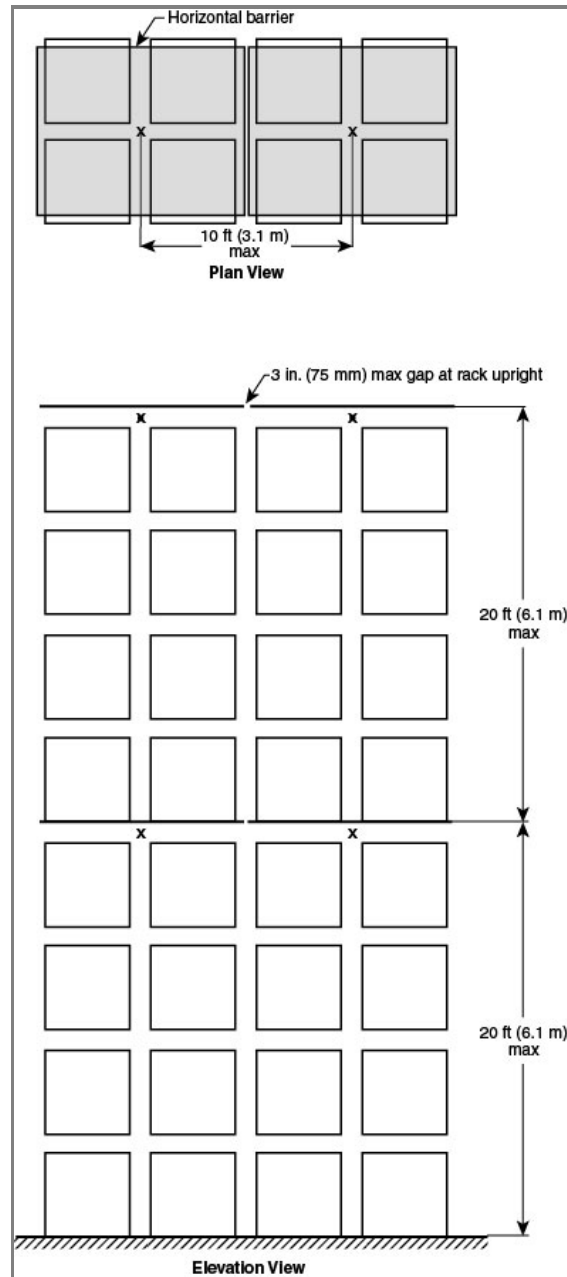


Figure 25.8.3.2(A)(b) Alternative In-Rack Sprinkler Protection for Exposed Group A Plastic Commodities in Double-Row Racks, Option 3.



(B)

The maximum linear spacing between sprinklers shall not exceed 10 ft (3.1 m).

25.8.3.3.3 Multiple-Row Racks.

(A)

For multiple-row racks with an overall depth between aisles not exceeding 15 ft 6 in. (4.7 m), an alternating sprinkler arrangement shall be installed within adjacent transverse flue spaces as shown in Figure 25.8.3.3.3(A)(a) for Class I through Class IV and cartoned Group A plastic commodity and Figure 25.8.3.3.3(A)(b) for exposed Group A plastic commodity.

Figure 25.8.3.3.3(A)(a) Alternative In-Rack Sprinkler Protection for Class I Through Class IV and Cartoned Group A Plastic Commodities in Multiple-Row Racks, Option 3.

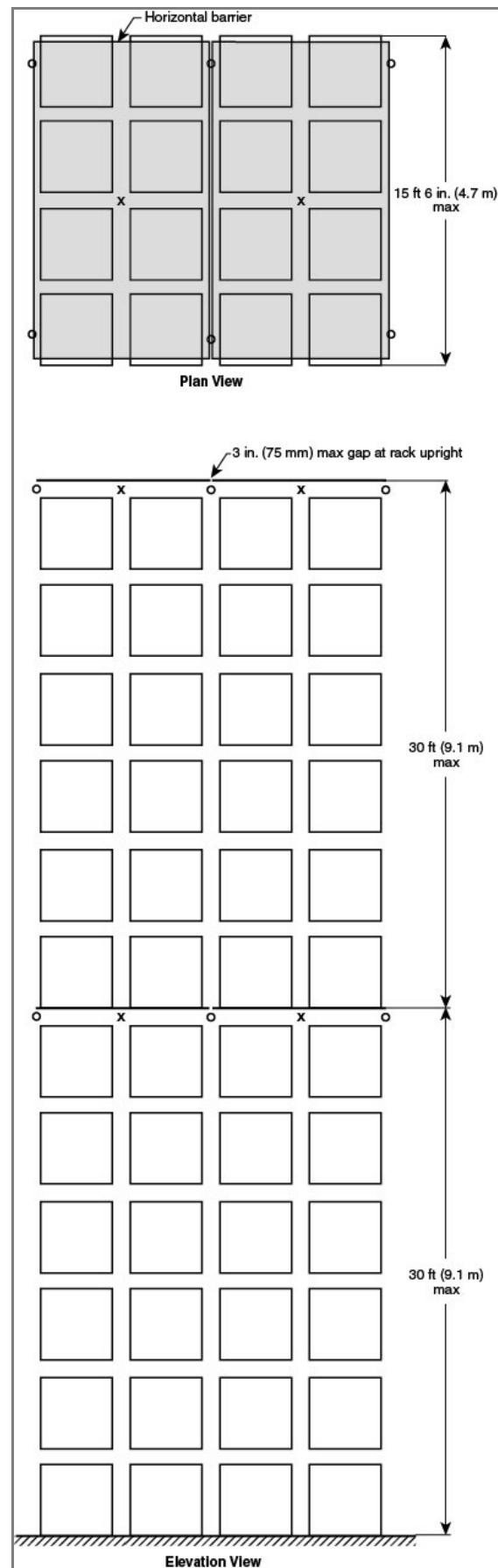
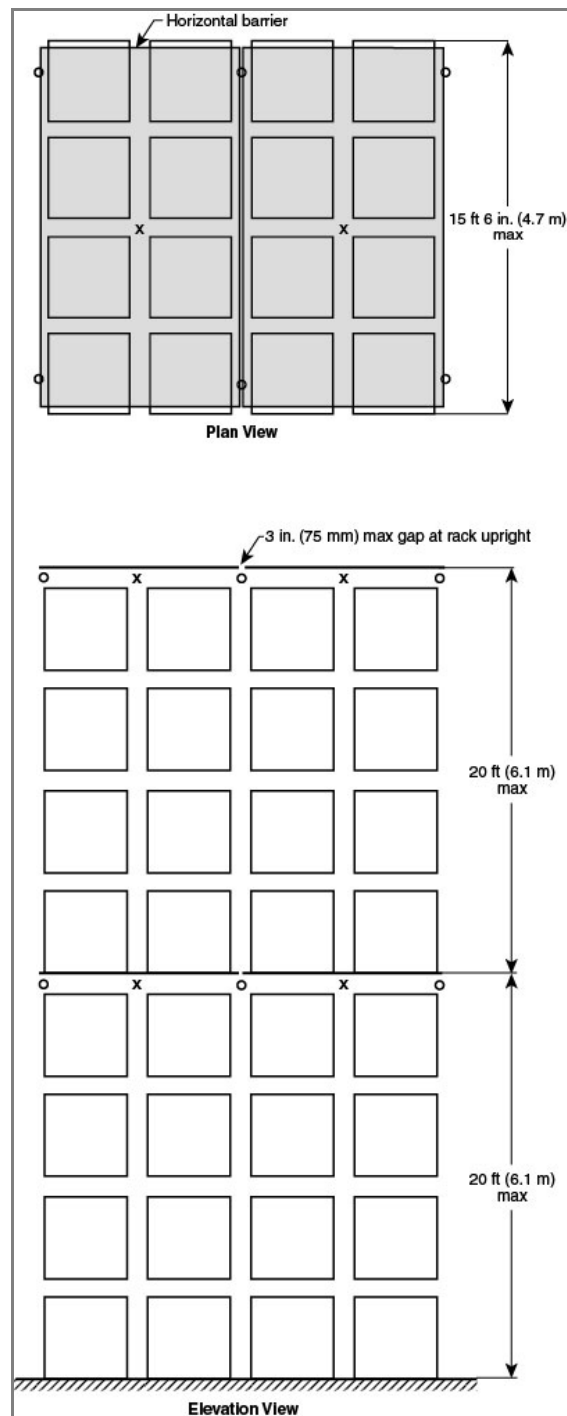


Figure 25.8.3.3(A)(b) Alternative In-Rack Sprinkler Protection for Exposed Group A Plastic Commodities in Multiple-Row Racks, Option 3.

**(B)**

The maximum linear spacing between sprinklers at the face shall not exceed 10 ft (3.1 m) and shall not exceed 10 ft (3.1 m) between sprinklers at every other bay.

25.8.3.4

The design of the in-rack sprinkler system shall be based on a minimum flow of 138 gpm (520 L/min) from each of the four most remote sprinklers for single-row and double-row racks or each of the eight most remote in-rack sprinklers (three at each face and two in-between) for multiple-row racks.

25.8.3.5

The in-rack sprinkler demand shall not be required to be hydraulically balanced with the ceiling-level sprinkler system.

25.8.3.6 Ceiling Sprinkler System.

The ceiling-level sprinkler system shall be designed based on the highest commodity hazard not protected by the criteria prescribed by this section.

25.9 In-Rack Sprinkler Arrangements in Combination with CMDA Sprinklers at Ceiling Level.**25.9.1 Rack Storage of Class I Through Class IV Commodities Up to and Including 25 ft (7.6 m) in Height.**

The in-rack arrangements for rack storage up to and including 25 ft (7.6 m) in height shall be in accordance with the guidelines outlined in Sections 25.4 through 25.7 as applicable.

25.9.2 Rack Storage of Class I Through Class IV Commodities Over 25 ft (7.6 m) in Height.**25.9.2.1 Single-Row Racks.****25.9.2.1.1***

In single-row racks with a maximum of 10 ft (3.0 m) between the top of storage and the ceiling, in-rack sprinklers shall be installed in accordance with [Table 25.9.2.1.1](#) and [Figure 25.9.2.1.1\(a\)](#) through [Figure 25.9.2.1.1\(e\)](#) .

Table 25.9.2.1.1 Single-Row Racks of Class I Through Class IV Commodities Stored Over 25 ft (7.6 m) in Height with Aisles 4 ft (1.2 m) or More in Width Protected by CMDA Sprinklers at Ceiling Level

Commodity Class	<u>In-Rack Sprinklers Approximate Vertical Spacing at Tier Nearest the Vertical Distance and Maximum Horizontal Spacing a, b</u>	<u>Figure</u>	<u>Maximum Storage Height</u>	<u>Stagger</u>
	<u>Center of Rack c, d</u>			
<u>I, II, III</u>	Vertical 20 ft (6.1 m), Horizontal 5 ft (1.5 m)	25.9.2.1.1(a)	<u>Higher than 25 ft (7.6 m)</u>	<u>No</u>
	Vertical 20 ft (6.1 m), Horizontal 10 ft (3.0 m) with horizontal barriers	25.9.2.1.1(b)		<u>No</u>
<u>I, II, III, IV</u>	Vertical 15 ft (4.6 m), Horizontal 5 ft (1.5 m)	25.9.2.1.1(c)		<u>No</u>
	Vertical 15 ft (4.6 m), Horizontal 10 ft (3.0 m) with horizontal barriers	25.9.2.1.1(d)		<u>No</u>
	Vertical 10 ft (3.0 m), Horizontal 10 ft (3.0 m)	25.9.2.1.1(e)		<u>Yes</u>

a [Water shields required.](#)

b [All in-rack sprinkler spacing dimensions start from the floor.](#)

c [Install sprinklers at least 3 in. \(75 mm\) from uprights.](#)

d [In Figure 25.9.2.1.1\(a\) through Figure 25.9.2.1.1\(e\), each square represents a storage cube that measures 4 ft to 5 ft \(1.2 m to 1.5 m\) on a side. Actual load heights can vary from approximately 18 in. to 10 ft \(450 mm to 3.0 m\). Therefore, there can be one load to six or seven loads between in-rack sprinklers that are spaced 10 ft \(3.0 m\) apart vertically.](#)

Figure 25.9.2.1.1(a) In-Rack Sprinkler Arrangement, Class I, II, or III Commodities, Single-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 1.

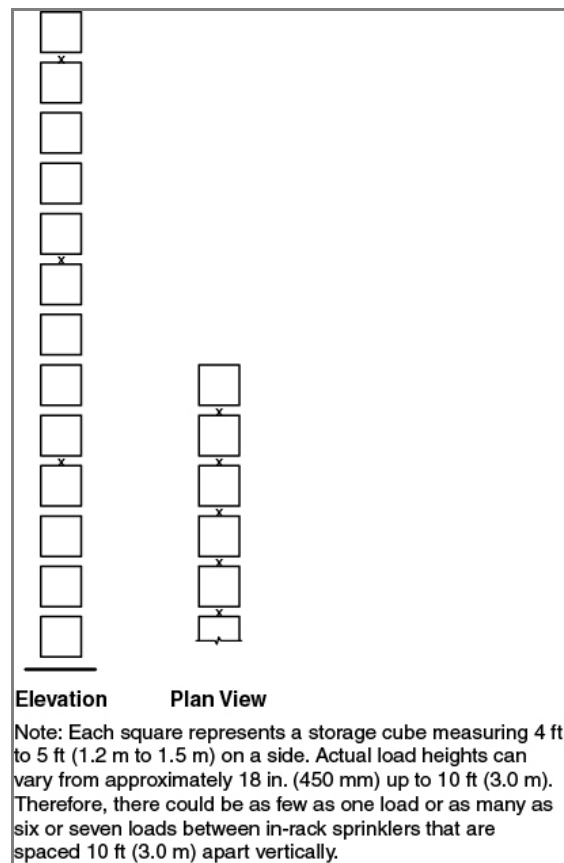


Figure 25.9.2.1.1(b) In-Rack Sprinkler Arrangement, Class I, II, or III Commodities, Single-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 2.

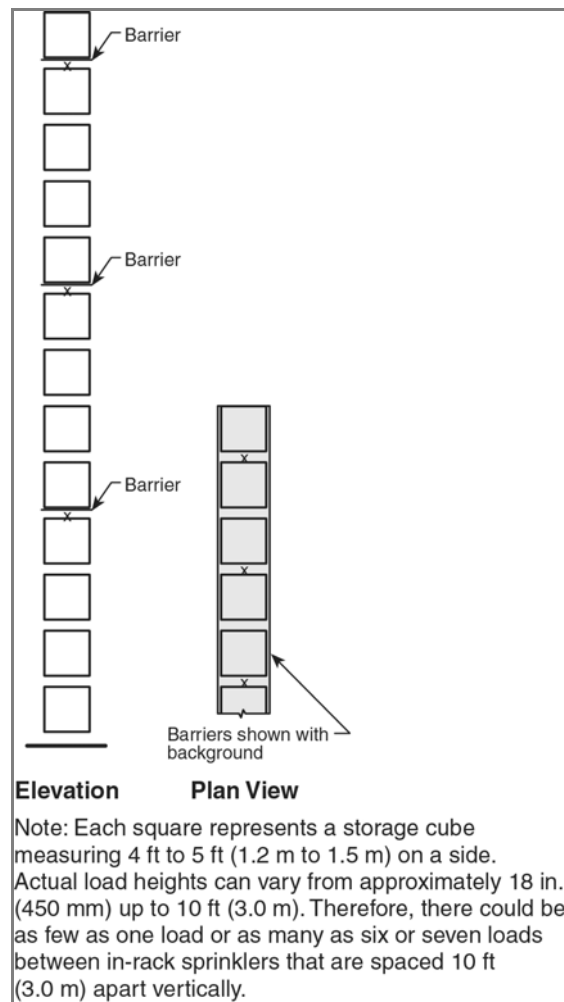


Figure 25.9.2.1.1(c) In-Rack Sprinkler Arrangement, Class I, II, III, or IV Commodities, Single-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 1.

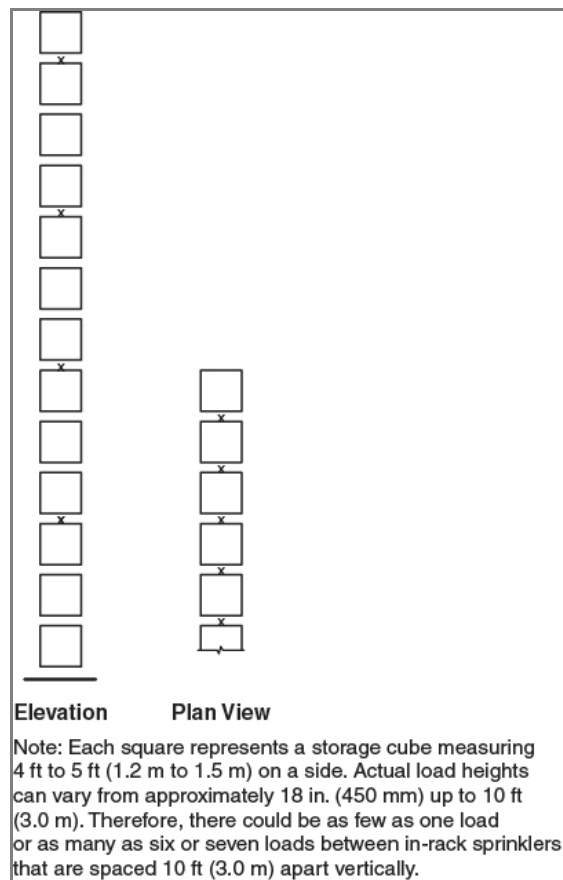


Figure 25.9.2.1.1(d) In-Rack Sprinkler Arrangement, Class I, II, III, or IV Commodities, Single-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 2.

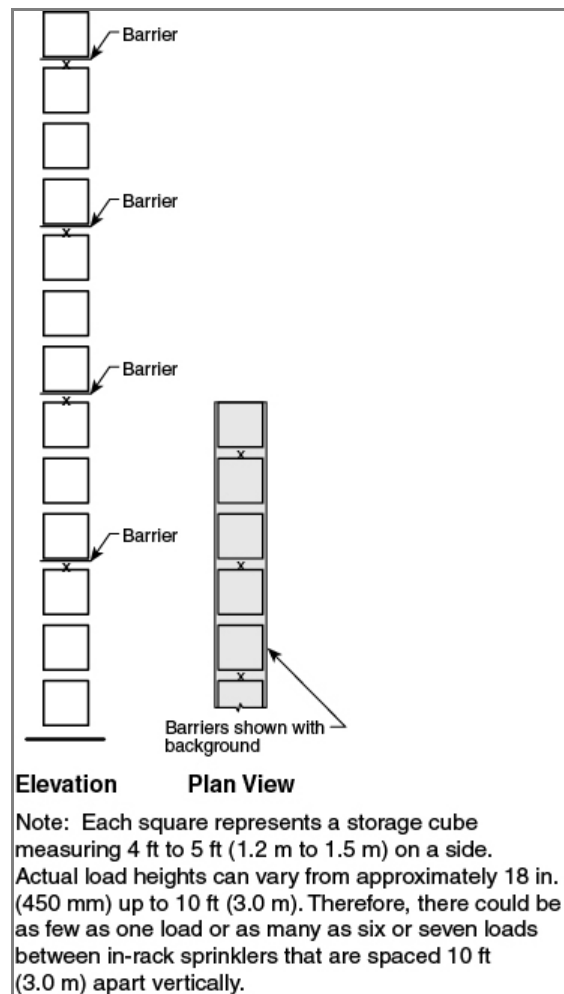
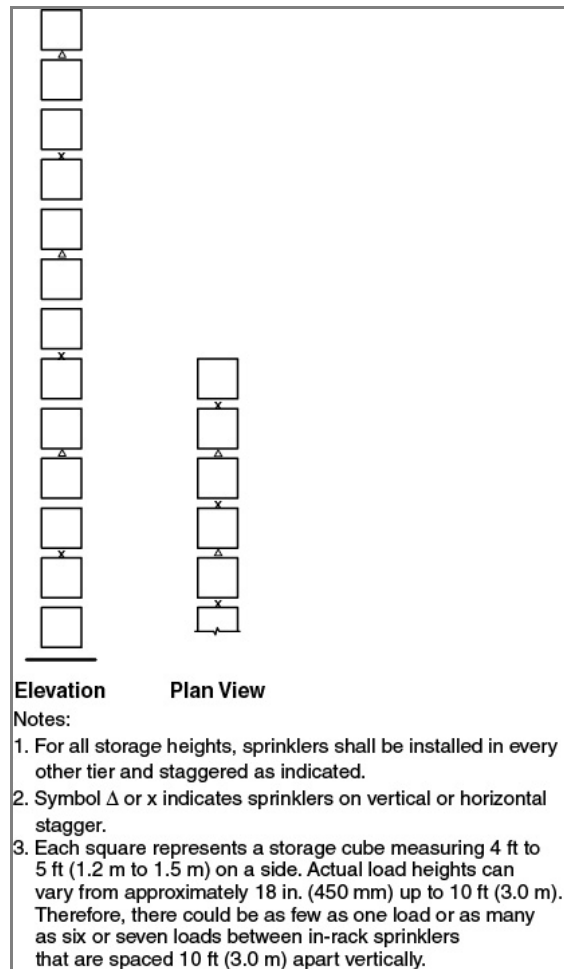


Figure 25.9.2.1.1(e) In-Rack Sprinkler Arrangement, Class I, II, III, or IV Commodities, Single-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 3.



A.25.9.2.1.1

In single-row racks with more than 10 ft (3.0 m) between the top of storage and the ceiling, a horizontal barrier should be installed above storage with one line of sprinklers under the barrier.

25.9.2.1.2

Where a single-row rack is located against a wall, the in-rack sprinkler arrangement shall be permitted to be in accordance with Figure 25.9.2.2.1(a) through Figure 25.9.2.2.1(j).

25.9.2.1.3

Where in-rack sprinkler arrangement figures for single-row racks show in-rack sprinklers in transverse flue spaces centered between the rack faces, it shall be permitted to position these in-rack sprinklers in the transverse flue at any point between the load faces.

25.9.2.2 Double-Row Racks.

25.9.2.2.1*

In double-row racks with a maximum of 10 ft (3.0 m) between the top of storage and the ceiling, in-rack sprinklers shall be installed in accordance with [Table 25.9.2.2.1](#) and [Figure 25.9.2.2.1\(a\)](#) through [Figure 25.9.2.2.1\(j\)](#).

Table 25.9.2.2.1 Double-Row Racks of Class I Through Class IV Commodities Stored Over 25 ft (7.6 m) in Height with Aisles 4 ft (1.2 m) or More in Width Protected by CMDA Sprinklers at Ceiling Level

<u>Commodity Class</u>	<u>In-Rack Sprinklers Approximate Vertical Spacing at Tier Nearest the Vertical Distance and Maximum Horizontal Spacing ^{a,b}</u>		<u>Figure</u>	<u>Maximum Storage Height</u>	<u>Stagger</u>
	<u>Longitudinal Flue ^c</u>	<u>Face ^{d,e}</u>			
<u>I</u>	<u>Vertical 20 ft (6.1 m), Horizontal 10 ft (3.0 m) under horizontal barriers</u>	<u>None</u>	25.9.2.2.1(a)	<u>30 ft (9.1 m)</u>	<u>No</u>
	<u>Vertical 20 ft (6.1 m), Horizontal 10 ft (3.0 m)</u>	<u>Vertical 20 ft (6.1 m), Horizontal 10 ft (3.0 m)</u>	25.9.2.2.1(b)	<u>Higher than 25 ft (7.6 m)</u>	<u>Yes</u>
<u>I, II, III</u>	<u>Vertical at 10 ft (3.0 m) or at 15 ft (4.6 m) and at 25 ft (7.6 m)</u>	<u>None</u>	25.2.2.1(c)	<u>30 ft (9.1 m)</u>	<u>Yes</u>
	<u>Vertical 10 ft (3.0 m), Horizontal 10 ft (3.0 m)</u>	<u>Vertical 30 ft (9.1 m), Horizontal 10 ft (3.0 m)</u>	25.9.2.2.1(d)	<u>Higher than 25 ft (7.6 m)</u>	<u>Yes</u>
	<u>Vertical 20 ft (6.1 m), Horizontal 10 ft (3.0 m)</u>	<u>Vertical 20 ft (6.1 m), Horizontal 5 ft (1.5 m)</u>	25.9.2.2.1(e)		<u>Yes</u>
	<u>Vertical 25 ft (7.6 m), Horizontal 5 ft (1.5 m)</u>	<u>Vertical 25 ft (7.6 m), Horizontal 5 ft (1.5 m)</u>	25.9.2.2.1(f)		<u>No</u>
	<u>Vertical 20 ft (6.1 m), Horizontal 10 ft (3.0 m) under horizontal barriers with two lines of staggered in-rack sprinklers</u>	<u>-</u>	25.9.2.2.1(g)		<u>Yes</u>
	<u>Vertical 15 ft (4.6 m), Horizontal 10 ft (3.0 m)</u>	<u>Vertical 20 ft (6.1 m), Horizontal 10 ft (3.0 m)</u>	25.9.2.2.1(h)		<u>Yes</u>
<u>I, II, III, IV</u>	<u>Vertical 20 ft (6.1 m), Horizontal 5 ft (1.5 m)</u>	<u>Vertical 20 ft (6.1 m), Horizontal 5 ft (1.5 m)</u>	25.9.2.2.1(i)	<u>Higher than 25 ft (7.6 m)</u>	<u>No</u>
	<u>Vertical 15 ft (4.6 m), Horizontal 10 ft (3.0 m) under horizontal barriers with two lines of staggered in-rack sprinklers</u>	<u>-</u>	25.9.2.2.1(j)		<u>Yes</u>

^a Water shields required.

^b All in-rack sprinkler spacing dimensions start from the floor.

^c Install sprinklers at least 3 in. (75 mm) from uprights.

^d Face sprinklers shall not be required for a Class I commodity consisting of noncombustible products on wood pallets (without combustible containers), except for arrays shown in [Figure 25.9.2.2.1\(g\)](#) and [Figure 25.9.2.2.1\(j\)](#).

In Figure 25.9.2.2.1(a) through Figure 25.9.2.2.1(j), each square represents a storage cube that measures 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. to 10 ft (450 mm to 3.0 m). Therefore, there can be one load to six or seven loads between in-rack sprinklers that are spaced 10 ft (3.0 m) apart vertically.

Figure 25.9.2.2.1(a) In-Rack Sprinkler Arrangement, Class I Commodities, Storage Height 25 ft to Maximum 30 ft (7.6 m to Maximum 9.1 m).

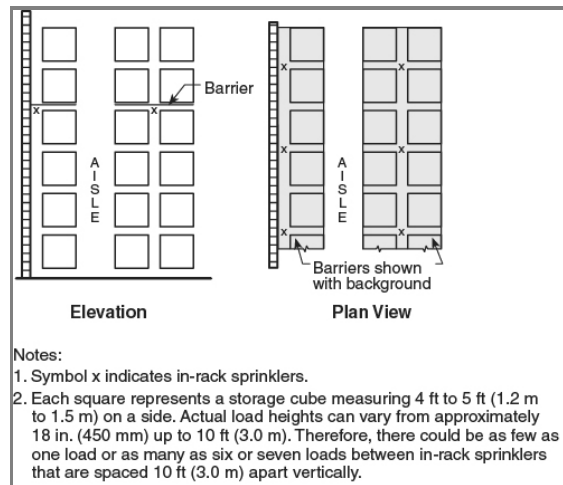


Figure 25.9.2.2.1(b) In-Rack Sprinkler Arrangement, Class I Commodities, Storage Height Over 25 ft (7.6 m).

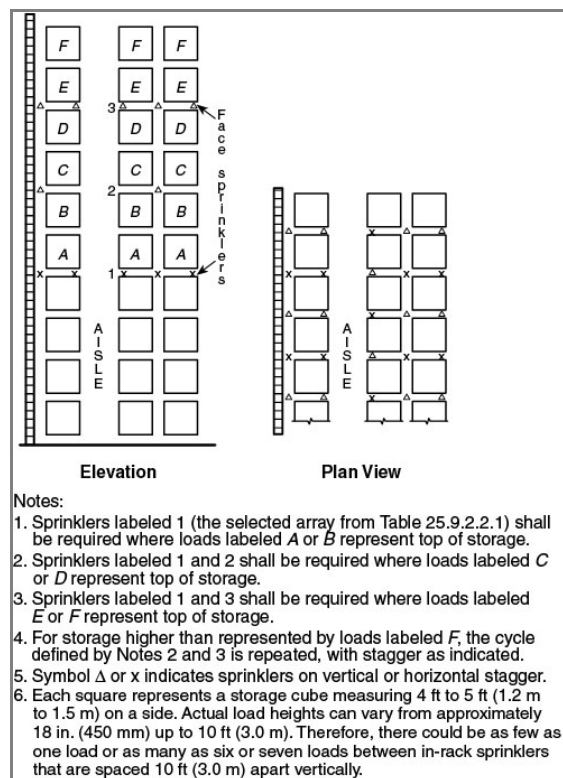


Figure 25.9.2.2.1(c) In-Rack Sprinkler Arrangement, Class I, II, or III Commodities, Storage Height 25 ft to Maximum 30 ft (7.6 m to Maximum 9.1 m).

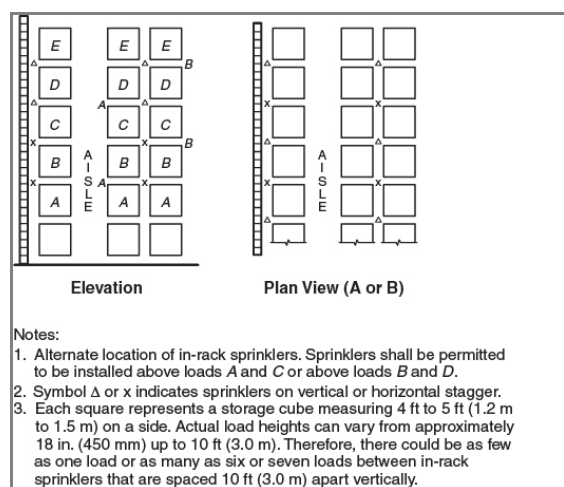


Figure 25.9.2.2.1(d) In-Rack Sprinkler Arrangement, Class I, II, or III Commodities, Storage Height Over 25 ft (7.6 m) — Option 1.

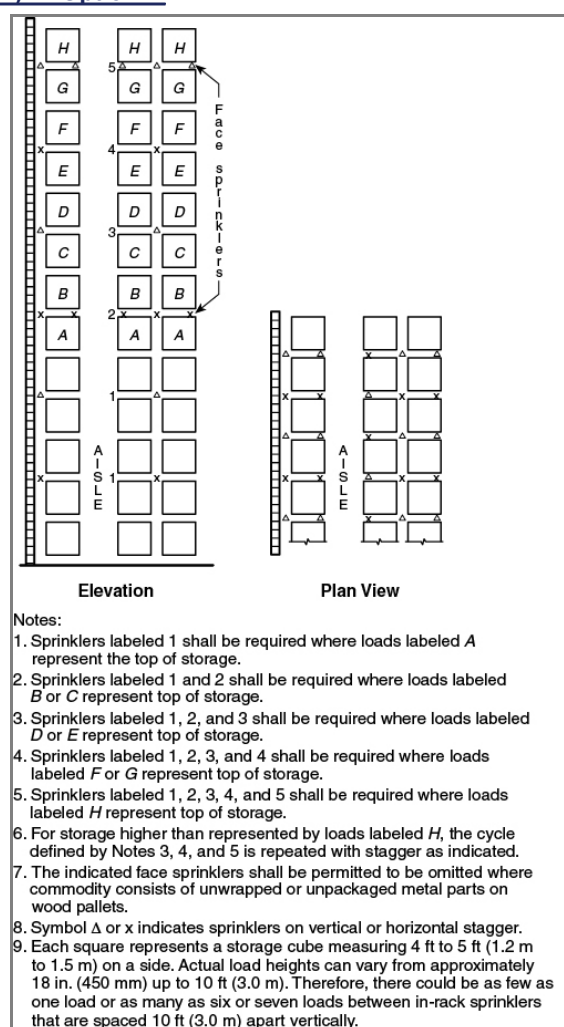


Figure 25.9.2.2.1(e) In-Rack Sprinkler Arrangement, Class I, II, or III Commodities, Storage Height Over 25 ft (7.6 m) — Option 2.

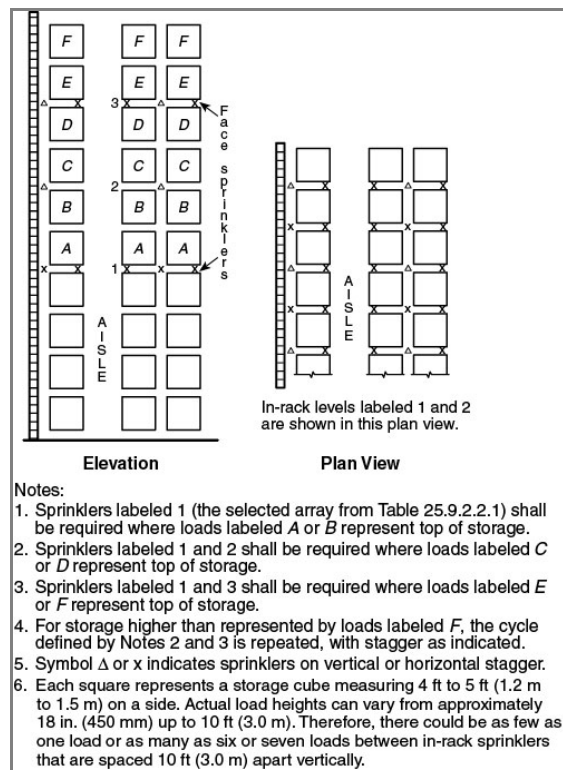


Figure 25.9.2.2.1(f) In-Rack Sprinkler Arrangement, Class I, II, or III Commodities, Storage Height Over 25 ft (7.6 m) — Option 3.

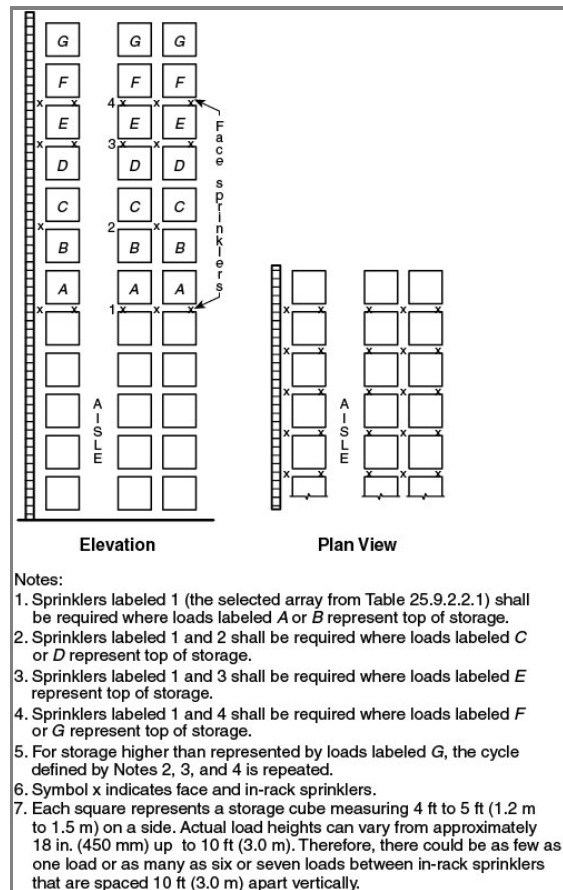


Figure 25.9.2.2.1(g) In-Rack Sprinkler Arrangement, Class I, II, or III Commodities, Storage Height Over 25 ft (7.6 m) — Option 4.

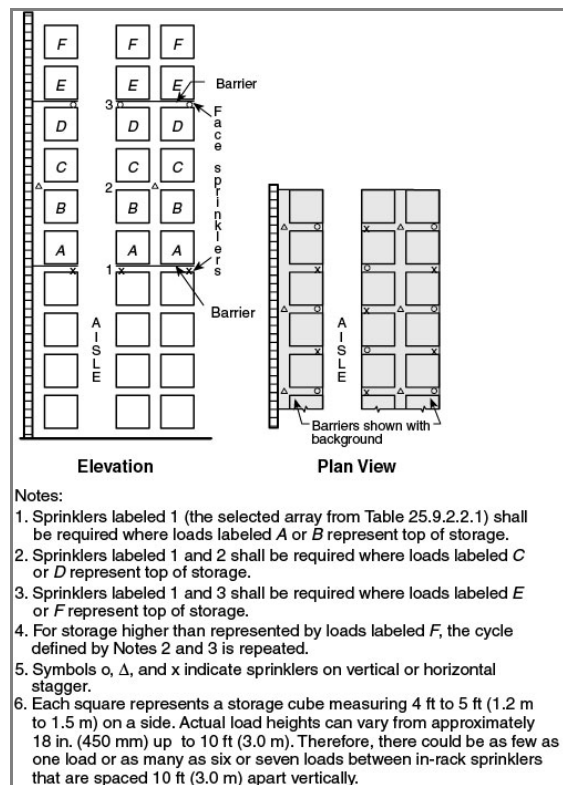


Figure 25.9.2.2.1(h) In-Rack Sprinkler Arrangement, Class I, II, III, or IV Commodities, Storage Height Over 25 ft (7.6 m) — Option 1.

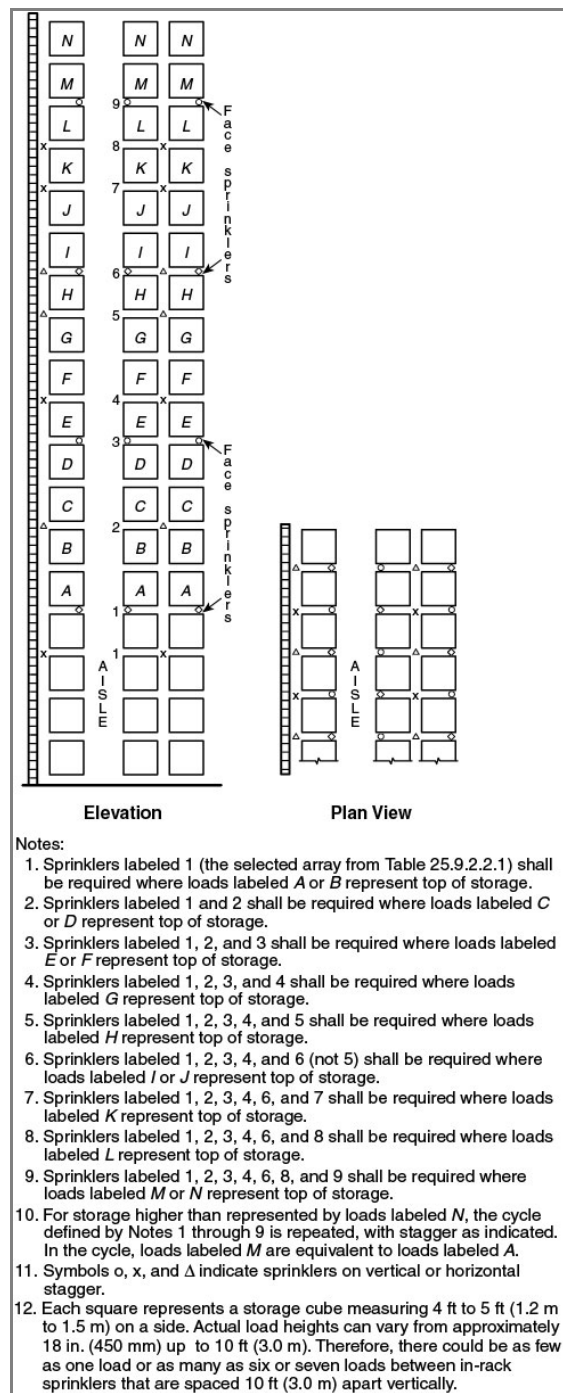


Figure 25.9.2.2.1(i) In-Rack Sprinkler Arrangement, Class I, II, III, or IV Commodities, Storage Height Over 25 ft (7.6 m) — Option 2.

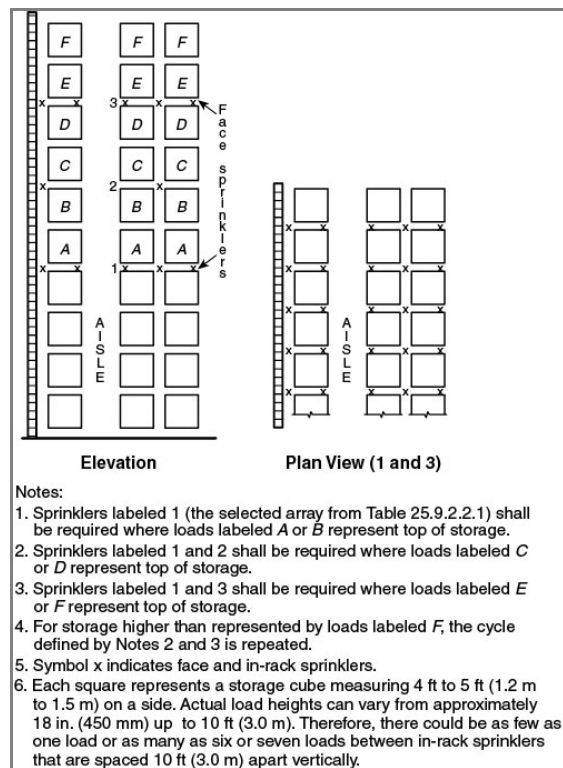
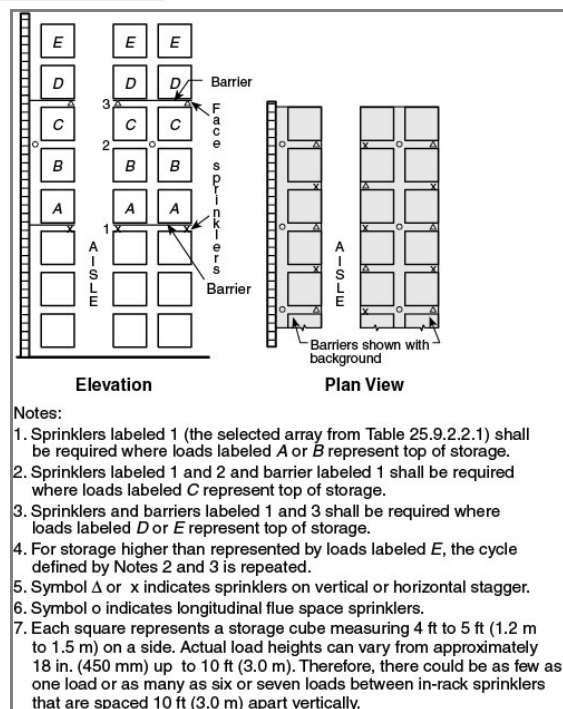


Figure 25.9.2.2.1(j) In-Rack Sprinkler Arrangement, Class I, II, III, or IV Commodities, Storage Height Over 25 ft (7.6 m) — Option 3.

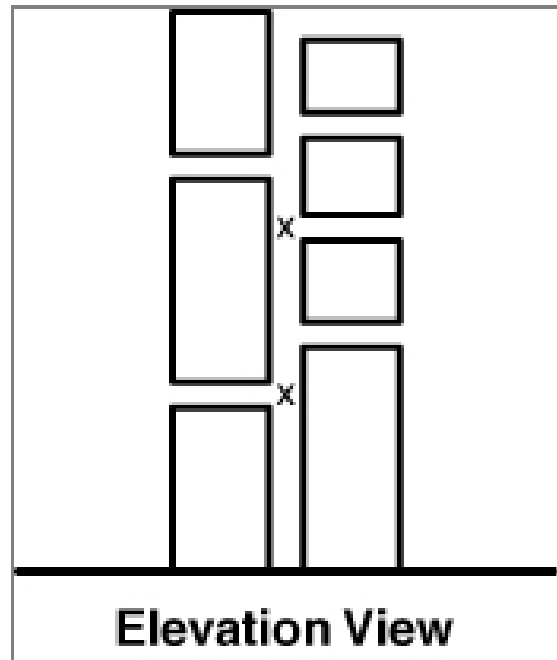


A.25.9.2.2.1

In double-row racks with more than 10 ft (3.0 m) between the top of storage and the ceiling, a horizontal barrier should be installed above storage with one line of sprinklers under the barrier.

Where storage tiers are not the same size on each side of the longitudinal flue, one side of the flue should be protected with sprinklers at the proper elevation above the load. The next level of sprinklers should protect the other side of the flue with the sprinklers at the proper elevation above that load as indicated in Figure A.25.9.2.2.1. The vertical spacing requirements for in-rack sprinklers specified in Table 25.9.2.2.1 and Section 25.4 for Group A plastic commodities should be followed.

Figure A.25.9.2.2.1 Placement of In-Rack Sprinklers Where Rack Levels Have Varying Heights.

**25.9.2.3 Multiple-Row Racks.****25.9.2.3.1***

In multiple-row racks with a maximum of 10 ft (3.0 m) between the top of storage and the ceiling, in-rack sprinklers shall be in accordance with [Table 25.9.2.3.1](#) and [Figure 25.9.2.3.1\(a\)](#) through [Figure 25.9.2.3.1\(c\)](#).

Table 25.9.2.3.1 Multiple-Row Racks of Nonencapsulated Class I Through Class IV Commodities Stored Over 25 ft (7.6 m) in Height Protected by CMDA Sprinklers at Ceiling Level

<u>Commodity Class</u>	<u>In-Rack Sprinklers a,b,c</u>						<u>Stagger</u>	<u>Figure</u>	<u>Maximum Allowable Storage Height Above Top In-Rack Sprinkler Level</u>	
	<u>Maximum Vertical Spacing</u>		<u>Maximum Horizontal Spacing in a Flue</u>		<u>Maximum Horizontal Spacing across Flue</u>				<u>ft</u>	<u>m</u>
	<u>ft</u>	<u>m</u>	<u>ft</u>	<u>m</u>	<u>ft</u>	<u>m</u>				
I	<u>20</u>	<u>6.1</u>	<u>12</u>	<u>3.7</u>	<u>10</u>	<u>3</u>	<u>Between adjacent flues</u>	<u>25.9.2.3.1(a)</u>	<u>10</u>	<u>3</u>
I, II, III	<u>15</u>	<u>4.6</u>	<u>10</u>	<u>3</u>	<u>10</u>	<u>3</u>		<u>25.9.2.3.1(b)</u>	<u>10</u>	<u>3</u>
I, II, III, IV	<u>10</u>	<u>3</u>	<u>10</u>	<u>3</u>	<u>10</u>	<u>3</u>		<u>25.9.2.3.1(c)</u>	<u>5</u>	<u>1.5</u>

aAll four rack faces shall be protected by sprinklers located within the racks and no more than 18 in. (450 mm) from the faces, as indicated in [Figure 25.9.2.3.1\(a\)](#) through [Figure 25.9.2.3.1\(c\)](#). It shall not be required for each sprinkler level to protect all faces.

bAll in-rack sprinkler spacing dimensions start from the floor.

cIn [Figure 25.9.2.3.1\(a\)](#) through [Figure 25.9.2.3.1\(c\)](#), each square represents a storage cube that measures 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. to 10 ft (450 mm to 3.0 m). Therefore, there can be one load to six or seven loads between in-rack sprinklers that are spaced 10 ft (3.0 m) apart vertically.

Figure 25.9.2.3.1(a) In-Rack Sprinkler Arrangement, Class I Commodities, Multiple-Row Racks, Storage Height Over 25 ft (7.6 m).

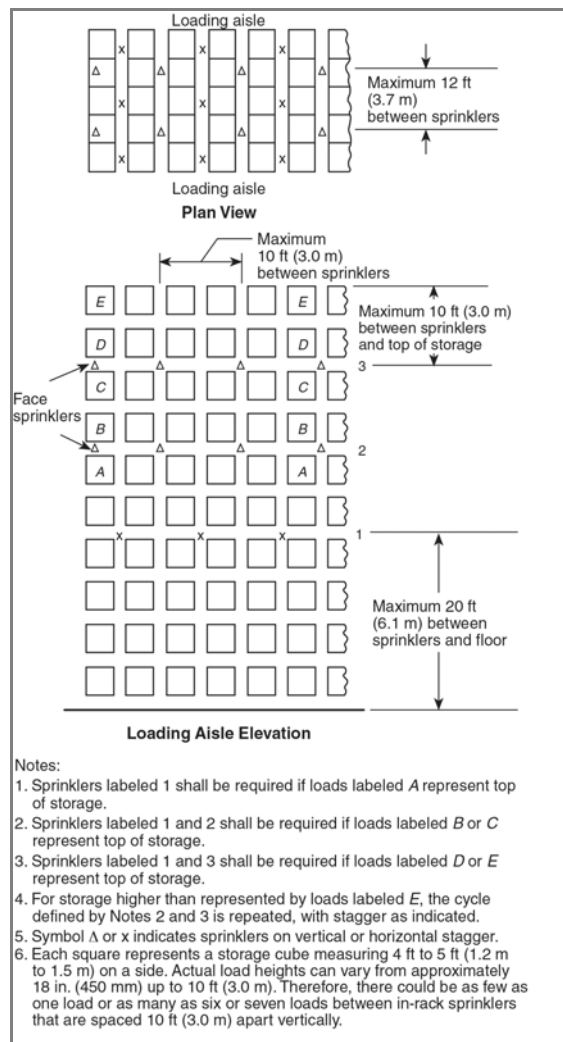


Figure 25.9.2.3.1(b) In-Rack Sprinkler Arrangement, Class I, II, or III Commodities, Multiple-Row Racks, Storage Height Over 25 ft (7.6 m).

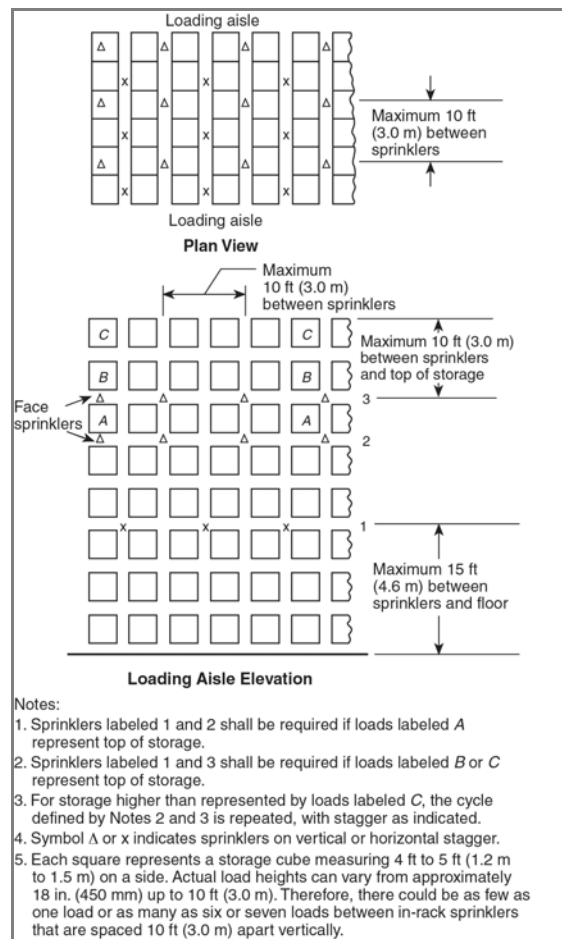
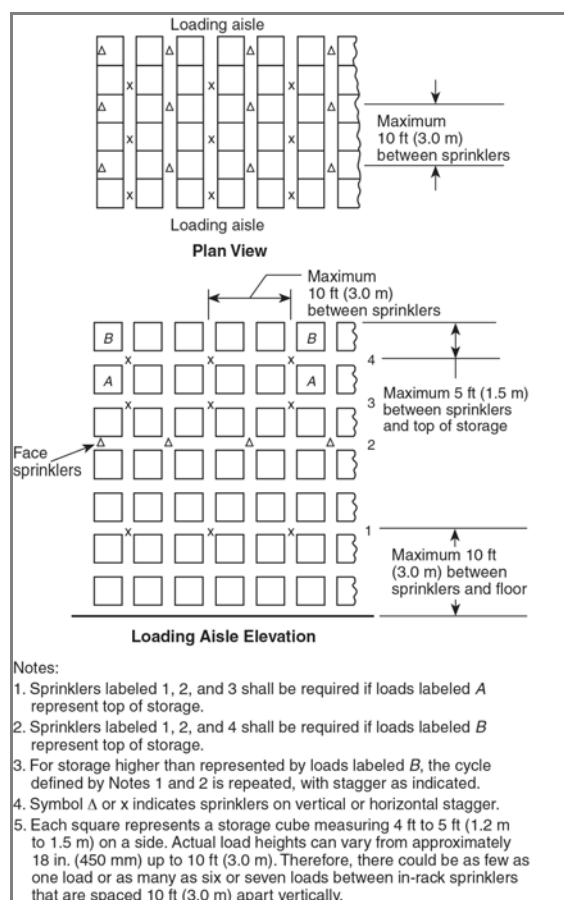


Figure 25.9.2.3.1(c) In-Rack Sprinkler Arrangement, Class I, II, III, or IV Commodities, Multiple-Row Racks, Storage Height Over 25 ft (7.6 m).



A.25.9.2.3.1

In multiple-row racks with more than 10 ft (3.0 m) between the maximum height of storage and ceiling, a horizontal barrier should be installed above storage with a level of sprinklers, spaced as stipulated for in-rack sprinklers, installed directly beneath the barrier. In-rack sprinklers should be installed as indicated in Figure 25.9.2.3.1(a) through Figure 25.9.2.3.1(c). Data indicate that the sprinkler protection criteria in 25.9.2.3 are ineffective, by themselves, for rack storage with solid shelves if the required flue spaces are not maintained. Use of Table 25.9.2.3.1, along with the additional provisions that are required by this standard, can provide acceptable protection.

25.9.3 Rack Storage of Group A Plastic Commodities Up to and Including 25 ft (7.6 m) in Height.

25.9.3.1

Where rack storage of cartoned Group A plastic commodities, encapsulated or nonencapsulated, having a clearance to ceiling up to and including 10 ft (3.1 m) require in-rack sprinklers, in-rack sprinkler arrangements shall be selected from Figure 25.9.3.1(a) through Figure 25.9.3.1(e).

Figure 25.9.3.1(a) In-Rack Sprinkler Arrangement, Cartoned Group A Plastic Storage Up to 15 ft (4.6 m) in Height with Up to 10 ft (3.0 m) Clearance to Ceiling.

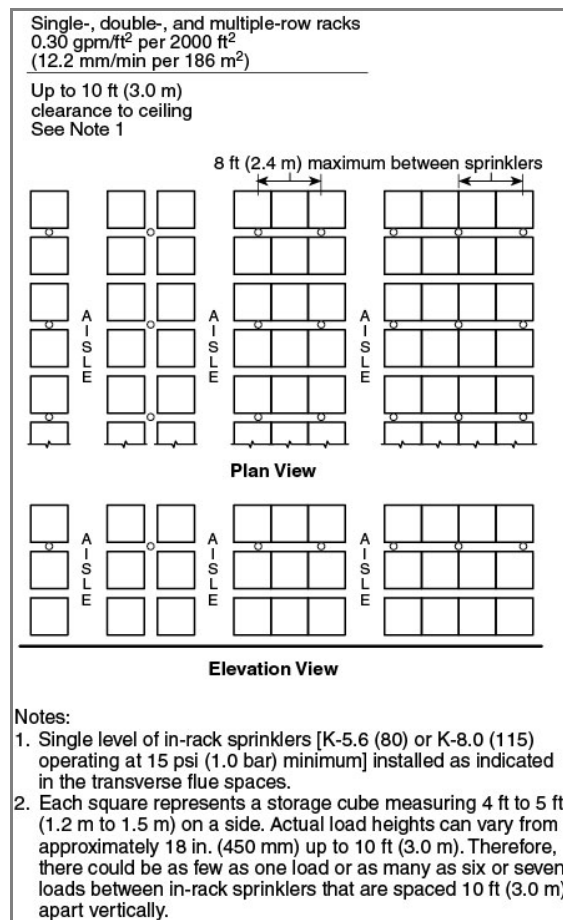


Figure 25.9.3.1(b) In-Rack Sprinkler Arrangement, Cartoned Group A Plastic Storage Up to 20 ft (6.1 m) in Height with <5 ft (1.5 m) Clearance to Ceiling.

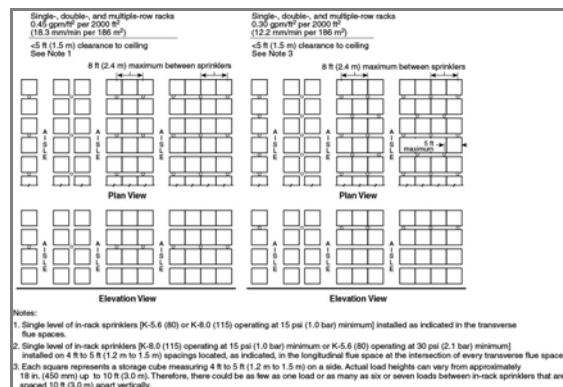


Figure 25.9.3.1(c) In-Rack Sprinkler Arrangement, Cartoned Group A Plastic Storage Up to 20 ft (6.1 m) in Height with 5 ft to 10 ft (1.5 m to 3.0 m) Clearance to Ceiling.

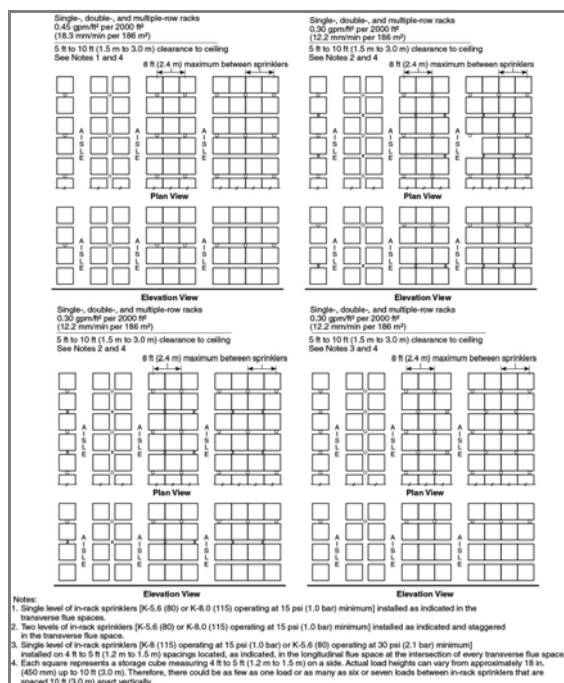


Figure 25.9.3.1(d) In-Rack Sprinkler Arrangement, Cartoned Group A Plastic Storage Up to 25 ft (7.6 m) in Height with <5 ft (1.5 m) Clearance to Ceiling.

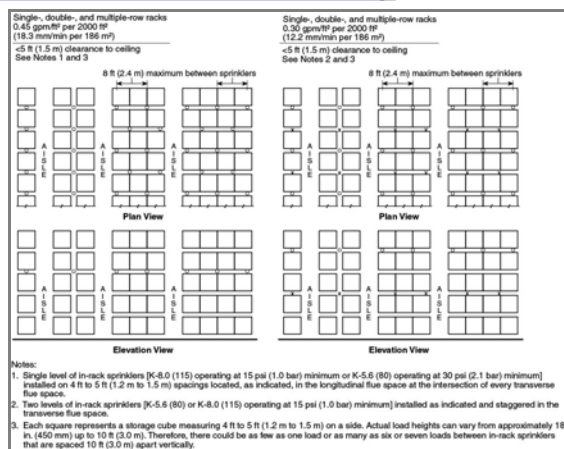
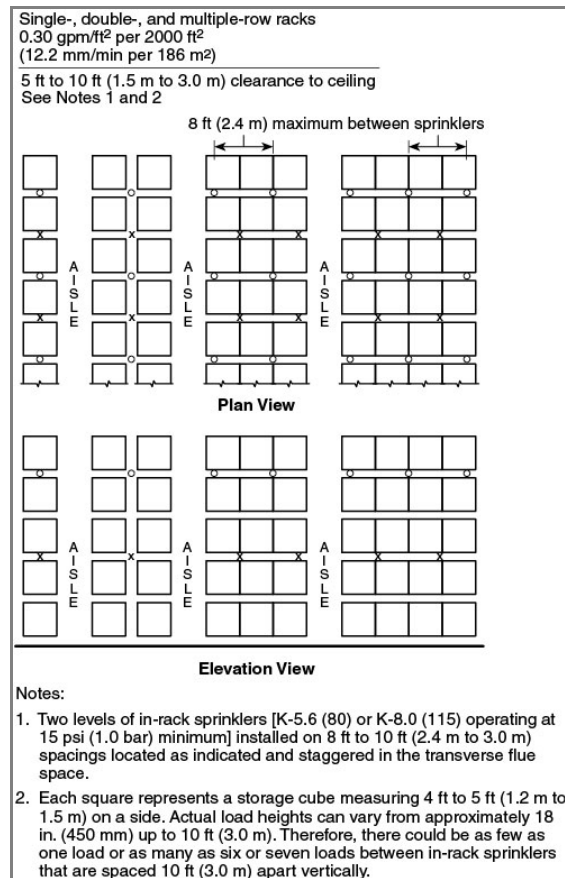


Figure 25.9.3.1(e) In-Rack Sprinkler Arrangement, Cartoned Group A Plastic Storage Up to 25 ft (7.6 m) in Height with 5 ft to 10 ft (1.5 m to 3.0 m) Clearance to Ceiling.



25.9.3.2*

Notes in each figure shall be permitted to clarify options.

A.25.9.3.2

In most of Figure 25.9.3.1(a) through Figure 25.9.3.1(e), the designer is presented with multiple options from which to choose. The single column of boxes in the elevation view represents single-row rack storage. The double column of boxes in the elevation view represents double-row rack storage, and the options with three or four columns of boxes represent different arrangements of multiple-row rack storage. The "o" and "x" characters in the elevation and plan views represent different rows of in-rack sprinklers. The "o" and "x" characters in the elevation view show the vertical spacing of in-rack sprinklers while the characters in the plan view show the horizontal spacing of in-rack sprinklers. Different symbols are used so that the upper and lower levels of in-rack sprinklers can be determined when looking at the plan view.

25.9.3.3*

Where rack storage of exposed nonexpanded Group A plastic commodities, encapsulated or nonencapsulated, require in-rack sprinklers, in-rack sprinkler arrangements shall be selected from Figure 25.9.3.3(a) through Figure 25.9.3.3(k).

Figure 25.9.3.3(a) In-Rack Sprinkler Arrangement, Exposed Nonexpanded Group A Plastic Commodities Up to 10 ft (3.0 m) in Height in Up to a 20 ft (6.1 m) High Building — Option 1.

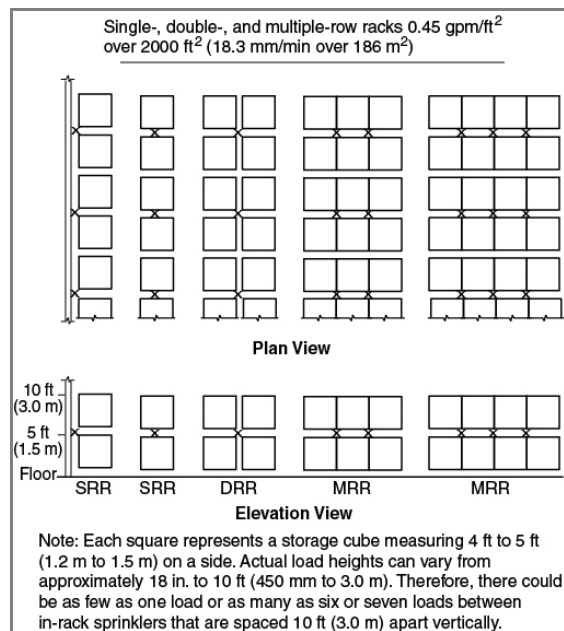


Figure 25.9.3.3(b) In-Rack Sprinkler Arrangement, Exposed Nonexpanded Group A Plastic Commodities Up to 10 ft (3.0 m) in Height in Up to a 20 ft (6.1 m) High Building — Option 2.

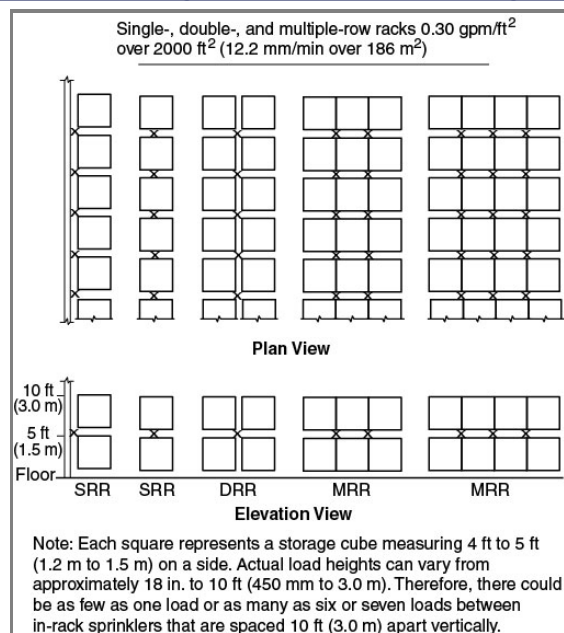


Figure 25.9.3.3(c) In-Rack Sprinkler Arrangement, Exposed Nonexpanded Group A Plastic Commodities Up to 15 ft (4.6 m) in Height in Up to a 25 ft (7.6 m) High Building — Option 1.

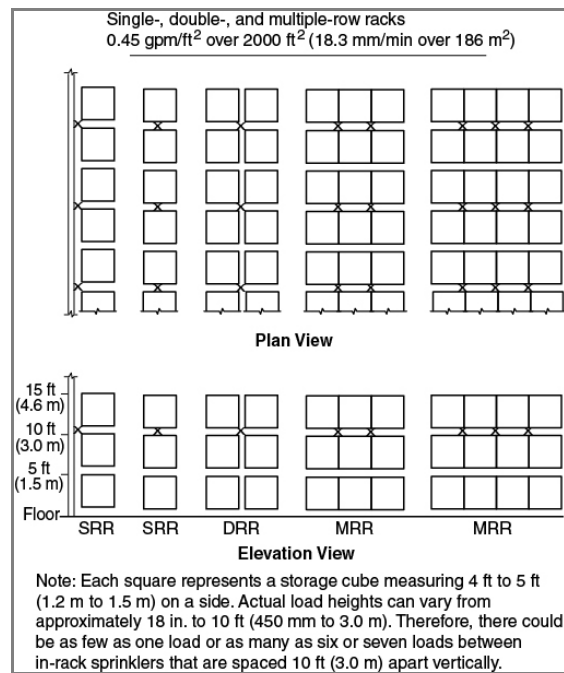


Figure 25.9.3.3(d) In-Rack Sprinkler Arrangement, Exposed Nonexpanded Group A Plastic Commodities Up to 15 ft (4.6 m) in Height in Up to a 25 ft (7.6 m) High Building — Option 2.

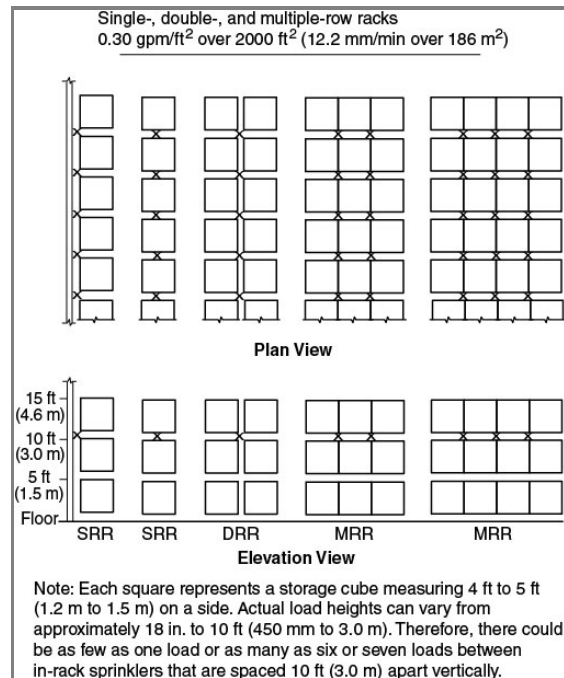


Figure 25.9.3.3(e) In-Rack Sprinkler Arrangement, Exposed Nonexpanded Group A Plastic Commodities Up to 20 ft (6.1 m) in Height in Up to a 25 ft (7.6 m) High Building — Option 1.

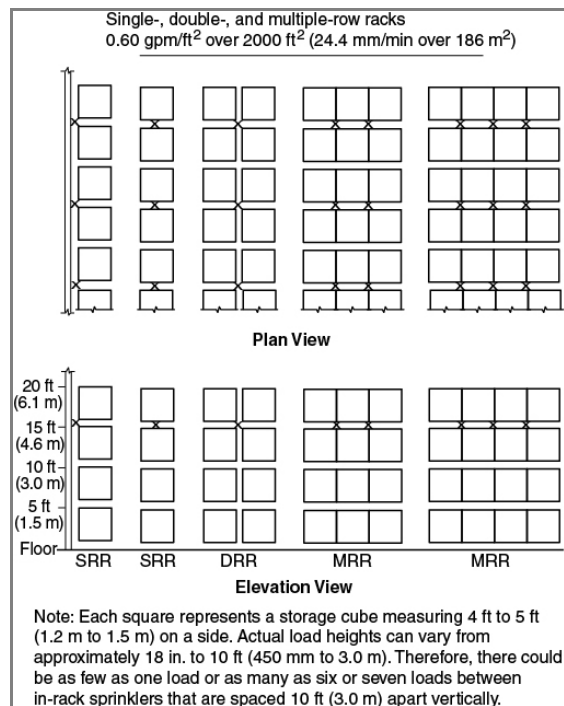


Figure 25.9.3.3(f) In-Rack Sprinkler Arrangement, Exposed Nonexpanded Group A Plastic Commodities Up to 20 ft (6.1 m) in Height in Up to a 25 ft (7.6 m) High Building — Option 2.

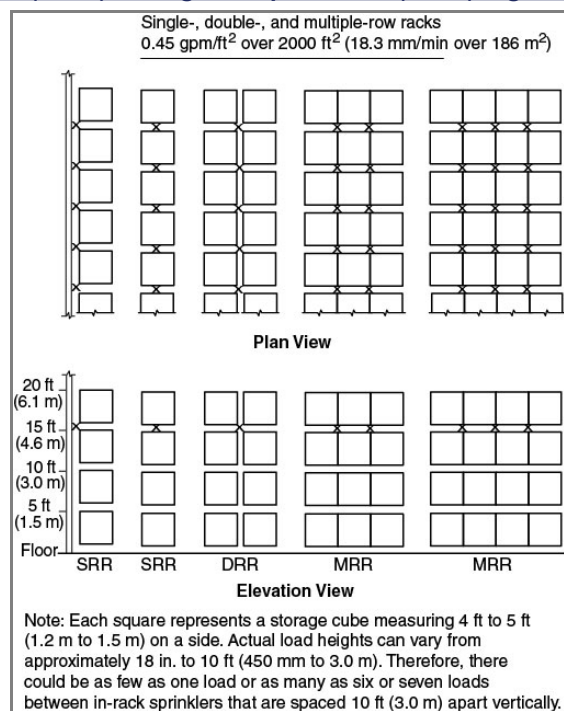


Figure 25.9.3.3(g) In-Rack Sprinkler Arrangement, Exposed Nonexpanded Group A Plastic Commodities Up to 20 ft (6.1 m) in Height in Up to a 30 ft (9.1 m) High Building — Option 1.

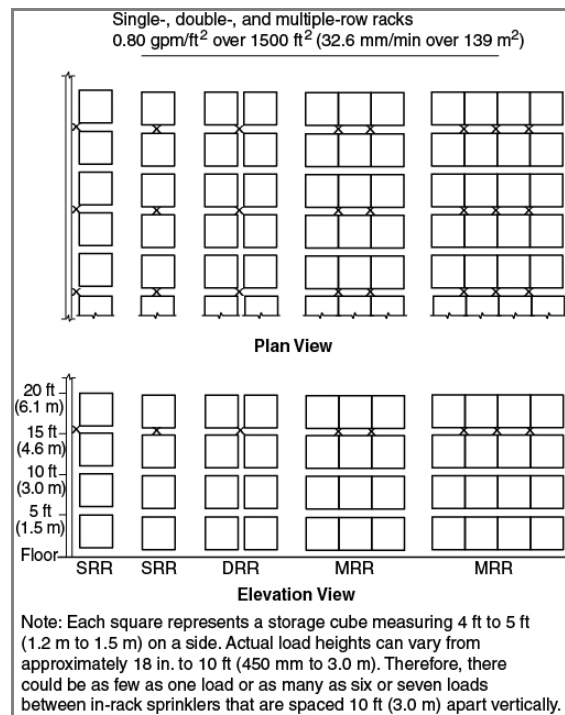


Figure 25.9.3.3(h) In-Rack Sprinkler Arrangement, Exposed Nonexpanded Group A Plastic Commodities Up to 20 ft (6.1 m) in Height in Up to a 30 ft (9.1 m) High Building — Option 2.

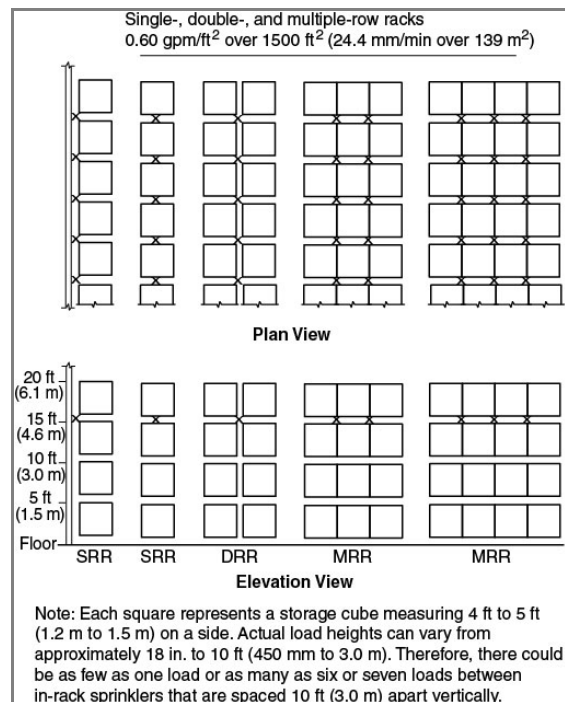


Figure 25.9.3.3(i) In-Rack Sprinkler Arrangement, Exposed Nonexpanded Group A Plastic Commodities Up to 20 ft (6.1 m) in Height in Up to a 30 ft (9.1 m) High Building — Option 3.

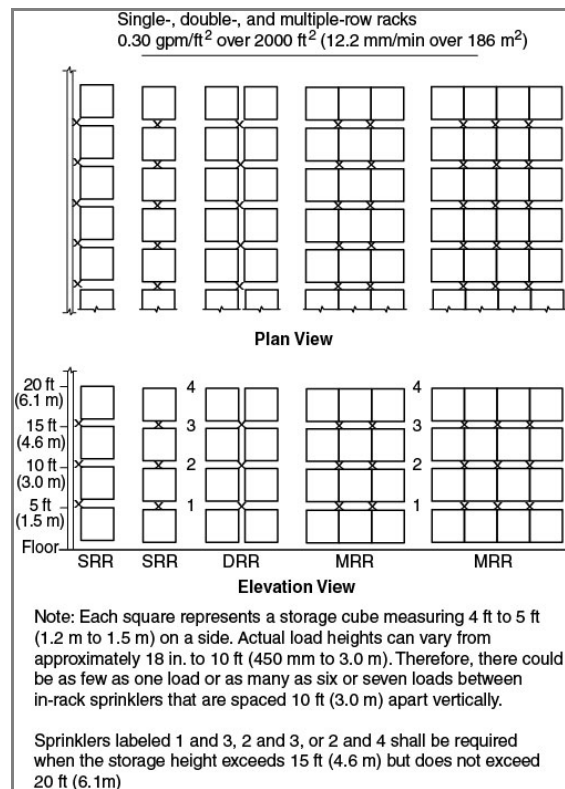


Figure 25.9.3.3(j) In-Rack Sprinkler Arrangement, Exposed Nonexpanded Group A Plastic Commodities Up to 25 ft (7.6 m) in Height in Up to a 35 ft (10.7 m) High Building — Option 1.

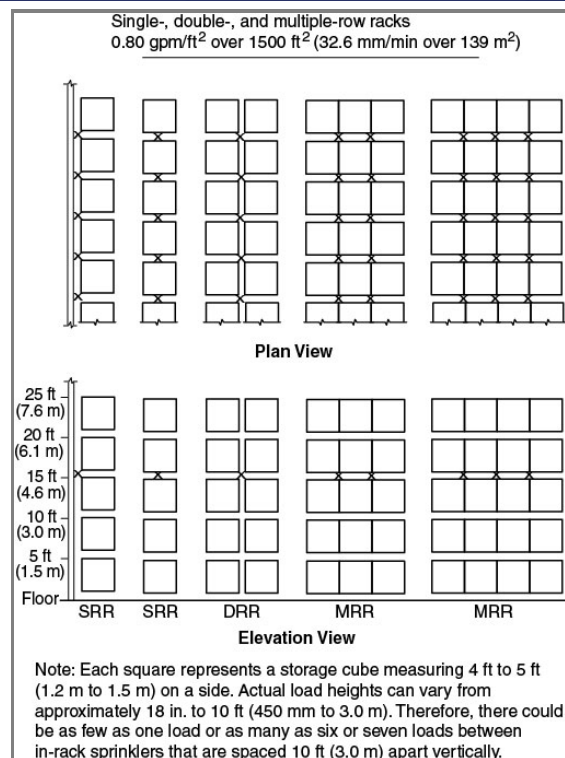
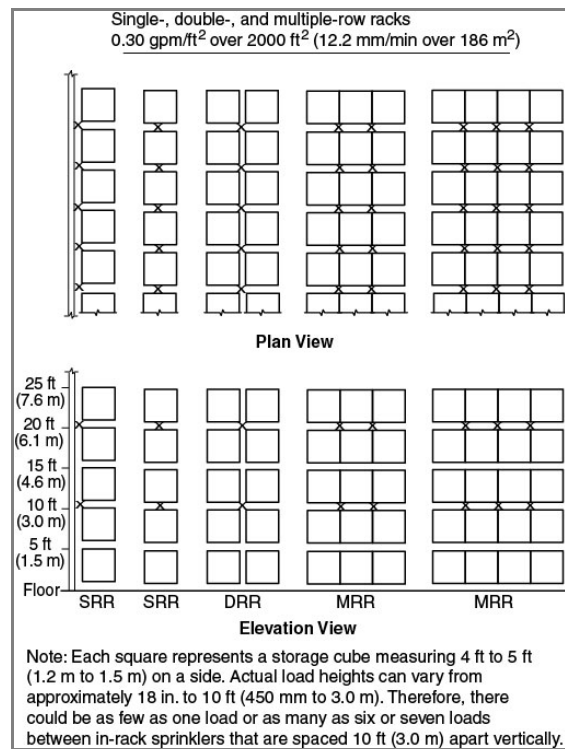


Figure 25.9.3.3(k) In-Rack Sprinkler Arrangement, Exposed Nonexpanded Group A Plastic Commodities Up to 25 ft (7.6 m) in Height in Up to a 35 ft (10.7 m) High Building — Option 2.



A.25.9.3.3

Each of the figures in [25.9.3.3](#) shows a variety of different potential rack arrangements. The first single-row rack (SRR) to the left in each figure shows a rack against a wall. The second SRR shows a single-row rack with aisles on each side. The double-row rack (DRR) is in the center of the figure. The first multiple-row rack (MRR) shows the in-rack sprinkler position for racks up to 15 ft (4.6 m) long in the dimension parallel to the transverse flue. The second MRR shows longer rack structures where the in-rack sprinkler pattern would repeat.

25.9.4 Rack Storage of Group A Plastic Commodities Over 25 ft (7.6 m) in Height.

25.9.4.1 Single-Row Racks.

25.9.4.1.1

Where single-row rack storage of cartoned Group A plastic commodities, expanded or nonexpanded, encapsulated or nonencapsulated, is over 25 ft (7.6 m) in height, in-rack sprinklers shall be arranged in accordance with one of the options in Figure 25.9.4.1.1(a) through Figure 25.9.4.1.1(d).

Figure 25.9.4.1.1(a) In-Rack Sprinkler Arrangement, Cartoned Group A Plastic Commodities, Single-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 1.

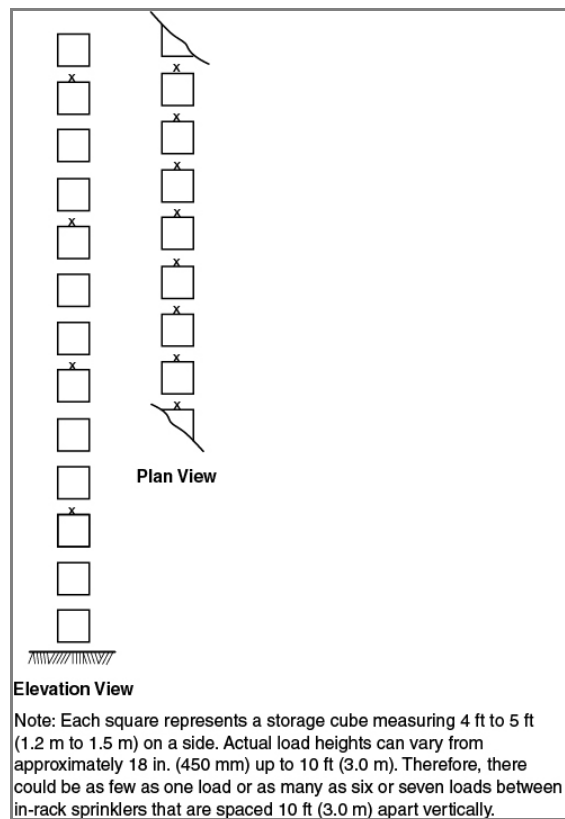


Figure 25.9.4.1.1(b) In-Rack Sprinkler Arrangement, Cartoned Group A Plastic Commodities, Single-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 2.

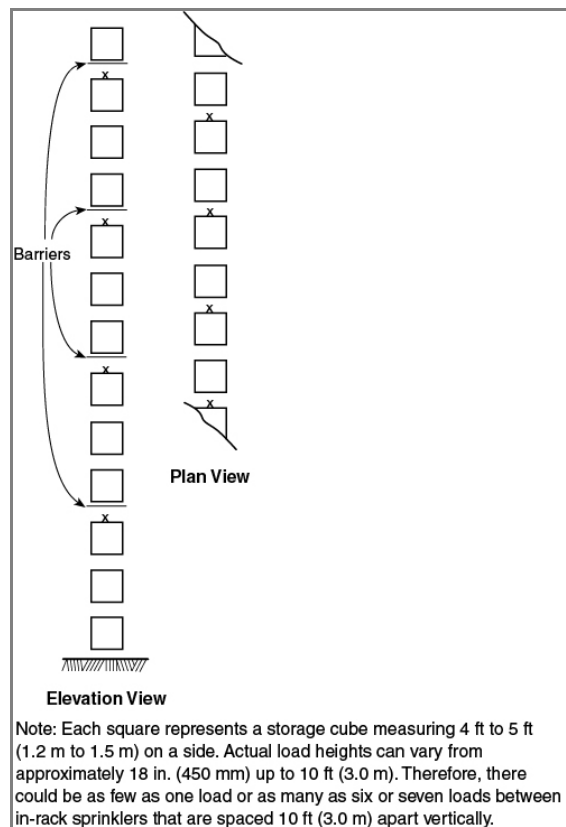


Figure 25.9.4.1.1(c) In-Rack Sprinkler Arrangement, Cartoned Group A Plastic Commodities, Single-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 3.

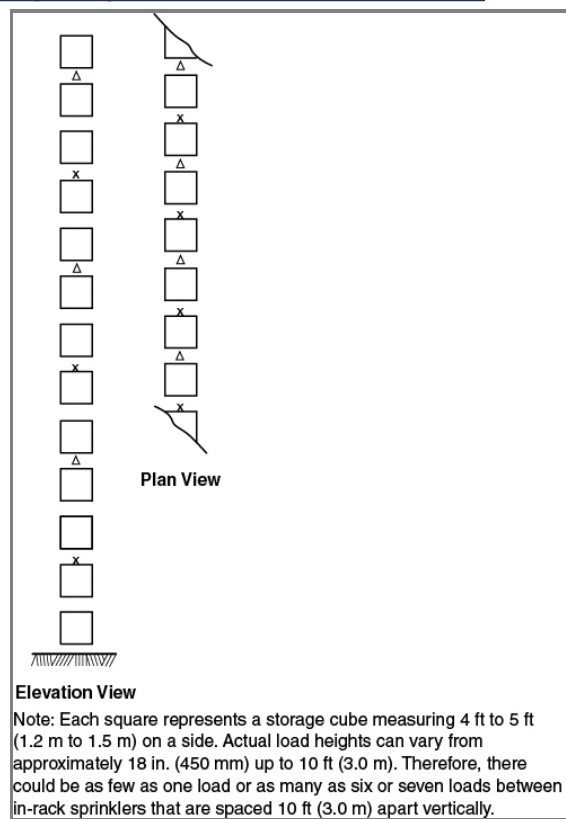
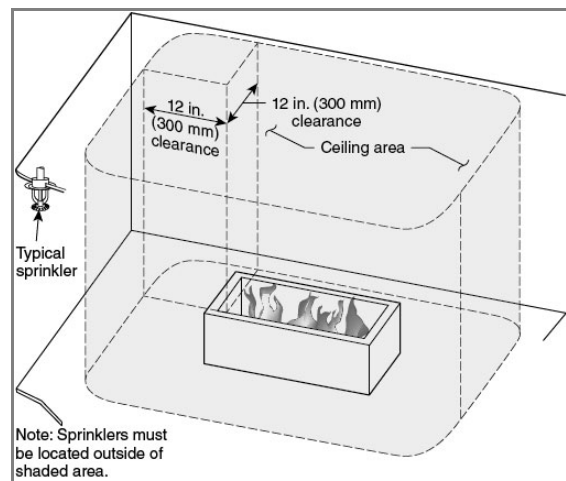


Figure 25.9.4.1.1(d) In-Rack Sprinkler Arrangement, Cartoned Group A Plastic Commodities, Single-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 4.



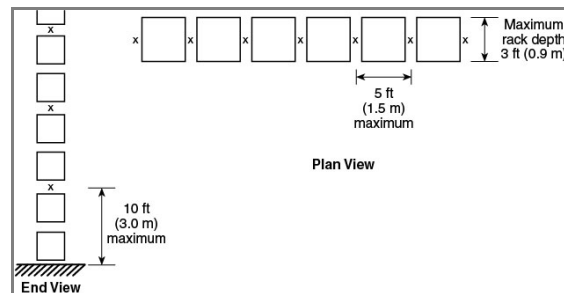
25.9.4.1.2

Where a single-row rack of cartoned Group A plastic commodities is located against a wall, the in-rack sprinkler arrangement shall be permitted to be in accordance with [Figure 25.9.4.2.1\(a\)](#) or [Figure 25.9.4.2.1\(b\)](#).

25.9.4.1.3

Where single-row rack storage of exposed nonexpanded Group A plastic commodities, encapsulated or nonencapsulated, is over 25 ft (7.6 m) in height and the rack depth is a maximum 3 ft (0.9 m), in-rack sprinklers shall be arranged in accordance with [Figure 25.9.4.1.3](#).

Figure 25.9.4.1.3 In-Rack Sprinkler Arrangement, Exposed, Nonexpanded Group A Plastic Commodities, Single-Row Racks Up to 3 ft (0.9 m) Deep, Storage Height Over 25 ft (7.6 m).



25.9.4.1.3.1

The highest level of in-rack sprinklers shall not be more than 10 ft (3.0 m) below the top of storage.

25.9.4.1.3.2

Where [Figure 25.9.4.1.3](#) is used, aisles shall be at least 4 ft (1.2 m) wide and the ceiling sprinklers shall be designed for a minimum discharge density of 0.45 gpm/ft² over 2000 ft² (18.3 mm/min over 186 m²).

25.9.4.1.4

Where single-row rack storage of exposed nonexpanded Group A plastic commodities, encapsulated or nonencapsulated, is over 25 ft (7.6 m) in height and the rack depth is greater than 3 ft (0.9 m), in-rack sprinklers shall be arranged in accordance with [Section 25.8](#).

25.9.4.2 Double-Row Racks.

25.9.4.2.1

Where double-row rack storage of cartoned Group A plastic commodities, expanded or nonexpanded, encapsulated or nonencapsulated, is over 25 ft (7.6 m) in height, in-rack sprinklers shall be arranged in accordance with one of the options in [Figure 25.9.4.2.1\(a\)](#) or [Figure 25.9.4.2.1\(b\)](#). [Figure 25.9.4.2.1\(c\)](#) shall be permitted to be used as an option for double-row racks up to 9 ft (2.7 m) deep.

Figure 25.9.4.2.1(a) In-Rack Sprinkler Arrangement, Cartoned Group A Plastic Commodities, Double-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 1.

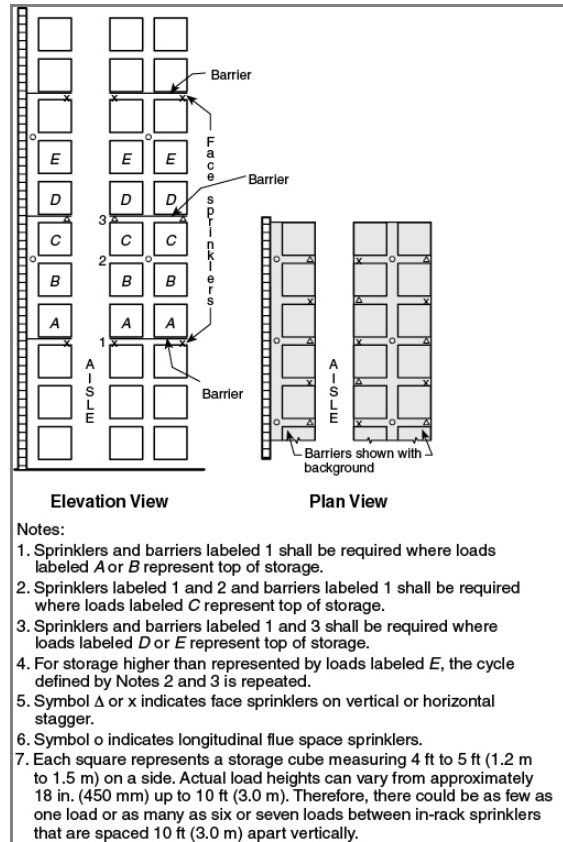


Figure 25.9.4.2.1(b) In-Rack Sprinkler Arrangement, Cartoned Group A Plastic Commodities, Double-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 2.

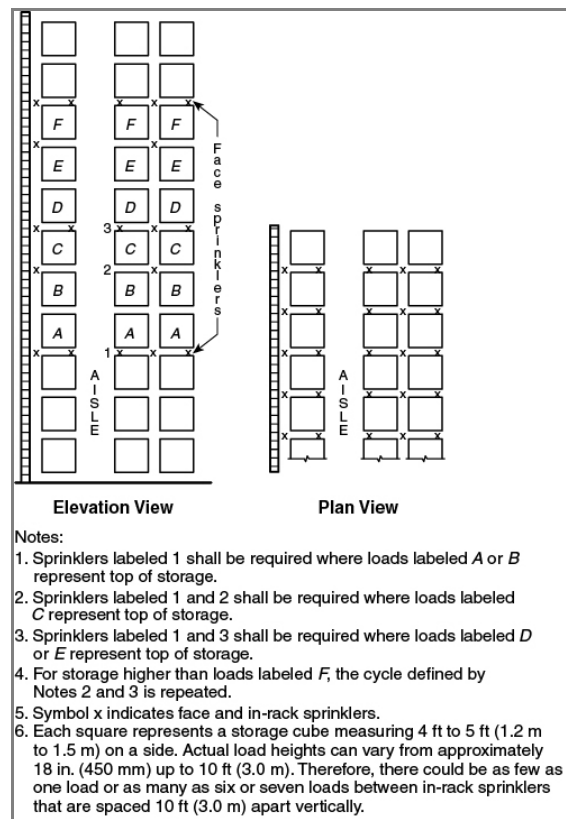
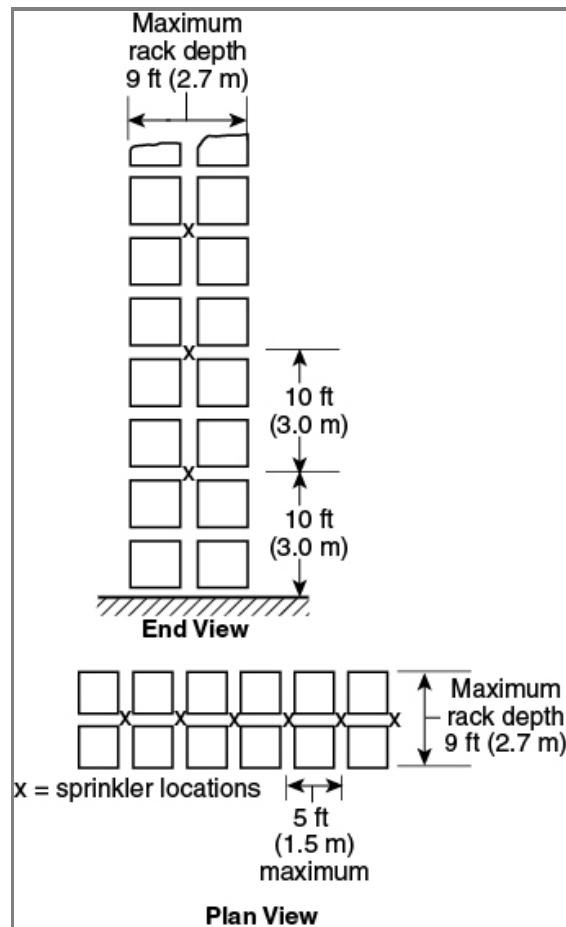


Figure 25.9.4.2.1(c) In-Rack Sprinkler Arrangement, Cartoned Group A Plastic Commodities, Double-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 3.



25.9.4.2.2*

Where double-row rack storage of exposed nonexpanded Group A plastic commodities, whether encapsulated or nonencapsulated, is over 25 ft (7.6 m) in height and has minimum 4 ft (1.2 m) wide aisles, in-rack sprinklers shall be arranged in accordance with Section 25.8 .

A.25.9.4.2.2

All arrangements of exposed nonexpanded Group A plastic commodities cannot be protected with all types of sprinklers. Only certain combinations of ceiling sprinklers and in-rack sprinklers have been found to provide acceptable protection.

25.9.4.2.3

Protection of Group A plastic commodities that are exposed and nonexpanded, whether encapsulated or nonencapsulated racks and with a clearance to ceiling up to and including 10 ft (3.1 m), shall be permitted to only use in-rack sprinkler arrangements that are specifically permitted to be used with exposed nonexpanded Group A plastic commodities.

25.9.4.3 Multiple-Row Racks.**25.9.4.3.1***

Where multiple-row rack storage of exposed nonexpanded Group A plastic commodities, encapsulated or nonencapsulated, or cartoned Group A plastic commodities, expanded or nonexpanded, encapsulated or nonencapsulated, is over 25 ft (7.6 m) in height, in-rack sprinklers shall be arranged in accordance with one of the options in Figure 25.9.4.3.1(a) through Figure 25.9.4.3.1(f).

Figure 25.9.4.3.1(a) In-Rack Sprinkler Arrangement, Cartoned Group A Plastic and Exposed Nonexpanded Group A Plastic Commodities, Multiple-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 1 [10 ft (3.0 m) Maximum Spacing].

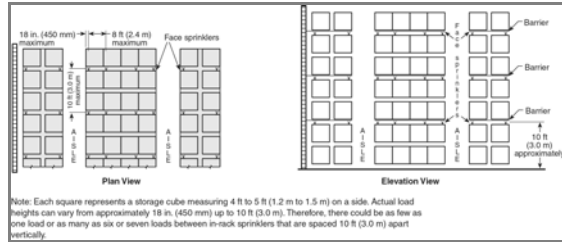


Figure 25.9.4.3.1(b) In-Rack Sprinkler Arrangement, Cartoned Group A Plastic and Exposed Nonexpanded Group A Plastic Commodities, Multiple-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 2 [10 ft (3.0 m) Maximum Spacing].

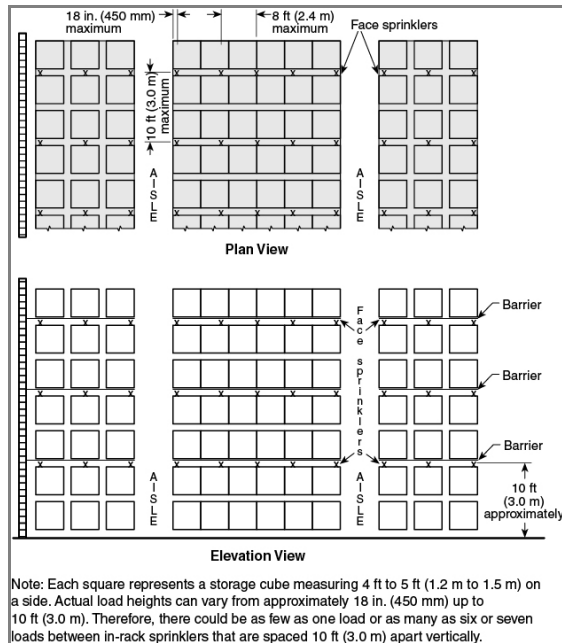


Figure 25.9.4.3.1(c) In-Rack Sprinkler Arrangement, Cartoned Group A Plastic and Exposed Nonexpanded Group A Plastic Commodities, Multiple-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 1 [5 ft (1.5 m) Maximum Spacing].

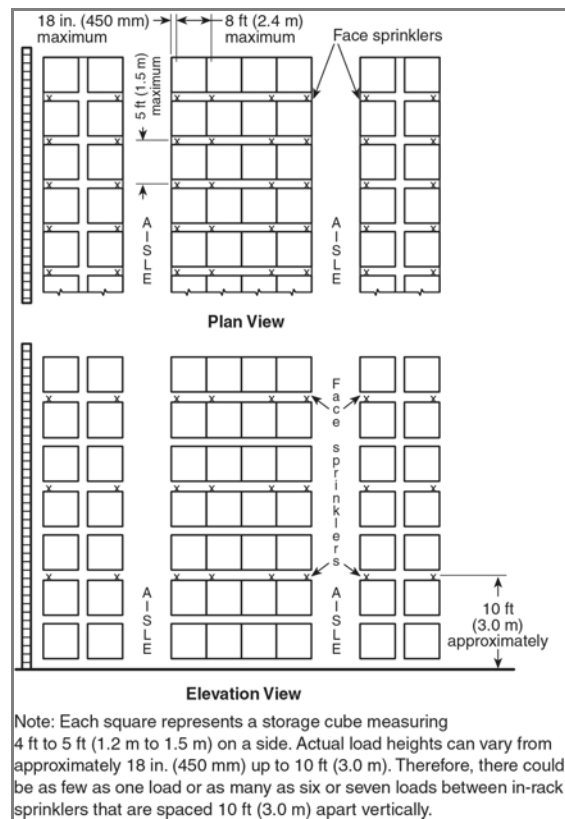


Figure 25.9.4.3.1(d) In-Rack Sprinkler Arrangement, Cartoned Group A Plastic and Exposed Nonexpanded Group A Plastic Commodities, Multiple-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 2 [5 ft (1.5 m) Maximum Spacing].

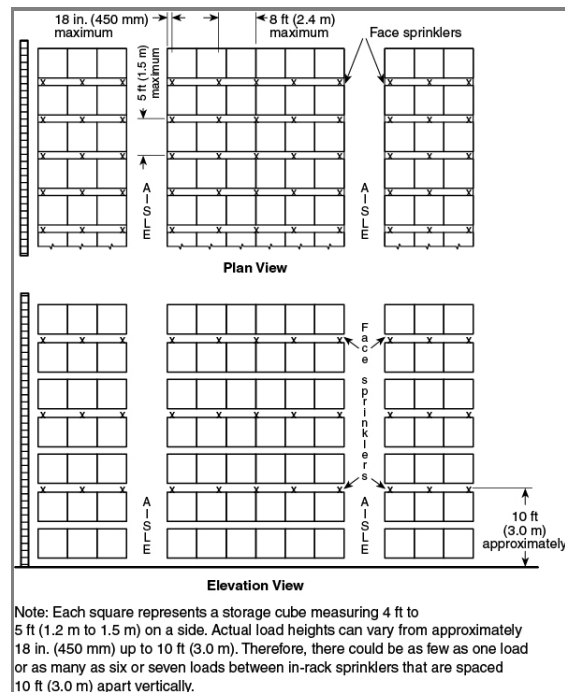


Figure 25.9.4.3.1(e) In-Rack Sprinkler Arrangement, Cartoned Group A Plastic and Exposed Nonexpanded Group A Plastic Commodities, Multiple-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 3 [5 ft (1.5 m) Maximum Spacing].

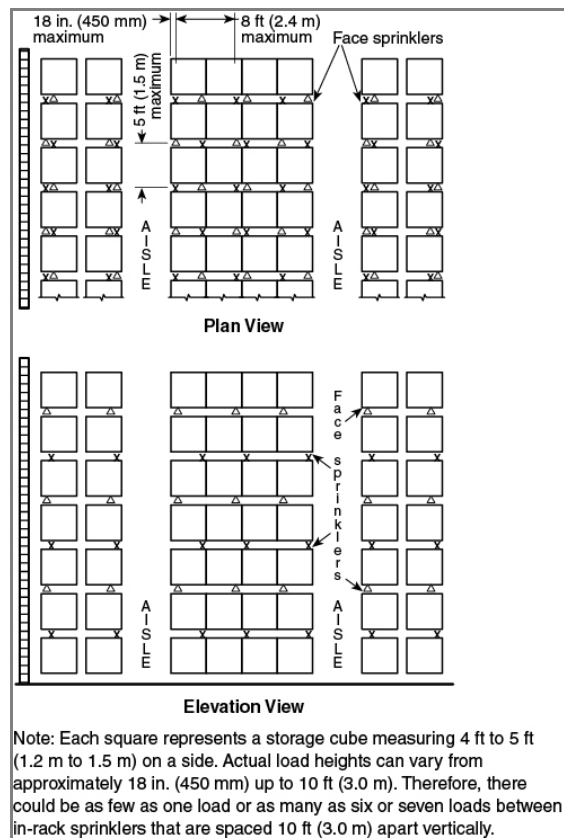
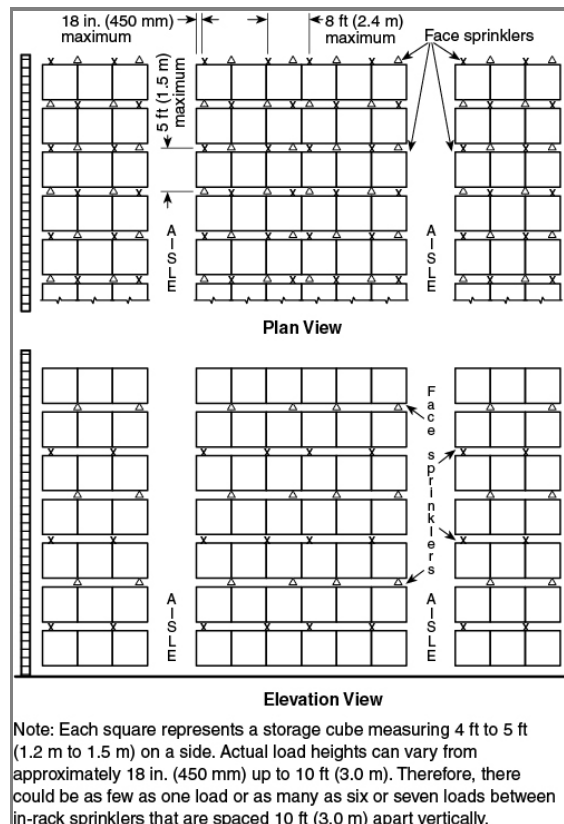


Figure 25.9.4.3.1(f) In-Rack Sprinkler Arrangement, Cartoned Group A Plastic and Exposed Nonexpanded Group A Plastic Commodities, Multiple-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 4 [5 ft (1.5 m) Maximum Spacing].



A.25.9.4.3.1

All arrangements of exposed nonexpanded Group A plastic commodities cannot be protected with all types of sprinklers. Only certain combinations of ceiling sprinklers and in-rack sprinklers have been found to provide acceptable protection.

25.9.5 In-Rack Sprinkler Arrangements Due to Excessive Clearance.**25.9.5.1**

Where the clearance to ceiling for rack storage of Class 1 through Class IV commodities up to and including 25 ft (7.6 m) in height protected by CMDA ceiling-level sprinklers exceeds 20 ft (6.1 m) and the ceiling-level protection is not capable of providing the protection needed for the storage height that would result in a clearance to ceiling of 20 ft (6.1 m), one level of supplemental, quick-response in-rack sprinklers located directly below the top tier of storage and at every flue space intersection shall be installed.

25.9.5.2

Where the clearance to ceiling for rack storage of Group A plastic commodities up to and including 25 ft (7.6 m) in height protected by CMDA ceiling-level sprinklers exceeds 10 ft (3.0 m), and the ceiling-level protection is not capable of providing the protection needed for the storage height that would result in a clearance to ceiling of 10 ft (3.0 m), one level of supplemental, quick-response in-rack sprinklers located directly below the top tier of storage and at every flue space intersection shall be installed.

25.9.5.3

Where the clearance to ceiling exceeds 10 ft (3.0 m) for rack storage over 25 ft (7.6 m) in height, and the ceiling-level protection is not capable of providing the protection needed for the storage height that would result in a clearance to ceiling of 10 ft (3.0 m), one level of supplemental, quick-response in-rack sprinklers located directly below the top tier of storage and at every flue space intersection shall be installed.

25.9.5.4

Where the supplemental in-rack sprinkler protection has been installed in accordance with this section, the ceiling-level sprinkler system design shall be based on the storage height that results in an acceptable clearance to ceiling.

25.9.5.5

Where in-rack sprinklers are required for the actual storage height based on a theoretical acceptable clearance to ceiling, in-rack sprinklers shall be installed as indicated by that criteria and supplemented as outlined in this section.

25.9.6 Rack Storage of Rubber Tires Up to and Including 20 ft (6.1 m) in Height.

The in-rack arrangements for rack storage of rubber tires, either on-side or on-tread, up to and including 20 ft (6.1 m) in height shall be in accordance with the guidelines outlined in Sections 25.4 through 25.7 as applicable.

25.10 In-Rack Sprinkler Arrangements in Combination with CMSA Sprinklers at Ceiling Level.**25.10.1* Rack Storage of Class I Through Class IV and Group A Plastic Commodities.**

The in-rack arrangements for rack storage of Class I through Class IV and Group A plastic commodities protected by CMSA sprinklers at ceiling level shall be in accordance with the guidelines outlined in Sections 25.4 through 25.7 as applicable.

A.25.10.1

There are currently no situations where in-rack sprinklers are required to be used to protect Group A plastic commodities stored over 25 ft (7.6 m) in height where CMSA sprinklers are used at the ceiling.

25.11 In-Rack Sprinkler Arrangements in Combination with ESFR Sprinklers at Ceiling Level.

25.11.1 Rack Storage of Class I Through Class IV and Group A Plastic Commodities.

The in-rack arrangements for rack storage of Class I through Class IV and Group A plastic commodities protected by ESFR sprinklers at ceiling level shall be in accordance with the guidelines outlined in Sections 25.4 through 25.7 as applicable.

25.12 Design Criteria for In-Rack Sprinklers in Combination with Ceiling-Level Sprinklers.**25.12.1 General.****25.12.1.1**

In-rack sprinkler design criteria for Group A plastic commodities shall be permitted for the protection of the same storage height and configuration of Class I, II, III, and IV commodities.

25.12.1.2

Pipe sizing of an in-rack sprinkler system shall be permitted to be based on hydraulic calculations and not restricted by any pipe schedule.

25.12.1.3

Where in-rack sprinklers are being installed to protect a storage rack and, due to the length of the rack, fewer in-rack sprinklers will be installed than the number of in-rack sprinklers specified in the in-rack design, the in-rack sprinkler design shall be based on only those in-rack sprinklers installed within the protected rack.

25.12.1.4

Where in-rack sprinkler arrangements have been installed in accordance with this chapter, except for Section 25.8, the flow and pressure requirements of both the ceiling and in-rack sprinkler systems over the same protected area shall be hydraulically balanced together to the higher sprinkler system pressure requirement at their point of connection.

25.12.1.5

The minimum water supply requirements for a hydraulically designed occupancy hazard automatic in-rack sprinkler system shall be determined by adding the hose stream allowance from Table 20.12.2.6 to the water supply for ceiling-level sprinklers determined in Section 25.2, unless indicated otherwise.

25.12.2 Number of Operating In-Rack Sprinklers.

25.12.2.1

The number of in-rack sprinklers in the design of the in-rack sprinkler system shall be in accordance with [Table 25.12.2.1](#) .

Table 25.12.2.1 In-Rack Sprinkler System Design: Number of In-Rack Sprinklers

<u>Type of Storage</u>	<u>Commodity Class</u>	<u>Rack Type</u>	<u>Ceiling Sprinkler Type</u>	<u>No. of Required In-Rack Sprinkler Levels</u>	<u>No. of In-Rack Sprinklers in the Design</u>
Miscellaneous	Class I through IV, Group A plastics, and rubber tires	Any	Any	Any	4
Storage not meeting the definition of miscellaneous	Class I through III	Solid shelf	Any	One	6
			Any	More than one	10 (5 on each of the top two levels)
		Open	CMDA	One	6
			CMDA	More than one	10 (5 on each of the top two levels)
	Class I through IV	Open	CMSA	One	8
	Class I through IV and Group A plastics	Open	ESFR	One	8
	Class IV	Open	CMDA	More than one	10 (5 on each of the top two levels)
	Class IV and Group A plastics	Solid shelf	Any	One	8
				More than one	14 (7 on each of the top two levels)
		Open	CMDA	One	8
				More than one	14 (7 on each of the top two levels)
	Group A plastics	Open	CMSA	One	8
	Rubber tires	Open	CMDA	One	12

25.12.3 [In-Rack Sprinkler Flow/Pressure.](#)

25.12.3.1

The required flow or pressure required from the most remote in-rack sprinkler in the design of the in-rack sprinkler system shall be in accordance with [Table 25.12.3.1](#).

Table 25.12.3.1 In-Rack Sprinkler System Design: Minimum Required Flow/Pressure from In-Rack Sprinklers

Type of Storage	Commodity Class	Rack Type	Ceiling Sprinkler Type	Storage Height		Minimum Design Flow/Pressure for In-Rack Sprinklers
				ft	m	
Miscellaneous	Class I through IV, Group A plastics, and rubber tires	Any	Any	Any	Any	15 psi (1.0 bar)
Storage not meeting the definition of miscellaneous	Class I through IV	Open	CMDA	Up to 25	Up to 7.6	15 psi (1.0 bar)
			CMSA	Any	Any	15 psi (1.0 bar)
	Class I through IV and Group A plastics	Open	CMDA	Over 25	Over 7.6	30 gpm (115 L/min)
			ESFR	Any	Any	60 gpm (230 L/min)
		Solid shelves	Any	Any	Any	30 gpm (115 L/min)
	Group A plastics	Open	CMDA	Up to 25	Up to 7.6	15 psi (1.0 bar)
			CMSA	Up to 25	Up to 7.6	15 psi (1.0 bar)
	Rubber tires	Open	CMDA	Any	Any	30 psi (2.1 bar)

25.1 General Requirements of In-Rack Sprinklers.**25.1.1 Scope.**

This section shall apply where rack storage of Class I through Class IV commodities, Group A plastic commodities, or rubber tires will be protected with in-rack sprinklers.

25.1.2 Open-Frame Storage Racks.**25.1.2.1**

The in-rack sprinkler arrangements as well as the ceiling and in-rack sprinkler design criteria for rack storage in this chapter shall be based on open-frame rack configurations as defined in [3.3.141](#) unless indicated otherwise.

25.1.2.2

Where Group A commodities are being stored in racks with aisles less than 3.5 ft (1.1 m) wide, in-rack sprinkler protection shall be in accordance with the guidelines for multiple-row racks.

25.1.2.3

Where open-frame double-row racks with storage up 25 ft (7.6 m) in height have no longitudinal flue, but have transverse flues at maximum 5 ft (1.5 m) intervals, the double-row rack storage arrangement shall be considered open-frame.

25.1.2.4

Where multiple-row racks of any height have no longitudinal flue, but have transverse flues at maximum 5 ft (1.5 m) intervals, the multiple-row rack storage arrangement shall be considered open-frame.

25.1.3 In-Rack Sprinkler System.**25.1.3.1 In-Rack Sprinkler System Size.**

25.1.3.1.1

The area protected by a single in-rack sprinkler system shall not exceed 40,000 ft² (3720 m²) of floor area occupied by the racks, including aisles, regardless of the number of in-rack sprinkler levels.

25.1.3.1.2

An in-rack sprinkler system shall be permitted to be supplied from the overhead ceiling sprinkler system where the area of the racks protected by the in-rack sprinklers, including the adjacent aisles, do not exceed 8,000 ft² (740 m²).

25.1.3.2* In-Rack Sprinkler System Control Valves.**25.1.3.2.1**

Unless the requirements of 25.1.3.2.2 or 25.1.3.2.3 are met, separate indicating control valves and drains shall be provided and arranged so that ceiling and in-rack sprinkler systems can be controlled independently.

25.1.3.2.2

Installation of 20 or fewer in-rack sprinklers supplied by any one ceiling sprinkler system shall not require a separate indicating control valve.

25.1.3.2.3

The separate indicating valves shall be permitted to be arranged as sectional control valves supplied from the ceiling sprinkler system where in-rack sprinklers are required and the racks including the adjacent aisles occupy 8000 ft² (740 m²) or less of the area protected by the ceiling sprinklers.

25.1.3.3* Sprinkler Waterflow Alarm for In-Rack Sprinklers.

See Section C.4.

25.1.4 Flue Space Requirements for Racks Protected by In-Rack Sprinklers.**25.1.4.1**

Where in-rack sprinklers are protecting rack storage, nominal 6 in. (150 mm) transverse flue spaces between loads and at rack uprights shall be maintained.

25.1.4.2

Where in-rack sprinklers are protecting rack storage, random variations in the width of flue spaces or in their vertical alignment shall be permitted.

25.1.4.3

Where in-rack sprinklers are protecting double and multiple row rack storage up to and including 25 ft (7.6 m) in height, a longitudinal (back to back clearance between loads) flue space shall not be required.

25.1.4.4

Where in-rack sprinklers are protecting double row racks over 25 ft (7.6 m) in height, nominal 6 in. (150 mm) longitudinal flue spaces shall be provided.

25.1.5 Building Steel Protection.

Where in-rack sprinklers are installed in accordance with this chapter, building steel shall not require special protection.

25.1.6 Movable Racks.

Rack storage in movable racks shall be protected in the same manner as multiple row racks.

25.2 Ceiling-Level Sprinkler Design Criteria in Combination with In-Rack Sprinklers.**25.2.1 General.****25.2.1.1***

This section shall apply to storage of materials, such as Class I through Class IV and Group A plastic commodity as well as rubber tires, representing the broad range of combustibles stored in racks that are being protected by in-rack sprinklers. The requirements of Chapter 20 shall apply unless modified by this chapter. (See Section C.9.)

25.2.1.2*

Ceiling-level sprinkler design criteria for single-, double-, and multiple-row racks in 25.2 shall be based on open rack configurations as defined in 3.3.144.

25.2.1.3*

Ceiling-level sprinkler design criteria for Group A plastic commodities in this chapter shall be permitted for the protection of the same storage height and configuration of Class I, II, III, and IV commodities.

25.2.1.4

Ceiling-level sprinkler design criteria for single- and double-row rack storage of Group A plastic commodities shall be applicable where aisles are 3.5 ft (1.1 m) or greater in width.

25.2.1.5

Ceiling-level sprinkler design criteria for rack storage of Group A plastic commodities shall be protected as multiple-row racks where aisles are less than 3.5 ft (1.1 m) in width.

25.2.1.6

The minimum water supply requirements for a hydraulically designed occupancy hazard automatic ceiling-level sprinkler system shall be determined by adding the hose stream allowance from Table 20.12.2.6 to the water supply for in-rack sprinklers determined in Section 25.12, unless indicated otherwise.

25.2.2 Miscellaneous and Low-Piled Storage.**25.2.2.1 Miscellaneous Storage.****25.2.2.1.1**

This section shall apply to any of the following situations:

Miscellaneous storage of Class I through Class IV commodities up to and including 12 ft (3.7 m) in height

Miscellaneous storage of Group A plastic commodities up to and including 12 ft (3.7 m) in height

Miscellaneous storage of rubber tires up to and including 12 ft (3.7 m) in height

25.2.2.1.2

Where in-rack sprinklers are installed in accordance with Section 25.4 through Section 25.7 to protect miscellaneous rack storage of Class I through Class IV and Group A plastic commodities, as well as miscellaneous rack storage of rubber tires, up to and including 12 ft (3.7 m) in height under a maximum 32 ft (10.0 m) high ceiling, the ceiling-level sprinkler design criteria shall be in accordance with Figure 25.2.2.1.2.

Figure 25.2.2.1.2 CMDA Ceiling-Level Sprinkler Design Criteria for Miscellaneous Storage Protected with One Level of In-Rack Sprinklers**25.2.2.1.3**

Installation criteria as permitted by NFPA 13 and design criteria and modifiers as permitted by the density/area method of Section 19.2 for ordinary hazard Group 2 occupancies shall be applicable.

25.2.2.1.4 Hose Connections.

Hose connections shall not be required for the protection of miscellaneous storage.

25.2.2.2 Low-Piled Storage.**25.2.2.2.1**

This section shall apply to any of the following situations:

Storage of Class I through Class IV commodities up to 12 ft and including (3.7 m) in height.

* Storage of Group A plastic commodities up to and including 5 ft (1.5 m) in height.

25.2.2.2.2

For low-piled rack storage with solid shelves of Class I through Class IV commodities up to and including 12 ft (3.7 m) in height, in-rack sprinklers shall be provided in accordance with Section 25.6 , and the ceiling-level sprinkler design shall be in accordance with Figure 25.2.2.1.2 .

25.2.2.2.3

For low-piled rack storage with solid shelves of Group A plastic commodities up to and including 5 ft (1.5 m) in height, in-rack sprinklers shall be provided in accordance with Section 25.6 , and the ceiling-level sprinkler design shall be in accordance with Figure 25.2.2.1.2 .

25.2.3 CMDA Ceiling Level Sprinkler Design Criteria in Combination with In-Rack Sprinklers.**25.2.3.1** General.**25.2.3.1.1**

Ceiling-level sprinkler design criteria for the rack storage of Class I through Class IV commodities shall be in accordance with Section 25.2.3.2 for storage over 12 ft (3.7 m) and up to and including 25 ft (7.6 m) in height and Section 25.2.3.3 for storage over 25 ft (7.6 m) in height.

25.2.3.1.2

Ceiling-level sprinkler design criteria for the rack storage of Group A plastic commodities shall be in accordance with Section 25.2.3.4 for storage over 5 ft (1.5 m) and up to and including 25 ft (7.6 m) in height and Section 25.2.3.5 for storage over 25 ft (7.6 m) in height.

25.2.3.1.3

This chapter also shall be used to determine protection for commodities that are not entirely Group A plastic commodities but contain such quantities and arrangements of Group A plastic commodities that they are deemed more hazardous than Class IV commodities.

25.2.3.2 Rack Storage of Class I Through Class IV Commodities Stored Over 12 ft (3.7 m) and Up to and Including 25 ft (7.6 m) in Height.

25.2.3.2.1* ~~Single and Double Row Racks.~~

For single- or double-row rack storage of Class I through Class IV commodities, encapsulated or nonencapsulated, stored over 12 ft (3.7 m) and up to and including 25 ft (7.6 m) in height, Table 25.2.3.2.1 shall be used to determine the appropriate figure for determining ceiling-level sprinkler design criteria with the provision of one level of in-rack sprinklers.

Table 25.2.3.2.1 Single- or Double-Row Racks — Storage Height Over 12 ft (3.7 m) Up to and Including 25 ft (7.6 m)

Height	Commodity Class	Encapsulated	-		Sprinklers Mandatory In-Rack	Ceiling Sprinkler Water Der			
			Aisles*			With In-Rack Sprinklers			Withou
			ft	m		Figure	Curves	Apply Figure 16.2.1.3.4.1	Figure
Over 12 ft (3.7 m) up to and including 20 ft (6.1 m)	I	No	4	1.2	No	16.2.1.3.2(a)	C and D	Yes	16.2.1.3.2(a)
			8	2.4			A and B		
		Yes	4	1.2	No	16.2.1.3.2(e)	C and D		16.2.1.3.2(e)
			8	2.4			A and B		
	II	No	4	1.2	No	16.2.1.3.2(b)	C and D		16.2.1.3.2(b)
			8	2.4			A and B		
		Yes	4	1.2	No	16.2.1.3.2(e)	C and D		16.2.1.3.2(e)
			8	2.4			A and B		
	III	No	4	1.2	No	16.2.1.3.2(c)	C and D		16.2.1.3.2(c)
			8	2.4			A and B		
		Yes	4	1.2	1 level	16.2.1.3.2(f)	C and D		—
			8	2.4			A and B		
	IV	No	4	1.2	No	16.2.1.3.2(d)	C and D		16.2.1.3.2(c)
			8	2.4			A and B		
		Yes	4	1.2	1 level	16.2.1.3.2(g)	C and D		—
			8	2.4			A and B		
Over 20 ft (6.1 m) up to and including 22 ft (6.7 m)	I	No	4	1.2	No	16.2.1.3.2(a)	C and D	No	16.2.1.3.2(a)
			8	2.4			A and B		
		Yes	4	1.2	1 level	16.2.1.3.2(e)	C and D		—
			8	2.4			A and B		
	II	No	4	1.2	No	16.2.1.3.2(b)	C and D		16.2.1.3.2(b)
			8	2.4			A and B		
		Yes	4	1.2	1 level	16.2.1.3.2(e)	C and D		—
			8	2.4			A and B		
	III	No	4	1.2	No	16.2.1.3.2(c)	C and D		16.2.1.3.2(c)
			8	2.4			A and B		
		Yes	4	1.2	1 level	16.2.1.3.2(f)	C and D		—
			8	2.4			A and B		

Ceiling Sprinkler Water Der									
Height	Commodity Class	Encapsulated	Aisles*		Sprinklers Mandatory In-Rack	With In-Rack Sprinklers			Without
			ft	m		Figure	Curves	Apply Figure 16.2.1.3.4.1	
Over 22 ft (6.7 m) up to and including 25 ft (7.6 m)	IV	No	4	1.2	No	16.2.1.3.2(d)	C and D		16.2.1.3.2(e)
			8	2.4			A and B		
		Yes	4	1.2	1 level	16.2.1.3.2(g)	C and D		—
			8	2.4			A and B		
	I	No	4	1.2	No	16.2.1.3.2(a)	C and D		16.2.1.3.2(e)
			8	2.4			A and B		
		Yes	4	1.2	1 level	16.2.1.3.2(e)	C and D		—
			8	2.4			A and B		
	II	No	4	1.2	No	16.2.1.3.2(b)	C and D		16.2.1.3.2(e)
			8	2.4			A and B		
		Yes	4	1.2	1 level	16.2.1.3.2(e)	C and D	No	—
			8	2.4			A and B		
	III	No	4	1.2	No	16.2.1.3.2(c)	C and D		16.2.1.3.2(e)
			8	2.4			A and B		
		Yes	4	1.2	1 level	16.2.1.3.2(f)	C and D		—
			8	2.4			A and B		
		No	4	1.2	1 level	16.2.1.3.2(d)	C and D		—
			8	2.4			A and B		
		Yes	4	1.2	1 level	16.2.1.3.2(g)	C and D		—
			8	2.4			A and B		

*See 16.2.1.3.2.1 for interpolation of aisle widths.

25.2.3.2.2 Multiple-Row Racks.

25.2.3.2.2.1

For multiple-row racks, having a rack depth up to and including 16 ft (4.9 m) with aisles 8 ft (2.4 m) or wider, storing Class I through Class IV commodities, encapsulated or nonencapsulated, over 12 ft (3.7 m) and up to and including 25 ft (7.6 m) in height, Table 25.2.3.2.2.1 shall be used to determine the appropriate figure for determining ceiling-level sprinkler design criteria with the provision of one level of in-rack sprinklers.

Table 25.2.3.2.2.1 Multiple-Row Racks — Rack Depth Up to and Including 16 ft (4.9 m), Aisles 8 ft (2.4 m) or Wider and Storage Height Over 12 ft (3.7 m) Up to 25 ft (7.6 m)

Height	Commodity Class	Encap- sulated	Sprinklers Mandatory In-Rack	Ceiling Sprinkler Water Demand						
				With In-Rack Sprinklers				Without		
				Figure	Curves	Apply Figure 16.2.1.3.4.1	1.25 × Density	Figure	Cu	
Over 12 ft (3.7 m) up to and including 15 ft (4.6 m)	I	No	No	16.2.1.3.2(a)	C and D	Yes	No	16.2.1.3.2(a)	I an	
		Yes		16.2.1.3.2(a)			Yes	16.2.1.3.2(a)	I an	
	II	No		16.2.1.3.2(b)			No	16.2.1.3.2(b)	I an	
		Yes		16.2.1.3.2(b)			Yes	16.2.1.3.2(b)	I an	
	III	No	No	16.2.1.3.2(c)	A and B		No	16.2.1.3.2(c)	I an	
		Yes	1 level	16.2.1.3.2(c)			Yes	-	NA	
	IV	No	No	16.2.1.3.2(d)			No	16.2.1.3.2(d)	C a	
		Yes	1 level	16.2.1.3.2(d)			A and B	1.50 × density	-	NA
Over 15 ft (4.6 m) up to and including 20 ft (6.1 m)	I	No	No	16.2.1.3.2(a)	C and D	Yes	No	16.2.1.3.2(a)	I an	
		Yes		16.2.1.3.2(a)			Yes	16.2.1.3.2(a)	I an	
	II	No		16.2.1.3.2(b)			No	16.2.1.3.2(b)	I an	
		Yes		16.2.1.3.2(b)			Yes	16.2.1.3.2(b)	I an	
	III	No	No	16.2.1.3.2(c)	A and B		No	16.2.1.3.2(c)	I an	
		Yes	1 level	16.2.1.3.2(c)			Yes	NA	NA	
	IV	No	1 level	16.2.1.3.2(d)			No			
		Yes		16.2.1.3.2(d)			A nd B			1.50 × density
Over 20 ft (6.1 m) up to and including 25 ft (7.6 m)	I	No	No	16.2.1.3.2(a)	C and D	No	No	16.2.1.3.2(a)	I an	
		Yes	1 level	16.2.1.3.2(a)			Yes	NA	NA	
	II	No	1 level	16.2.1.3.2(b)			No			
		Yes		16.2.1.3.2(b)			Yes			
	III	No		16.2.1.3.2(c)			No			
		Yes		16.2.1.3.2(c)			Yes			
	IV	No	2 levels	16.2.1.3.2(d)	A and B		No			
		Yes		16.2.1.3.2(d)			1.50 × density			

NA: Not applicable.

25.2.3.2.2.2

For multiple-row racks, having a rack depth up to and including 16 ft (4.9 m) with aisles 8 ft (2.4 m) or wider, storing Class I through Class IV commodities, encapsulated or nonencapsulated, over 12 ft (3.7 m) and up to and including 25 ft (7.6 m) in height, Table 25.2.3.2.2.2 shall be used to determine the appropriate figure for determining ceiling-level sprinkler design criteria with the provision of one level of in-rack sprinklers.

Table 25.2.3.2.2.2 Determining Appropriate Ceiling-Level Protection Criteria Figure for Multiple-Row Racks of Class I through Class IV Commodities — Rack Depth Over 16 ft (4.9 m) or Aisles Narrower Than 8 ft (2.4 m), Storage Height Over 12 ft (3.7 m) Up to and Including 25 ft (7.6 m)

Height	Commodity Class	Encapsulated	Sprinklers Mandatory In-Rack	Ceiling Sprinkler Water Demand					
				With In-Rack Sprinklers				Without	
				Figure	Curves	Apply Figure 16.2.1.3.4.1	1.25 × Density	Figure	Cu
Over 12 ft (3.7 m) up to and including 15 ft (4.6 m)	I	No	No	16.2.1.3.2(a)	C and D	Yes	No	16.2.1.3.2(a)	La
		Yes		16.2.1.3.2(a)			Yes	16.2.1.3.2(a)	La
	II	No		16.2.1.3.2(b)			No	16.2.1.3.2(b)	La
		Yes		16.2.1.3.2(b)			Yes	16.2.1.3.2(b)	La
	III	No	1 level	16.2.1.3.2(c)			No	16.2.1.3.2(c)	La
		Yes		16.2.1.3.2(c)			Yes	-	
	IV	No	No	16.2.1.3.2(d)			No	16.2.1.3.2(d)	Ca
		Yes	1 level	16.2.1.3.2(d)			1.50 × density	-	
Over 15 ft (4.6 m) up to and including 20 ft (6.1 m)	I	No	1 level	16.2.1.3.2(a)	C and D	Yes	No	NA	A
		Yes		16.2.1.3.2(a)			Yes		
	II	No		16.2.1.3.2(b)			No		
		Yes		16.2.1.3.2(b)			Yes		
	III	No		16.2.1.3.2(c)			No		
		Yes		16.2.1.3.2(c)			Yes		
	IV	No		16.2.1.3.2(d)			No		
		Yes		16.2.1.3.2(d)			1.50 × density		
Over 20 ft (6.1 m) up to and including 25 ft (7.6 m)	I	No	1 level	16.2.1.3.2(a)	C and D	No	No	NA	A
		Yes		16.2.1.3.2(a)			Yes		
	II	No		16.2.1.3.2(b)			No		
		Yes		16.2.1.3.2(b)			Yes		
	III	No		16.2.1.3.2(c)			No		
		Yes		16.2.1.3.2(c)			Yes		
	IV	No	2 levels	16.2.1.3.2(d)			No		
		Yes		16.2.1.3.2(d)			1.50 × density		

NA: Not applicable.

25.2.3.2.3 Ceiling-Level Protection Criteria Figures.

~~25.2.3.2.3.1*~~

The ceiling-level sprinkler design criteria in terms of density [gpm/ft² = (mm/min)] and area of sprinkler operation [ft² = (m²) of ceiling or roof] obtained from the appropriate density/area curves of Figure 25.2.3.2.3.1(a) through Figure 25.2.3.2.3.1(g) shall be modified as appropriate by 25.2.3.2.4. These requirements shall apply to portable racks arranged in the same manner as single, double or multiple row racks. (See Section C.14.)

Figure 25.2.3.2.3.1(a) Sprinkler System Design Curves — 20 ft (6.1 m) High Rack Storage — Class I Nonencapsulated Commodities — Conventional Pallets.

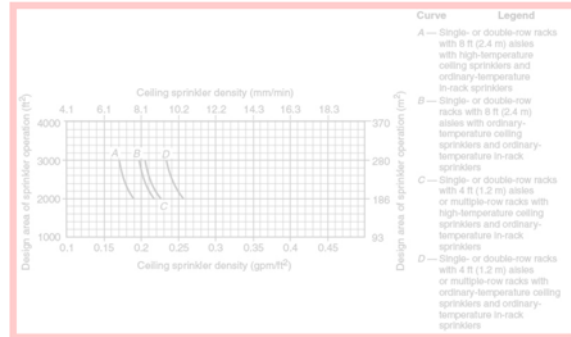


Figure 25.2.3.2.3.1(b) Sprinkler System Design Curves — 20 ft (6.1 m) High Rack Storage — Class II Nonencapsulated Commodities — Conventional Pallets.

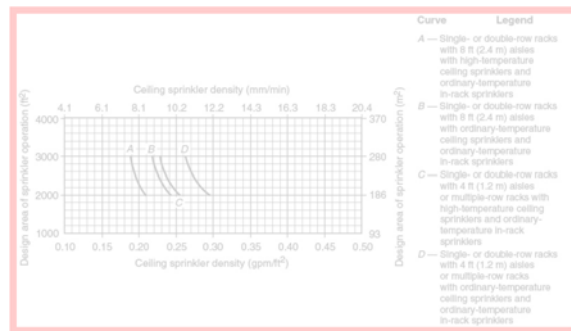


Figure 25.2.3.2.3.1(c) Sprinkler System Design Curves — 20 ft (6.1 m) High Rack Storage — Class III Nonencapsulated Commodities — Conventional Pallets.

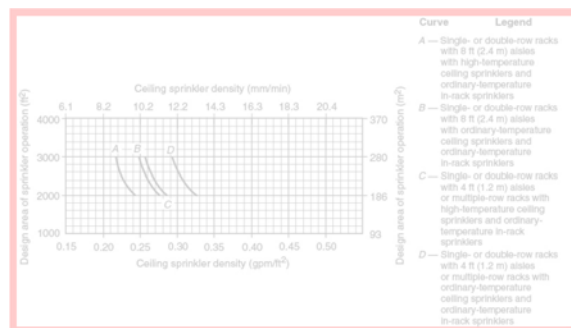


Figure 25.2.3.2.3.1(d) Sprinkler System Design Curves — 20 ft (6.1 m) High Rack Storage — Class IV Nonencapsulated Commodities — Conventional Pallets.

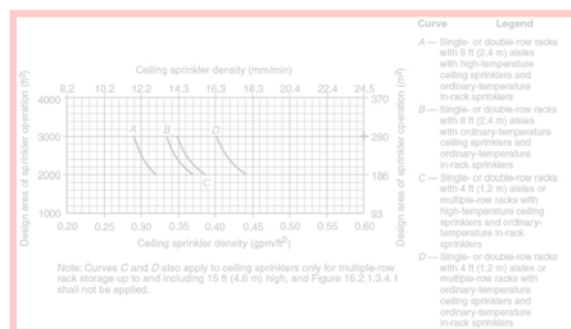


Figure 25.2.3.2.3.1(e) Single or Double Row Racks — 20 ft (6.1 m) High Rack Storage — Sprinkler System Design Curves — Class I and Class II Encapsulated Commodities — Conventional Pallets.

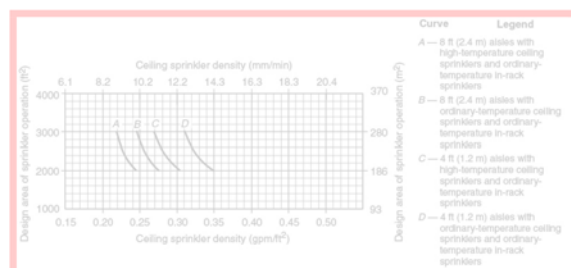


Figure 25.2.3.2.3.1(f) Single or Double Row Racks — 20 ft (6.1 m) High Rack Storage — Sprinkler System Design Curves — Class III Encapsulated Commodities — Conventional Pallets.

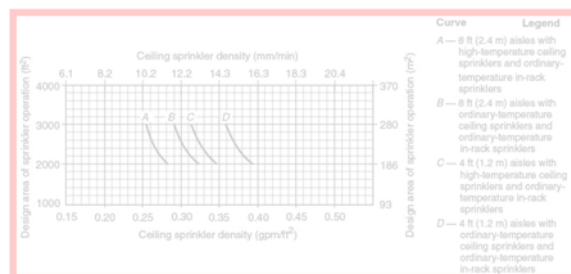
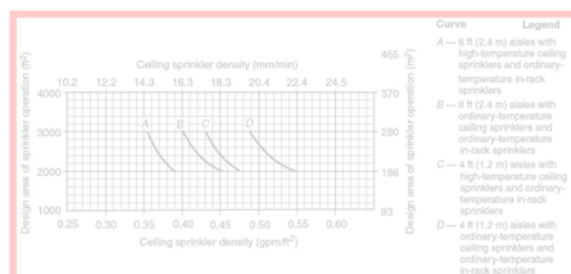


Figure 25.2.3.2.3.1(g) Single or Double Row Racks — 20 ft (6.1 m) High Rack Storage — Sprinkler System Design Curves — Class IV Encapsulated Commodities — Conventional Pallets.



25.2.3.2.3.2*

Design densities obtained from Figure 25.2.3.2.3.1(a) through Figure 25.2.3.2.3.1(g) for single and double row racks shall be selected to correspond to aisle width. (See Section C.15.)

(A)

For aisle widths between 4 ft (1.2 m) and 8 ft (2.4 m), the rules for 4 ft (1.2 m) aisle width shall be used or direct linear interpolation between the densities shall be permitted.

(B)

The density given for 8 ft (2.4 m) wide aisles shall be applied to aisles wider than 8 ft (2.4 m).

(C)

The density given for 4 ft (1.2 m) wide aisles shall be applied to aisles more narrow than 4 ft (1.2 m) down to 3 ¹/₂ ft (1.1 m).

(D)

Where aisles are more narrow than 3 ¹/₂ ft (1.1 m), racks shall be considered to be multiple-row racks.

25.2.3.2.4* Ceiling Sprinkler Density Adjustments.

25.2.3.2.4.1

Where Class I, Class II, and Class III commodities are encapsulated in multiple-row racks over 12 ft (3.7 m) and up to and including 25 ft (7.6 m) in height, the ceiling sprinkler density obtained from the applicable figure in 25.2.3.2.3.1 shall be increased by 25 percent over that required for nonencapsulated commodities.

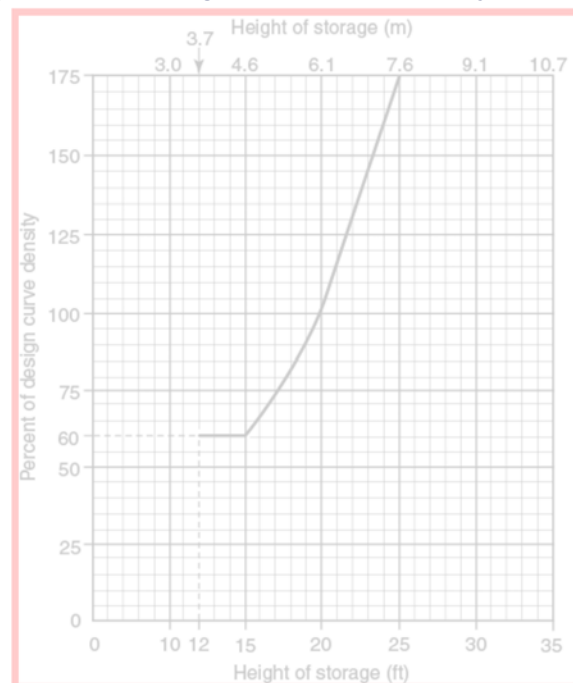
25.2.3.2.4.2

Where Class IV commodities are encapsulated in multiple-row racks over 12 ft (3.7 m) and up to and including 25 ft (7.6 m) in height, the ceiling sprinkler density obtained from the applicable figure in 25.2.3.2.3.1 shall be increased by 50 percent over that required for nonencapsulated.

25.2.3.2.4.3

Where in-rack sprinklers are being installed within racks of Class I through Class IV commodities stored over 12 ft (3.7 m) up to and including 20 ft (6.1 m) protected with CMDA sprinklers at ceiling level along with the minimum number of required in-rack sprinkler levels, densities obtained from design curves shall be adjusted in accordance with Figure 25.2.3.2.4.3.

Figure 25.2.3.2.4.3 Adjustment to Ceiling-Level Sprinkler Density Due to Storage Height.



25.2.3.2.4.4

Where in-rack sprinklers are being installed within racks of Class I through Class IV commodities stored over 12 ft (3.7 m) and up to and including 20 ft (6.1 m) in height protected with CMDA sprinklers at ceiling level along with more than one level of in-rack sprinklers, but not in every tier, densities obtained from design curves and adjusted in accordance with Figure 25.2.3.2.4.3 shall be permitted to be reduced an additional 20 percent, as indicated in Table 25.2.3.2.4.4.

Table 25.2.3.2.4.4 Adjustment to Ceiling Sprinkler Density for Storage Height and In-Rack Sprinklers

Storage Height	In-Rack Sprinklers	Apply Figure 16.2.1.3.4.1 for Storage Height Adjustment	Permitted Ceiling Sprinklers Density Adjustments Where In-Rack Sprinklers Are Installed
Over 12 ft (3.7 m) through 25 ft (7.6 m)	None	Yes	None
	Minimum required	Yes	None
Over 12 ft (3.7 m) through 20 ft (6.1 m)	More than minimum, but not in every tier	Yes	Reduce density 20% from that of minimum in-rack sprinklers
	In every tier except above the top tier	Yes	Reduce density 40% from that of minimum in-rack sprinklers
Over 20 ft (6.1 m) through 25 ft (7.3 m)	Minimum required	No	None
	More than minimum, but not in every tier	No	Reduce density 20% from that of minimum in-rack sprinklers
	In every tier except above the top tier	No	Reduce density 40% from that of minimum in-rack sprinklers

25.2.3.2.4.5*

Where in-rack sprinklers are being installed within racks of Class I through Class IV commodities stored over 12 ft (3.7 m) and up to and including 20 ft (6.1 m) in height protected with CMDA sprinklers at ceiling level along with in-rack sprinklers at each tier level, densities obtained from design curves and adjusted in accordance with Figure 25.2.3.2.4.3 shall be permitted to be reduced an additional 40 percent, as indicated in Table 25.2.3.2.4.4.

25.2.3.2.4.6

Where in-rack sprinklers are being installed within racks of Class I through Class IV commodities stored over 20 ft (6.1 m) and up to and including 25 ft (7.6 m) in height protected with CMDA sprinklers at ceiling level along with the minimum number of required in-rack sprinkler levels, densities obtained from design curves shall be used. Densities shall not be adjusted in accordance with Figure 25.2.3.2.4.3.

25.2.3.2.4.7

Where in-rack sprinklers are being installed within racks of Class I through Class IV commodities stored over 20 ft (6.1 m) and up to and including 25 ft (7.6 m) in height protected with CMDA sprinklers at ceiling level along with more than the minimum required level of in-rack sprinklers, but not in every tier, densities obtained from design curves shall be permitted to be reduced 20 percent, as indicated in Table 25.2.3.2.4.4. Densities shall not be adjusted in accordance with Figure 25.2.3.2.4.3 for storage height.

25.2.3.2.4.8

Where in-rack sprinklers are being installed within racks of Class I through Class IV commodities stored over 20 ft (6.1 m) and up to and including 25 ft (7.6 m) in height protected with CMDA sprinklers at ceiling level along with in-rack sprinklers at each tier level, except above the top tier, densities obtained from design curves shall be permitted to be reduced 40 percent, as indicated in Table 25.2.3.2.4.4. Densities shall not be adjusted in accordance with Figure 25.2.3.2.4.3 for storage height.

25.2.3.3 Rack Storage of Class I Through Class IV Commodities Over 25 ft (7.6 m) in Height.**25.2.3.3.1 Single and Double Row Racks.**

25.2.3.3.1.1*

Where in-rack sprinklers are being installed within single- and double-row racks separated by aisles at least 4 ft (1.2 m) wide and with a clearance to ceiling up to and including 10 ft (3.0 m) of nonencapsulated Class I through Class IV commodities stored over 25 ft (7.6 m) in height protected by CMDA sprinklers at ceiling level, the ceiling sprinkler designs shall be in accordance with Table 25.2.3.3.1.1.

25.2.3.3.1.2

Where storage as described in 25.2.3.3.1.1 is encapsulated, the ceiling sprinkler density obtained from Table 25.2.3.3.1.1 shall be increased by 25 percent over that required for nonencapsulated commodities.

25.2.3.3.2 Multiple-Row Racks.**25.2.3.3.2.1**

Where in-rack sprinkler are being installed within multiple-row racks separated by aisles at least 4 ft (1.2 m) wide and with a clearance to ceiling up to and including 10 ft (3.0 m) of nonencapsulated Class I through Class IV commodities stored over 25 ft (7.6 m) in height protected by CMDA sprinklers at ceiling level, the ceiling sprinkler designs shall be in accordance with Table 25.2.3.3.2.1.

25.2.3.3.2.2

Where storage as described in 25.2.3.3.2.1 is encapsulated, the ceiling sprinkler density obtained from Table 25.2.3.3.2.1 shall be increased by 25 percent over that required for nonencapsulated commodities.

25.2.3.4 Rack Storage of Group A Plastic Commodities Stored Over 5 ft (1.5 m) and Up to and Including 25 ft (7.6 m) in Height.**25.2.3.4.1 Cartoned Group A Plastic Commodities.****25.2.3.4.1.1**

Where rack storage of cartoned Group A plastic commodities, encapsulated or nonencapsulated, having a clearance to ceiling up to and including 10 ft (3.0 m) is protected by in-rack sprinklers, ceiling-level sprinkler designs in terms of density [gpm/ft^2 (mm/min)] and area of operation [ft^2 (m^2)] shall be selected from Figure 25.9.3.1(a) through Figure 25.9.3.1(e).

25.2.3.4.1.2

Linear interpolation of design densities and areas of application shall be permitted between storage heights with the same clearance to ceiling.

25.2.3.4.1.3

No interpolation between clearance to ceiling shall be permitted.

25.2.3.4.2 Exposed Nonexpanded Group A Plastic Commodities.

Where in-rack sprinkler protection is installed to protect rack storage of exposed nonexpanded Group A plastic commodities, encapsulated or nonencapsulated, stored over 5 ft (1.5 m) and up to and including 25 ft (7.6 m) in height protected by CMDA sprinklers at ceiling level, the ceiling sprinkler design shall be in accordance with one of the following:

Where in-rack sprinklers are installed in accordance with Figure 25.9.3.3(a), the ceiling-level sprinkler design shall be a minimum 0.45 gpm/ft^2 (18.3 mm/min) density over a 2000 ft^2 (186 m^2) demand area.

Where in-rack sprinklers are installed in accordance with Figure 25.9.3.3(b), the ceiling-level sprinkler design shall be a minimum 0.30 gpm/ft^2 (12.2 mm/min) density over a 2000 ft^2 (186 m^2) demand area.

Where in-rack sprinklers are installed in accordance with Figure 25.9.3.3(c), the ceiling-level sprinkler design shall be a minimum 0.45 gpm/ft^2 (18.3 mm/min) density over a 2000 ft^2 (186 m^2) demand area.

Where in-rack sprinklers are installed in accordance with Figure 25.9.3.3(d), the ceiling-level sprinkler design shall be a minimum 0.30 gpm/ft^2 (12.2 mm/min) density over a 2000 ft^2 (186 m^2) demand area.

Where in-rack sprinklers are installed in accordance with Figure 25.9.3.3(e), the ceiling-level sprinkler design shall be a minimum 0.6 gpm/ft^2 (24.4 mm/min) density over a 2000 ft^2 (186 m^2) demand area.

Where in-rack sprinklers are installed in accordance with Figure 25.9.3.3(f), the ceiling-level sprinkler design shall be a minimum 0.45 gpm/ft^2 (18.3 mm/min) density over a 2000 ft^2 (186 m^2) demand area.

Where in-rack sprinklers are installed in accordance with Figure 25.9.3.3(g), the ceiling-level sprinkler design shall be a minimum 0.8 gpm/ft^2 (32.6 mm/min) density over a 1500 ft^2 (139 m^2) demand area.

Where in-rack sprinklers are installed in accordance with Figure 25.9.3.3(h), the ceiling-level sprinkler design shall be a minimum 0.6 gpm/ft^2 (24.4 mm/min) density over a 1500 ft^2 (139 m^2) demand area.

Where in-rack sprinklers are installed in accordance with Figure 25.9.3.3(i), the ceiling-level sprinkler design shall be a minimum 0.30 gpm/ft^2 (12.2 mm/min) density over a 2000 ft^2 (186 m^2) demand area.

Where in-rack sprinklers are installed in accordance with Figure 25.9.3.3(j), the ceiling-level sprinkler design shall be a minimum 0.8 gpm/ft^2 (32.6 mm/min) density over a 1500 ft^2 (139 m^2) demand area.

Where in-rack sprinklers are installed in accordance with Figure 25.9.3.3(k), the ceiling-level sprinkler design shall be a minimum 0.30 gpm/ft^2 (12.2 mm/min) density over a 2000 ft^2 (186 m^2) demand area.

25.2.3.5* Rack Storage of Group A Plastic Commodities Stored Over 25 ft (7.6 m) in Height.

Where rack storage of Group A plastic commodities, encapsulated or nonencapsulated, over 25 ft (7.6 m) in height are protected by in-rack sprinklers in accordance with 25.9.4, ceiling-level sprinkler designs, in terms of density [gpm/ft^2 (mm/min)] and area of operation [ft^2 (m^2)], shall be selected from Table 25.2.3.5 based on the storage height of commodity above the top level of in-rack sprinklers.

Table 25.2.3.5 Control Mode Density/Area Sprinkler Discharge Criteria for Single, Double, and Multiple-Row Racks of Group A Plastic Commodities with Storage Over 25 ft (7.6 m) in Height

Storage Height Above Top Level In-Rack Sprinklers		Ceiling Sprinklers Density	
ft	m	gpm/ft^2 over ft^2	mm/min over m^2
5 or less	1.5 or less	0.30/2000	12.2/186
Over 5 up to 10	Over 1.5 up to 3.0	0.45/2000	18.3/186

25.2.3.6 Rack Storage of Rubber Tires Stored Over 12 ft (3.7 m) in Height.**25.2.3.6.1 General.**

The requirements of Chapter 20 shall apply unless modified in this section.

25.2.3.6.2* Ceiling Systems.

Where rack storage of rubber tires, either on-side or on-tread, over 5 ft (1.5 m) and up to and including 20 ft (6.1 m) in height protected by CMDA sprinklers at ceiling level with a maximum clearance to ceiling of 10 ft (3.0 m) along with one level of in-rack sprinklers, the ceiling-level sprinkler system design density and area of application shall be a minimum $0.40 \text{ gpm}/\text{ft}^2$ (16.3 mm/min) density over a 3000 ft^2 (279 m^2) demand area.

25.2.3.6.3 Reduced-Discharge Density.

Where high-expansion foam systems are installed in accordance with NFPA 11 to protect rack storage of rubber tires, either on-side or on-tread, over 5 ft (1.5 m) and up to and including 20 ft (6.1 m) in height protected by CMDA sprinklers at ceiling level with a maximum clearance to ceiling of 10 ft (3.0 m) and one level of in-rack sprinklers, the ceiling-level sprinkler system design density shall be permitted to be reduced from $0.40 \text{ gpm}/\text{ft}^2$ (16.3 mm/min) $0.24 \text{ gpm}/\text{ft}^2$ (9.8 mm/min).

25.2.3.6.4 Water Supplies.

Total water supplies shall be capable of providing flow for automatic sprinklers, hose streams, and foam systems (if provided) for the duration required in Table 20.12.2.6.

25.2.4 CMSA Ceiling Level Sprinkler Design Criteria in Combination with In-Rack Sprinklers.**25.2.4.1 General.****25.2.4.1.1 Open Wood Joist Construction with CMSA Sprinklers at Ceiling Level.****25.2.4.1.1.1**

Where CMSA sprinklers are installed under open wood joist construction, fire-stopping in accordance with 25.2.4.1.1.3 shall be provided or the minimum operating pressure of the sprinklers shall be 50 psi (3.4 bar) for a K-11.2 (160) sprinkler or 22 psi (1.5 bar) for a K-16.8 (240) sprinkler.

25.2.4.1.1.2

Where each joist channel of open wood joist construction is fully fire-stopped to its full depth at intervals not exceeding 20 ft (6.1 m), the lower pressures specified in Table 25.2.4.2.1 shall be permitted to be used.

25.2.4.1.2 Preaction Systems for CMSA Sprinklers.

For the purpose of using Table 25.2.4.2.1, preaction systems shall be classified as dry pipe systems.

25.2.4.2 Rack Storage of Class I Through Class IV Commodities.

25.2.4.2.1

~~Where rack storage of Class I through Class IV commodities is protected by CMSA sprinklers at ceiling level along with one level of in-rack sprinklers, the ceiling-level sprinkler design criteria shall be in accordance with Table 25.2.4.2.1.~~

25.2.4.2.2

~~Protection shall be provided as specified in Table 25.2.4.2.1 or appropriate NFPA standards in terms of minimum operating pressure and the number of ceiling-level sprinklers to be included in the design area.~~

25.2.4.3 Rack Storage of Group A Plastic Commodities.

25.2.4.3.1

Where rack storage of nonexpanded, cartoned and uncartoned, Group A plastic commodities is protected by CMSA sprinklers at ceiling level along with one level of in-rack sprinklers, the ceiling-level sprinkler system design criteria shall be in accordance with Table 25.2.4.3.1.

Table 25.2.4.3.1 CMSA Ceiling Level Sprinkler Design Criteria for Rack Storage of Group A Plastic Commodities Stored Up and Including 25 ft (7.6 m) in Height Supplemented with In-Rack Sprinklers

Storage Arrangement	Commodity Class	Maximum Storage Height		Maximum Ceiling/Roof Height		K-Factor/ Orientation	Type of System	Number of Design Sprinklers	Minimum Operating Pressure	
		ft	m	ft	m				psi	bar
Single, double, and multiple-row racks (no open-top containers)	Cartoned nonexpanded plastics	20	6.1	25	7.6	11.2 (160) Upright	Wet	15	50	3.4
-						16.8 (240) Upright	Wet	15	22	1.5
-						19.6 (280) Pendent	Wet	15	16	1.1
-						11.2 (160) Upright	Wet-Wet	30/20	50/75	3.4/5.2
-		-	-	30	9.1	16.8 (240) Upright	Wet	15*	22	1.5
-						19.6 (280) Pendent	Wet	15	16	1.1
-						11.2 (160) Upright	Wet	15 + 1 level of in-rack	50	3.4
-		25	7.6	30	9.1	16.8 (240) Upright	Wet	15*	22	1.5
-						19.6 (280) Pendent	Wet	15	16	1.1
-						11.2 (160) Upright	Wet	30 + 1 level of in-rack	50	3.4
-		25	7.6	35	11	16.8 (240) Upright	Wet	20 + 1 level of in-rack	75	5.2
-						19.6 (280) Pendent	Wet	30 + 1 level of in-rack	22	1.5
-						11.2 (160) Upright	Wet	20 + 1 level of in-rack	35	2.4
-						16.8 (240) Upright	Wet	15	25	1.7
-						11.2 (160) Upright	Wet	15	50	3.4
-	Exposed nonexpanded plastics	20	6.1	25	7.6	16.8 (240) Upright	Wet	15	22	1.5
-						11.2 (160) Upright	Wet	30	50	3.4
-		20	6.1	30	9.1	16.8 (240) Upright	Wet	20	75	5.2
-						11.2 (160) Upright	Wet	15*	22	1.5
-						16.8 (240) Upright	Wet	15 + 1 level of in-rack	50	3.4
-		25	7.6	30	9.1	11.2 (160) Upright	Wet	15*	22	1.5
-						16.8 (240) Upright	Wet	30 + 1 level of in-rack	50	3.4
-		25	7.6	35	11	11.2 (160) Upright	Wet	30 + 1 level of in-rack	50	3.4

Storage Arrangement	Commodity Class	Maximum Storage Height		Maximum Ceiling/Roof Height		K-Factor/ Orientation	Type of System	Number of Design Sprinklers	Minimum Operating Pressure	
		ft	m	ft	m				psi	bar
-							Wet	20 + 1 level of in-rack	75	5.2
-						16.8 (240) Upright	Wet	30 + 1 level of in-rack	22	1.5
-							Wet	20 + 1 level of in-rack	35	2.4

*Minimum 8 ft (2.4 m) aisle.

25.2.4.3.2

Protection shall be provided as specified in Table 25.2.4.3.1 or appropriate NFPA standards in terms of minimum operating pressure and the number of ceiling-level sprinklers to be included in the design area.

25.2.5 ESFR Ceiling Level Sprinkler Design Criteria in Combination with In-Rack Sprinklers.

25.2.5.1 Rack Storage of Class I Through Class IV Commodities.

25.2.5.1.1

Where rack storage of Class I through Class IV commodities is protected by ESFR sprinklers at ceiling level along with one level of in-rack sprinklers, the ceiling-level sprinkler design criteria shall be in accordance with Table 25.2.5.1.1.

25.2.5.1.2

ESFR sprinkler systems, when supplemented with in-rack sprinklers, shall be designed such that the minimum operating pressure is not less than that indicated in Table 25.2.5.1.1 for type of storage, commodity, storage height, and building height involved.

25.2.5.1.3

The design area applicable to the ceiling-level design options listed in Table 25.xx shall consist of the most hydraulically demanding area of 12 sprinklers, consisting of four sprinklers on each of three branch lines.

25.2.5.2 Rack Storage of Group A Plastic Commodities.

25.2.5.2.1

Where rack storage of cartoned or exposed nonexpanded Group A plastic and cartoned expanded Group A plastic commodity is protected by ESFR sprinklers at ceiling level along with one level of in-rack sprinklers, the ceiling-level sprinkler design criteria shall be in accordance with Table 25.2.5.2.1.

Table 25.2.5.2.1 ESFR Ceiling-Level Sprinkler Design Criteria for Rack Storage of Group A Plastic Commodities Supplemented with In-Rack Sprinklers

Storage Arrangement	Commodity	Maximum Storage Height		Maximum Ceiling/Roof Height		Nominal K-Factor	Orientation	Minimum Operating Pressure		In-Rack Sprinkler Requirement
		ft	m	ft	m			psi	bar	
Single-, double-, and multiple-row racks (no open-top containers)	Cartoned nonexpanded	20	6.1	25	7.6	14.0 (200)	Upright/pendent	50	3.4	No
	-	-	-			16.8 (240)	Upright/pendent	35	2.4	No
	-	-	-			22.4 (320)	Pendent	25	1.7	No
	-	-	-			25.2 (360)	Pendent	15	1.0	No
	-	-	-	30	9.1	14.0 (200)	Upright/pendent	50	3.4	No
	-	-	-			16.8 (240)	Upright/pendent	35	2.4	No
	-	-	-			22.4 (320)	Pendent	25	1.7	No
	-	-	-			25.2 (360)	Pendent	15	1.0	No
	-	-	-	35	11	14.0 (200)	Upright/pendent	75	5.2	No
	-	-	-			16.8 (240)	Upright/pendent	52	3.6	No
	-	-	-			22.4 (320)	Pendent	35	2.4	No
	-	-	-			25.2 (360)	Pendent	20	1.4	No
	-	-	-	40	12	16.8 (240)	Pendent	52	3.6	No
	-	-	-			22.4 (320)	Pendent	40	2.7	No
	-	-	-			25.2 (360)	Pendent	25	1.7	No
	-	-	-	45	14	14.0 (200)	Pendent	90	6.2	Yes
	-	-	-			16.8 (240)	Pendent	63	4.3	Yes
	-	-	-			22.4 (320)	Pendent	40	2.7	No
	-	-	-			25.2 (360)	Pendent	40	2.7	No
	-	25	7.6	30	9.1	14.0 (200)	Upright/pendent	50	3.4	No

Storage Arrangement	Commodity	Maximum Storage Height		Maximum Ceiling/Roof Height		Nominal K-Factor	Orientation	Minimum Operating Pressure		In-Rack Sprinkler Requirement
		ft	m	ft	m			psi	bar	
-	-	-	-			16.8 (240)	Upright/ pendent	35	2.4	No
-	-	-	-			22.4 (320)	Pendent	25	1.7	No
-	-	-	-			25.2 (360)	Pendent	15	1.0	No
-	-	-	-	32	10	14.0 (200)	Upright/ pendent	60	4.1	No
-	-	-	-			16.8 (240)	Upright/ pendent	42	2.9	No
-	-	-	-			14.0 (200)	Upright/ pendent	75	5.2	No
-	-	-	-	35	11	16.8 (240)	Upright/ pendent	52	3.6	No
-	-	-	-			22.4 (320)	Pendent	35	2.4	No
-	-	-	-			25.2 (360)	Pendent	20	1.4	No
-	-	-	-			16.8 (240)	Pendent	52	3.6	No
-	-	-	-	40	12	22.4 (320)	Pendent	40	2.7	No
-	-	-	-			25.2 (360)	Pendent	25	1.7	No
-	-	-	-			14.0 (200)	Pendent	90	6.2	Yes
-	-	-	-	45	14	16.8 (240)	Pendent	63	4.3	Yes
-	-	-	-			22.4 (320)	Pendent	40	2.7	No
-	-	-	-			25.2 (360)	Pendent	40	2.7	No
-	Exposed nonexpanded	20	6.1	25	7.6	14.0 (200)	Pendent	50	3.4	No
-	-	-	-			16.8 (240)	Pendent	35	2.4	No
-	-	-	-	30	9.1	14.0 (200)	Pendent	50	3.4	No
-	-	-	-			16.8 (240)	Pendent	35	2.4	No
-	-	-	-	35	11	14.0 (200)	Pendent	75	5.2	No
-	-	-	-			16.8 (240)	Pendent	52	3.6	No
-	-	-	-	40	12	16.8 (240)	Pendent	52	3.6	No

Storage Arrangement	Commodity	Maximum Storage Height		Maximum Ceiling/Roof Height		Nominal K-Factor	Orientation	Minimum Operating Pressure		In-Rack Sprinkler Requirement
		ft	m	ft	m			psi	bar	
-	-	-	-	45	14	14.0 (200)	Pendent	90	6.2	Yes
-	-	-	-	45	14	16.8 (240)	Pendent	63	4.3	Yes
-	-	25	7.6	30	9.1	14.0 (200)	Pendent	50	3.4	No
-	-	-	-	30	9.1	16.8 (240)	Pendent	35	2.4	No
-	-	-	-	32	10	14.0 (200)	Pendent	60	4.1	No
-	-	-	-	32	10	16.8 (240)	Pendent	42	2.9	No
-	-	-	-	35	11	14.0 (200)	Pendent	75	5.2	No
-	-	-	-	35	11	16.8 (240)	Pendent	52	3.6	No
-	-	-	-	35	11	16.8 (240)	Pendent	52	3.6	No
-	-	-	-	40	12	22.4 (320)	Pendent	50	3.4	No
-	-	-	-	40	12	25.2 (360)	Pendent	50	3.4	No
-	-	-	-	45	14	14.0 (200)	Pendent	90	6.2	Yes
-	-	-	-	45	14	16.8 (240)	Pendent	63	4.3	Yes
-	Cartoned expanded	20	6.1	25	7.6	14.0 (200)	Upright/pendent	50	3.4	No
-	-	-	-	25	7.6	16.8 (240)	Upright/pendent	35	2.4	No
-	-	-	-	30	9.1	14.0 (200)	Upright/pendent	50	3.4	No
-	-	-	-	30	9.1	16.8 (240)	Upright/pendent	35	2.4	No
-	-	-	-	30	9.1	14.0 (200)	Upright/pendent	50	3.4	No
-	-	-	-	30	9.1	16.8 (240)	Upright/pendent	35	2.4	No
-	-	25	7.6	32	10	14.0 (200)	Pendent	60	4.1	No
-	-	-	-	32	10	16.8 (240)	Upright/pendent	42	2.9	No

25.2.5.2.2

ESFR sprinkler systems, when supplemented with in-rack sprinklers, shall be designed such that the minimum operating pressure is not less than that indicated in Table 25.2.5.2.1 for type of storage, commodity, storage height, and building height involved.

25.2.5.2.3

The design area applicable to the ceiling-level design options listed in Table 25.2.5.2.1 shall consist of the most hydraulically demanding area of 12 sprinklers, consisting of four sprinklers on each of three branch lines.

25.3 In-Rack Sprinkler Characteristics.**25.3.1**

In-rack sprinklers shall be pendent or upright, standard or quick-response, ordinary-temperature rated and have a nominal K-factor of K-5.6 (80), K-8.0 (115), or K-11.2 (160).

25.3.2

In-rack sprinklers protecting open-frame rack storage where ESFR sprinklers are installed at ceiling level shall be quick-response, ordinary-temperature rated, and either K-8.0 (115) or K-11.2 (160).

25.3.3

In-rack sprinklers with intermediate- and high-temperature ratings shall be used near heat sources as required by 9.4.2.

25.3.4

In-rack sprinklers shall be permitted to have a different RTI rating than the ceiling sprinklers under which they are installed.

25.3.5 In-Rack Sprinkler Water Shields.**25.3.5.1 In-Rack Sprinkler Water Shields for Storage of Class I Through Class IV Commodities.**

Water shields shall be provided directly above in-rack sprinklers, or listed intermediate level/rack storage sprinklers shall be used where there is more than one level, if not shielded by horizontal barriers. (See Section C.3.)

25.3.5.2 In-Rack Sprinkler Water Shields for Plastic Storage.

Where in-rack sprinklers are not shielded by horizontal barriers, water shields shall be provided above the sprinklers, or listed intermediate level/rack storage sprinklers shall be used.

25.4 Vertical Spacing and Location of In-Rack Sprinklers.**25.4.1**

In-rack sprinklers shall not be required to meet the obstruction criteria and clearance from storage requirements of Section 9.5.

25.4.2

A minimum 6 in. (150 mm) vertical clear space shall be maintained between in-rack sprinkler deflectors and the top of storage located below them.

25.4.3*

Where in-rack sprinklers are being installed within single- and double-row racks of Class I through Class IV commodities up to and including 20 ft (6.1 m) in height, the vertical clear space of in-rack sprinkler deflectors with respect to the top of storage located below them shall be permitted to be less than 6 in. (150 mm). (See Section C.16.)

25.4.4

In-rack sprinkler discharge shall not be obstructed by horizontal rack members.

25.4.5

Where one level of in-rack sprinklers are required by the guidelines of this chapter, in-rack sprinklers shall be installed at the first tier level at or above one-half of the highest expected storage height.

25.4.6

Where two levels of in-rack sprinklers are required by the guidelines of this chapter for rack storage of Class I through Class IV commodities up to and including 25 ft (7.6 m) in height, in-rack sprinklers shall be installed at the first tier level at or above one-third and two-thirds of the highest expected storage height.

25.4.7 Maximum Storage Height Above Top In-Rack Sprinkler Level.

25.4.7.1

Where in-rack sprinklers are required for single- and double-row rack storage of Class I through Class IV commodities over 25 ft (7.6 m) in height and protected by CMDA sprinklers at ceiling level, storage above the top level of in-rack sprinklers shall not exceed 10 ft (3.0 m).

25.4.7.2

Where in-rack sprinklers are required for multiple-row rack storage of Class I through Class IV commodities over 25 ft (7.6 m) in height and protected by CMDA sprinklers at ceiling level, storage above the top level of in-rack sprinklers shall not exceed 10 ft (3.0 m) for Class I, Class II, or Class III commodities or 5 ft (1.5 m) for Class IV commodities.

25.4.7.3

Where in-rack sprinklers are required for rack storage of plastic commodities over 25 ft (7.6 m) in height and protected by CMDA sprinklers at ceiling level, storage above the top level of in-rack sprinklers shall not exceed 10 ft (3.0 m).

25.4.8

Where single- and double-row rack storage of Class I through Class IV commodities is over 25 ft (7.6 m) in height and protected by CMDA sprinklers at ceiling level, in-rack sprinklers shall be staggered vertically where installed in accordance with Table 25.9.2.1.1, Figure 25.9.2.2(A)(a) through Figure 25.9.2.2(A)(j), and Figure 25.9.2.1.1(A)(a) through Figure 25.9.2.1.1(A)(e).

25.4.9

Where multiple-row rack storage of Class I through Class IV commodities is over 25 ft (7.6 m) in height and protected by CMDA sprinklers at ceiling level, in-rack sprinklers shall be staggered vertically where installed in accordance with Table 25.9.2.1.1, Figure 25.9.2.2(A)(a) through Figure 25.9.2.2(A)(j), and Figure 25.9.2.1.1(A)(a) through Figure 25.9.2.1.1(A)(e).

25.5 Horizontal Spacing and Location of In-Rack Sprinklers.**25.5.1 Horizontal Spacing of In-Rack Sprinklers.****25.5.1.1 General.****25.5.1.1.1**

In-rack sprinklers shall be permitted to be installed horizontally less than 6 ft (1.8 m) apart.

25.5.1.1.2

For miscellaneous and low piled rack storage, the maximum allowable horizontal spacing of in-rack sprinklers shall be 8 ft (2.4 m).

25.5.1.1.3

For rack storage of rubber tires, the maximum allowable horizontal spacing of in-rack sprinklers shall be 8 ft (2.4 m).

25.5.1.2 CMDA Sprinklers Installed at Ceiling Level.**25.5.1.2.1***

Where single- and double-row rack storage of Class I through Class IV commodities is up to and including 25 ft (7.6 m) in height and protected by CMDA sprinklers at ceiling level, the maximum allowable horizontal spacing of in-rack sprinklers shall be in accordance with Table 25.5.1.2.1.

Table 25.5.1.2.1 In-Rack Sprinkler Horizontal Spacing for Class I, II, III, and IV Commodities Stored in Single- or Double-Row Racks Up to 25 ft (7.6 m) in Height Protected by Control Mode Density/Area Sprinklers at Ceiling Level

	Commodity Class								
	Aisle Widths		I and II		III		IV		
	Encapsulated	ft	m	ft	m	ft	m	ft	m
No	8	2.4	12	3.7	12	3.7	10	3.0	
No	4	1.2	12	3.7	10	3.0	10	3.0	
Yes	—	—	8	2.4	8	2.4	8	2.4	

25.5.1.2.2

Where multiple-row rack storage of Class I through Class IV commodities is up to and including 25 ft (7.6 m) in height and protected by CMDA sprinklers at ceiling level, the maximum allowable horizontal spacing of in-rack sprinklers shall be in accordance with Table 25.5.1.2.2.

Table 25.5.1.2.2 In-Rack Sprinkler Horizontal Spacing for Class I, II, III, and IV Commodities Stored in Multiple-Row Racks Up to 25 ft (7.6 m) in Height Protected by Control Mode Density/Area Sprinklers at Ceiling Level

Commodity Class										
I, II, III					IV					
Spacing		Area			Spacing		Area			
ft	m	ft ²	m ²		ft	m	ft ²	m ²		
12	3.7	100	9.3		8	2.4	80	7.4		

(A)

The rack plan view shall be considered in determining the area covered by each sprinkler.

(B)

The aisles shall not be included in area calculations.

25.5.1.2.3

Where rack storage of plastic commodities is up to and including 25 ft (7.6 m) in height and protected by CMDA sprinklers at ceiling level, the maximum allowable horizontal spacing of in-rack sprinklers shall be in accordance with Figure 25.9.3.1(a) through Figure 25.9.3.1(e).

25.5.1.2.4

Where single and double row rack storage of Class I through Class IV commodities is over 25 ft (7.6 m) in height and protected by CMDA sprinklers at ceiling level, the maximum allowable horizontal spacing of in-rack sprinklers shall be in accordance with Table 25.9.2.1.1 and Figure 25.9.2.2(a) through Figure 25.9.2.2(j).

25.5.1.2.5

Where multiple row rack storage of Class I through Class IV commodities is over 25 ft (7.6 m) in height and protected by CMDA sprinklers at ceiling level, the maximum allowable horizontal spacing of in-rack sprinklers shall be in accordance with Table 25.9.2.3.1 and Figure 25.9.2.3.1(a) through Figure 25.9.2.3.1(e).

25.5.1.2.6

Where single row rack storage of cartoned Group A plastic commodities, expanded or nonexpanded, encapsulated or nonencapsulated, is over 25 ft (7.6 m) in height and protected by CMDA sprinklers at ceiling level, the maximum allowable horizontal spacing of in-rack sprinklers shall be in accordance with Figure 25.9.4.1.1(a) through Figure 25.9.4.1.1(d) or Figure 25.9.4.2.2.

25.5.1.2.7

Where double row rack storage of cartoned Group A plastic commodities, expanded or nonexpanded, encapsulated or nonencapsulated, is over 25 ft (7.6 m) in height and protected by CMDA sprinklers at ceiling level, the maximum allowable horizontal spacing of in-rack sprinklers shall be in accordance with Figure 25.9.4.2.1(a) through Figure 25.9.4.2.1(e).

25.5.1.2.8

Where single and double row rack storage of exposed nonexpanded Group A plastic commodities, whether encapsulated or nonencapsulated, is over 25 ft (7.6 m) in height and protected by CMDA sprinklers at ceiling level, the maximum allowable horizontal spacing of in-rack sprinklers shall be in accordance with Figure 25.9.4.2.2.

25.5.1.2.9*

Where multiple-row rack storage of exposed nonexpanded Group A plastic commodities, whether encapsulated or nonencapsulated, or cartoned Group A plastic commodities, expanded or nonexpanded, encapsulated or nonencapsulated, is over 25 ft (7.6 m) in height and protected by CMDA sprinklers at ceiling level, the maximum allowable horizontal spacing of in-rack sprinklers shall be in accordance with Figure 25.9.4.3.1(a) through Figure 25.9.4.3.1(f).

25.5.1.3 CMSA Sprinklers Installed at Ceiling Level.**25.5.1.3.1**

Where rack storage of Class I through Class IV commodities is up to and including 25 ft (7.6 m) in height and protected by CMSA sprinklers at ceiling level, the maximum allowable horizontal spacing of in-rack sprinklers shall be 8 ft (2.4 m).

25.5.1.3.2

Where rack storage of plastic commodities is up to and including 25 ft (7.6 m) in height and protected by CMSA sprinklers at ceiling level, the maximum allowable horizontal spacing of in-rack sprinklers shall be 5 ft (1.5 m).

25.5.1.3.3

Where rack storage of Class I through Class IV commodities is over 25 ft (7.6 m) in height and protected by CMSA sprinklers at ceiling level, the maximum allowable horizontal spacing of in-rack sprinklers shall be 5 ft (1.5 m).

25.5.1.4 ESFR Sprinklers Installed at Ceiling Level.

Where rack storage is protected by ESFR sprinklers at ceiling level, the maximum allowable horizontal spacing of in-rack sprinklers shall be 5 ft (1.5 m).

25.5.2 Horizontal Location of In-Rack Sprinklers.**25.5.2.1**

In-rack sprinklers shall not be required to meet the obstruction criteria and clearance from storage requirements of Section 9.5.

25.5.2.2*

Where in-rack sprinklers are installed in longitudinal flues, they shall be located at an intersection of transverse and longitudinal flues while not exceeding the maximum horizontal spacing rules.

25.5.2.3

Where horizontal distances between transverse flues exceed the maximum allowable horizontal linear spacing for in-rack sprinklers, in-rack sprinklers shall be installed at the intersection of the transverse and longitudinal flues, and additional in-rack sprinklers shall be installed between transverse flues to meet the maximum allowable horizontal linear spacing rules for in-rack sprinklers.

25.5.2.4

Where no transverse flues exist, horizontal spacing of in-rack sprinklers shall not exceed the maximum allowable spacing rules.

25.5.2.5

Where in-rack sprinklers are installed to protect a higher-hazard commodity that occupies only a portion of the length of a rack, in-rack sprinklers shall be extended a minimum of 8 ft (2.4 m) or one bay, whichever is greater, in each direction along the rack on either side of the higher hazard. The in-rack sprinklers protecting the higher hazard shall not be required to extend across the aisle.

25.5.2.6

The in-rack sprinkler arrangement protecting the higher hazard outlined in 25.5.2.5 shall not be required to be extended across the aisle.

25.5.2.7*

Where rack storage is over 25 ft (7.6 m) in height, in-rack sprinklers shall be a minimum 3 in. (75 mm) radially from the side of rack uprights.

25.5.2.8

Where rack storage of Class I through Class IV commodities is up to and including 25 ft (7.6 m), in-rack sprinklers shall be permitted to be installed horizontally without regard to rack uprights. (See Section C.17.)

25.5.2.9

Where rack storage is over 25 ft (7.6 m) in height, face sprinklers shall be located within the rack a minimum 3 in. (75 mm) from rack uprights and no more than 18 in. (450 mm) from the aisle face of storage.

25.5.2.10

Where single- and double-row rack storage of Class I through Class IV commodities is over 25 ft (7.6 m) in height and protected by CMDA sprinklers at ceiling level, in-rack sprinklers shall be staggered horizontally where installed in accordance with Table 25.9.2.1.1, Figure 25.9.2.2(a) through Figure 25.9.2.2(j), and Figure 25.9.2.1.1(a) through Figure 25.9.2.1.1(e).

25.5.2.11

Where multiple-row rack storage of Class I through Class IV commodities is over 25 ft (7.6 m) in height and protected by CMDA sprinklers at ceiling level, in-rack sprinklers shall be staggered horizontally where installed in accordance with Table 25.9.2.3.1 and Figures 25.9.2.3.1(a) through Figure 25.9.2.3.1(c).

25.5.2.12

Where rack storage of plastic commodities is over 25 ft (7.6 m) in height, in-rack sprinklers in longitudinal flues shall be installed with the deflector located at or below the bottom of horizontal load beams or above or below other adjacent horizontal rack members.

25.5.2.13

Where miscellaneous and low piled single- and double-row rack storage does not have a longitudinal flue, in-rack sprinklers shall be located within 12 in. (300 mm) of the center of the rack while not exceeding the maximum allowable horizontal in-rack sprinkler spacing.

25.6 Protection of Racks with Solid Shelves.**25.6.1 General.**

The requirements of Section 25.6 shall apply to racks with solid shelves except as modified in this section.

25.6.2

Ceiling-level sprinkler design criteria for CMDA, CMSA, and ESFR sprinklers shall be an applicable option for open racks combined with in-rack sprinklers installed in accordance with the criteria for solid shelving.

25.6.3 Vertical Spacing and Location of In-Rack Sprinklers in Racks with Solid Shelves.**25.6.3.1**

Where CMDA sprinklers are at ceiling level protecting racks with solid shelving that exceeds 20 ft $\leq$ (1.9 m $\leq$) in area but not 64 ft $\leq$ (5.9 m $\leq$), in-rack sprinklers shall not be required below every shelf, but shall be installed below solid shelves at intermediate levels not more than 6 ft (1.8 m) apart vertically. (See Section C.11.)

25.6.3.2

Where CMDA sprinklers are at ceiling level protecting racks with solid shelving that exceeds 64 ft² (5.9 m²) in area or where the levels of storage exceed 6 ft (1.8 m), in-rack sprinklers shall be installed below each level of solid shelving.

25.6.3.3

Where CMSA sprinklers are at ceiling level and protect racks with solid shelving, in-rack sprinklers shall be installed beneath all tiers under the highest solid shelf.

25.6.3.4

Where ESFR sprinklers are at ceiling level and protect racks with solid shelving, in-rack sprinklers shall be installed beneath all tiers under the highest solid shelf.

25.6.3.5

Where racks with solid shelves obstruct only a portion of an open-frame rack, in-rack sprinklers shall be installed vertically as follows:

In accordance with Section 25.6.3.1 25.6.3.1 and 25.6.3.2 25.6.3.2 where CMDA sprinklers are installed at ceiling level

In accordance with 25.6.3.3 25.6.3.3 where CMSA sprinklers are installed at ceiling level

In accordance with 25.6.3.4 25.6.3.4 where ESFR sprinklers are installed at ceiling level

25.6.3.6

Where CMDA sprinklers are at ceiling level and protecting single- or double-row racks with solid shelves of Class I through Class IV commodities stored up to and including 25 ft (7.6 m) in height, a minimum 6 in. (150 mm) vertical clear space shall be maintained between in-rack sprinkler deflectors and the top of storage located below them.

25.6.4 Horizontal Spacing and Location of In-Rack Sprinklers in Racks with Solid Shelves.**25.6.4.1**

Where racks with solid shelves contain storage of Class I through Class IV commodities, the maximum allowable horizontal spacing of in-rack sprinklers shall be 10 ft (3.0 m).

25.6.4.2

Where racks with solid shelves contain storage of plastic commodities, the maximum allowable horizontal spacing of in-rack sprinklers shall be 5 ft (1.5 m).

25.6.4.3

Where racks with solid shelves obstruct only a portion of an open-frame rack, in-rack sprinklers shall be extended beyond the end of the solid shelf a minimum of 4 ft (1.2 m) to the nearest flue space intersection.

25.7 Horizontal Barriers in Combination with In-Rack Sprinklers.**25.7.1***

Where required by sections of this chapter, horizontal barriers used in combination with in-rack sprinklers to impede vertical fire development shall be constructed of sheet metal, wood, or similar material and shall extend the full length and depth of the rack.

25.7.2

Barriers shall be fitted within 2 in. (50 mm) horizontally around rack uprights.

25.8 In-Rack Sprinkler Arrangements and Designs, Independent of Ceiling-Level Sprinklers.**25.8.1 Alternative In-Rack Sprinkler Protection Option 1.****25.8.1.1**

Where Class I, II, III, IV and Group A plastic commodities are protected in accordance with the guidelines of this section, the in-rack sprinkler system shall not be required to be hydraulically balanced with the ceiling-level sprinkler system.

25.8.1.2

Where a storage rack will not be solely dedicated to the in-rack sprinkler system outlined in this section, either of the following shall apply:

Extend the protection outlined in this section horizontally one pallet load in all directions beyond the commodity storage area that is being protected by the alternative in-rack sprinkler arrangement.

Install a vertical barrier to segregate the commodities that are being protected by the alternative in-rack sprinkler arrangement.

25.8.1.3

Where a storage rack is partially protected by the in-rack sprinkler system outlined in this section, commodities that can be protected by the ceiling-level sprinkler system shall be permitted to be stored vertically above and horizontally adjacent to the portions of the storage rack protected in accordance with this section.

25.8.1.4 Horizontal Barriers for Alternative In-Rack Sprinkler Protection Option 1.**25.8.1.4.1**

The barrier shall be constructed of minimum 22-gauge (0.7 mm) sheet metal or of minimum 3/8 in. (10 mm) plywood.

25.8.1.4.2

The barrier shall span horizontally to both aisle faces of the rack, covering up all flue spaces of the rack bays in which they are installed.

25.8.1.4.3

A maximum 3 in. (75 mm) wide horizontal gap shall be permitted at rack uprights or other equipment that would create an opening, such as vertical in-rack sprinkler pipe drops.

25.8.1.4.4

Where the dedicated storage is in open-frame racks, horizontal barriers shall be installed at vertical increments not exceeding 12 ft (3.6 m).

25.8.1.4.5

Where the dedicated storage is in racks with solid shelves, horizontal barriers shall be installed at every tier level of the dedicated storage rack.

25.8.1.5

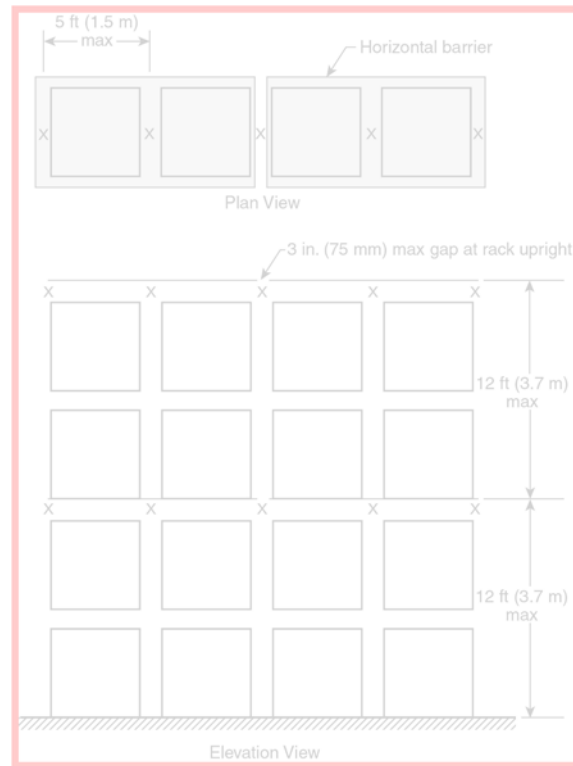
In-rack sprinklers shall be quick-response, minimum K-8.0 (K-115) installed as close to the underside of the horizontal barrier as possible.

25.8.1.6 Alternative In-Rack Sprinkler Protection Option 1 for Single-Row Racks.

25.8.1.6.1

For single-row racks, in-rack sprinklers shall be installed beneath horizontal barriers at each rack upright and within the rack bay as shown in Figure 25.8.1.6.1 Figure 25.8.1.6.1.

Figure 25.8.1.6.1 Alternative In-Rack Sprinkler Protection Option 1 for Single-Row Racks.

**25.8.1.6.2**

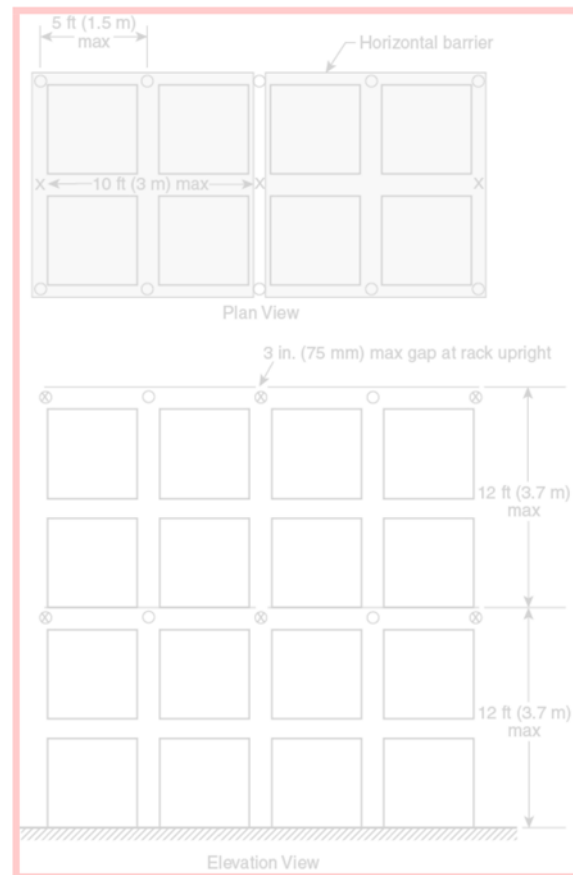
The maximum allowable horizontal spacing between in-rack sprinklers shall not exceed 5 ft (1.5 m).

25.8.1.7 Alternative In-Rack Sprinkler Protection Option 1 for Double-Row Racks.

25.8.1.7.1

For double-row racks, in-rack sprinklers shall be installed beneath horizontal barriers at each rack upright within the longitudinal flue space and at the face of the rack as well as at the face of each rack bay as shown in Figure 25.8.1.7.1.

Figure 25.8.1.7.1 Alternative In-Rack Sprinkler Protection Option 1 for Double-Row Racks.

**25.8.1.7.2**

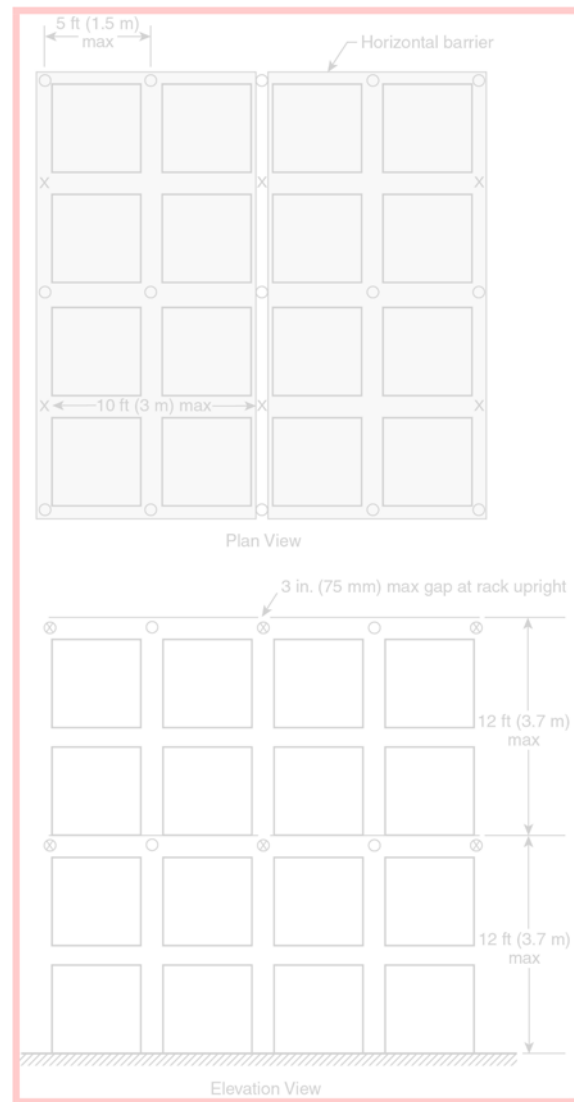
The maximum allowable horizontal spacing between in-rack sprinklers shall not exceed 5 ft (1.5 m) at the rack face and 10 ft (3.0 m) within the longitudinal flue space.

25.8.1.8 Alternative In-Rack Sprinkler Protection Option 1 for Multiple Row Racks.

25.8.1.8.1

For multiple-row racks, an alternating in-rack sprinkler arrangement shall be installed within adjacent transverse flue spaces and with sprinklers at the face of each flue space as shown in Figure 25.8.1.8.1. Figure 25.8.1.8.1.

Figure 25.8.1.8.1 Alternative In-Rack Sprinkler Protection Option 1 for Multiple-Row Racks.

**25.8.1.8.2**

The maximum allowable horizontal spacing between in-rack sprinklers at the face and at each alternating rack bay shall not exceed 5 ft (1.5 m) and shall not exceed 10 ft (3.0 m) between in-rack sprinklers at every other rack bay.

25.8.1.9 In-Rack Sprinkler System Design.

The in-rack sprinkler system design outlined in this section shall be based on a minimum flow of 60 gpm (230 L/min) from the most remote six in-rack sprinklers for single-row racks or the most remote eight in-rack sprinklers for both double-row and multiple-row racks.

25.8.1.10 Ceiling-Level Sprinkler System Design.

The ceiling-level sprinkler system shall be designed based on the highest commodity hazard not protected by the in-rack sprinkler system outlined in this section.

25.8.2 Alternative In-Rack Sprinkler Protection Option 2.

25.8.2.1

Where Class I, II, III, IV and Group A plastic commodities are protected in accordance with this section, the in-rack sprinkler system shall not be required to be hydraulically balanced with the ceiling-level sprinkler system.

25.8.2.2

For open-frame storage racks, install horizontal barriers as outlined in 25.7 as well as in-rack sprinklers a maximum of every 6 ft (1.8 m) vertically.

25.8.2.3

For storage racks having solid shelves with shelf areas that exceed 20 ft² (1.9 m²) but not 64 ft² (5.9 m²) and CMDA sprinklers are installed at ceiling level, in-rack sprinklers shall be installed below shelves at intermediate levels not more than 6 ft (1.8 m) apart vertically.

25.8.2.4

For storage racks having solid shelves with shelf areas that exceed 20 ft² (1.9 m²) but not 64 ft² (5.9 m²) and CMSA or ESFR sprinklers are installed at ceiling level, in-rack sprinklers shall be installed below each level of shelving.

25.8.2.5

For storage racks having solid shelves with shelf areas that exceed 64 ft² (5.9 m²), in-rack sprinklers shall be installed below each level of shelving.

25.8.2.6

Where CMDA sprinklers are at ceiling level and protecting single- or double-row racks with solid shelves of Class I through Class IV commodities stored up to and including 25 ft (7.6 m) in height, a minimum 6 in. (150 mm) vertical clear space shall be maintained between in-rack sprinkler deflectors and the top of storage located below them.

25.8.2.7

Where racks contain storage of Class I through Class IV commodities, the maximum allowable horizontal spacing of in-rack sprinklers shall be 10 ft (3.0 m).

25.8.2.8

Where racks with solid shelves contain storage of plastic commodities, the maximum allowable horizontal spacing of in-rack sprinklers shall be 5 ft (1.5 m).

25.8.2.9

Face sprinklers shall be installed under each solid shelf or horizontal barrier at rack uprights.

25.8.2.10 In-Rack Sprinkler System Design.

The in-rack sprinkler design for the in-rack sprinkler arrangement outlined in this section shall be based on a minimum flow of 60 gpm (230 L/min) from the most remote eight in-rack sprinklers.

25.8.2.11

Where a storage rack will not be solely dedicated to the in-rack sprinkler system outlined in this section, either of the following shall apply:

25.8.2.11.1

Extend the protection outlined in this section horizontally one pallet load in all directions beyond the commodity storage area that is being protected by the alternative in-rack sprinkler arrangement.

25.8.2.11.2

Install a vertical barrier to segregate the commodities that are being protected by the alternative in-rack sprinkler arrangement.

25.8.2.12

Where a storage rack is partially protected by the in-rack sprinkler system outlined in this section, commodities that can be protected by the ceiling-level sprinkler system shall be permitted to be stored vertically above and horizontally adjacent to the portions of the storage rack protected in accordance with this section.

25.9 In-Rack Sprinkler Arrangements in Combination with CMDA Sprinklers at Ceiling Level.**25.9.1 Rack Storage of Class I through Class IV Commodities Up to and Including 25 ft (7.6 m) in Height.**

The in-rack arrangements for rack storage up to and including 25 ft (7.6 m) in height shall be in accordance with the guidelines outlined in Section 25.4 through 25.7 as applicable.

25.9.2 Rack Storage of Class I through Class IV Commodities Over 25 ft (7.6 m) in Height.**25.9.2.1 Single-Row Racks.**

25.9.2.1.1*

In single-row racks with a maximum of 10 ft (3.0 m) between the top of storage and the ceiling, in-rack sprinklers shall be installed in accordance with Table 25.9.2.1.1 and Figure 25.9.2.1.1(a) through Figure 25.9.2.1.1(e).

Figure 25.9.2.1.1(a) In-Rack Sprinkler Arrangement, Class I, II, III, or IV Commodities, Single-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 1.

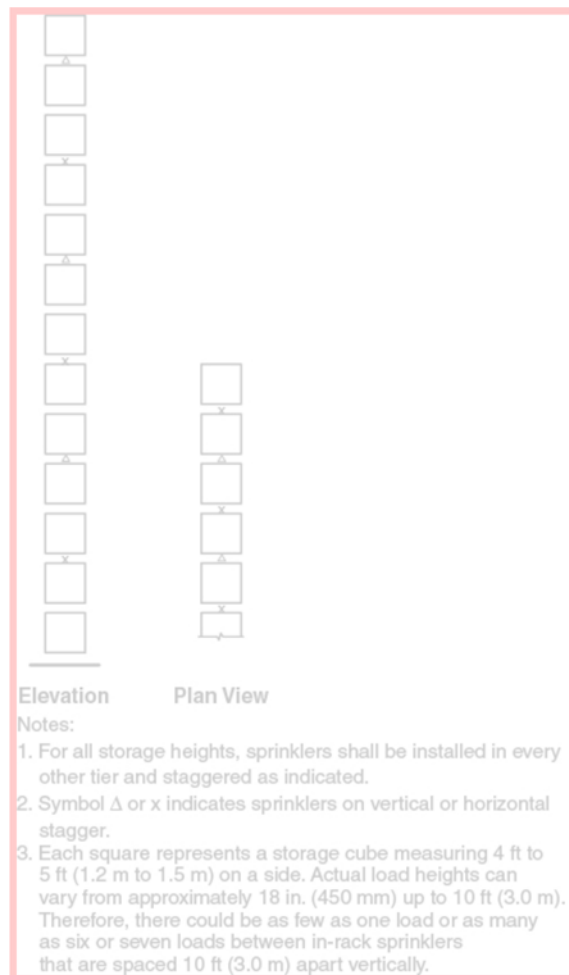


Figure 25.9.2.1.1(b) In-Rack Sprinkler Arrangement, Class I, II, or III Commodities, Single-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 1.

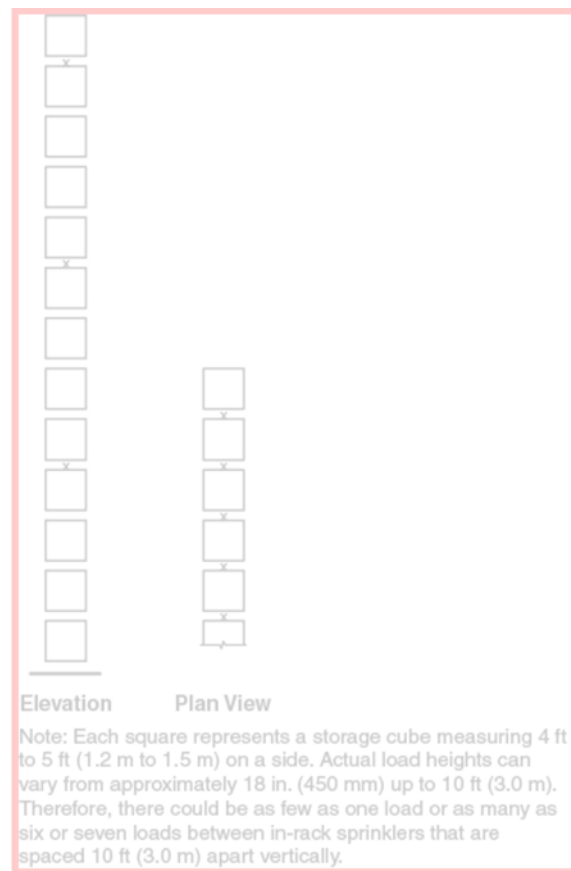


Figure 25.9.2.1.1(c) In-Rack Sprinkler Arrangement, Class I, II, or III Commodities, Single-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 1.

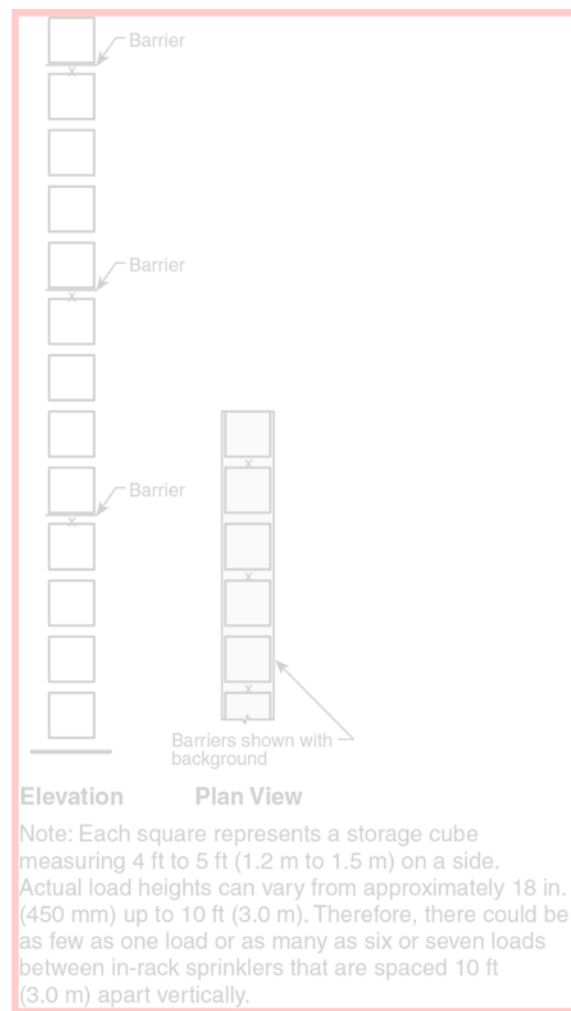


Figure 25.9.2.1.1(d) In-Rack Sprinkler Arrangement, Class I, II, III, or IV Commodities, Single-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 2.

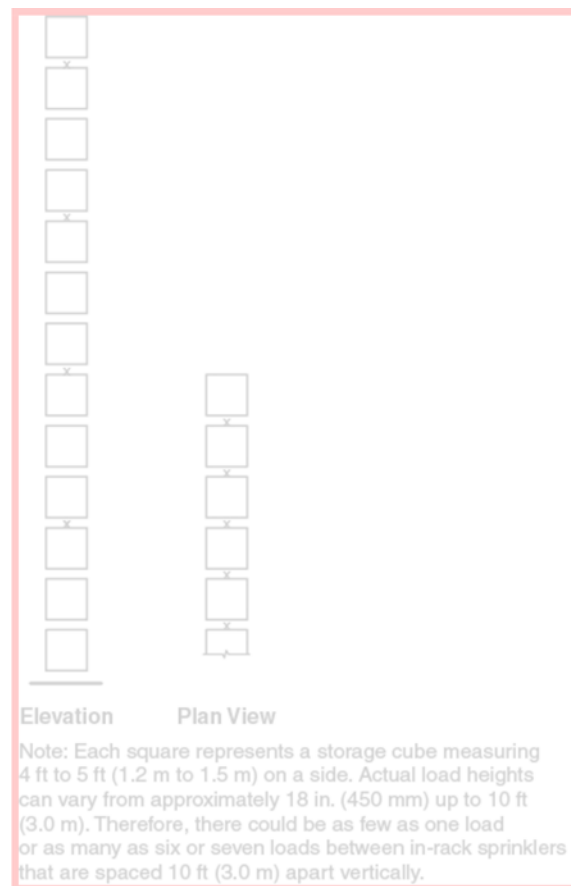
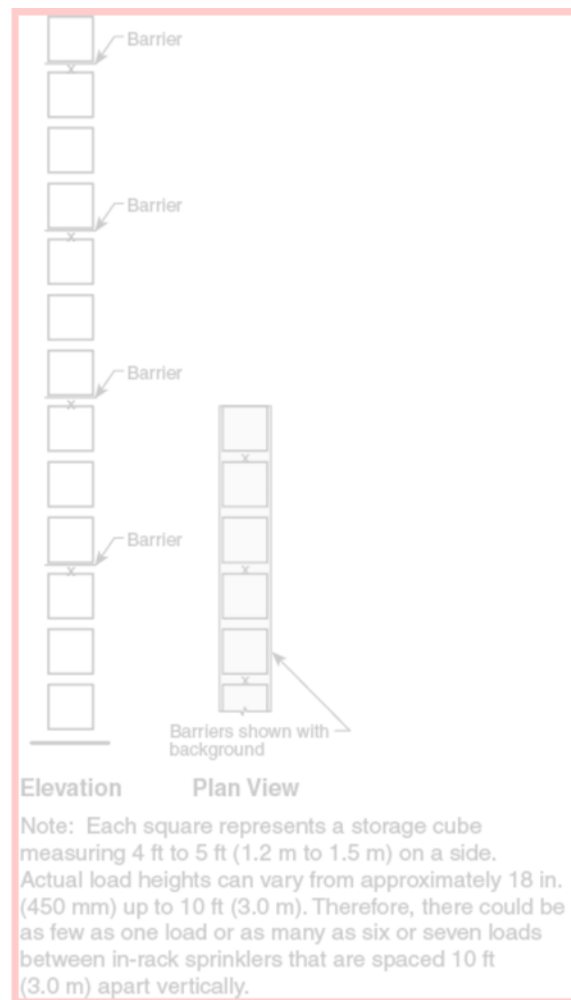


Figure 25.9.2.1.1(e) In-Rack Sprinkler Arrangement, Class I, II, III, or IV Commodities, Single-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 3.



25.9.2.1.2

Where a single-row rack is located against a wall, the in-rack sprinkler arrangement shall be permitted to be in accordance with Figure 25.9.2.2(a) through Figure 25.9.2.2(j).

25.9.2.1.3

Where in-rack sprinkler arrangement figures for single-row racks show in-rack sprinklers in transverse flue spaces centered between the rack faces, it shall be permitted to position these in-rack sprinklers in the transverse flue at any point between the load faces.

25.9.2.2 Double-Row Racks.

25.9.2.2.1*

In double-row racks with a maximum of 10 ft (3.0 m) between the top of storage and the ceiling, in-rack sprinklers shall be installed in accordance with Table 25.9.2.2.1 and Figure 25.9.2.2.1(a) through Figure 25.9.2.2.1(j).

Table 25.9.2.2.1 Single or Double-Row Racks of Class I Through Class IV Commodities Stored Over 25 ft (7.6 m) in Height with Aisles 4 ft (1.2 m) or More in Width

Commodity Class	In-Rack Sprinklers Approximate Vertical Spacing at Tier Nearest the Vertical Distance and Maximum Horizontal Spacing <u>a,b,c</u>		Figure	Maximum Storage Height	Stagger	Coiling Sprinkler Operating Area		Ceiling Sprinkle Coiling Up	
	Longitudinal Flue <u>d</u>	Face <u>e,f</u>				ft ²	m ²	Ordinary Temperature	
								gpm/ft ²	mm/m
I	Vertical 20 ft (6.1 m) Horizontal 10 ft (3.0 m) under horizontal barriers	None	16.3.1.3.1.1(A)(a)	30 ft (9.1 m)	No	2000	186	0.25	10.2
	Vertical 20 ft (6.1 m) Horizontal 10 ft (3.0 m)	Vertical 20 ft (6.1 m) Horizontal 10 ft (3.0 m)	16.3.1.3.1.1(A)(b)	Higher than 25 ft (7.6 m)	Yes			0.25	10.2
I, II, III	Vertical 10 ft (3.0 m) or at 15 ft (4.6 m) and 25 ft (7.6 m)	None	16.3.1.3.1.1(A)(c)	30 ft (9.1 m)	Yes	2000	186	0.3	12.2
	Vertical 10 ft (3.0 m m) Horizontal 10 ft (3.0 m m)	Vertical 30 ft (9.1 m) Horizontal 10 ft (3.0 m)	16.3.1.3.1.1(A)(d)	Higher than 25 ft (7.6 m)	Yes			0.3	12.2
	Vertical 20 ft (6.1 m) Horizontal 10 ft (3.0 m)	Vertical 20 ft (6.1 m) Horizontal 5 ft (1.5 m)	16.3.1.3.1.1(A)(e)		Yes			0.3	12.2
	Vertical 25 ft (7.6 m) Horizontal 5 ft (1.5 m)	Vertical 25 ft (7.6 m) Horizontal 5 ft (1.5 m)	16.3.1.3.1.1(A)(f)		No			0.3	12.2
	Horizontal barriers at 20 ft (6.1 m) Vertical intervals — two lines of	-	16.3.1.3.1.1(A)(g)		Yes			0.3	12.2

I, II, III, IV	sprinklers under barriers — maximum horizontal spacing 10 ft (3.0 m), staggered						
	Vertical 15 ft (4.6 m)	Vertical 20 ft (6.1 m)	16.3.1.3.1.1(A)(h)	Yes	0.35	14.3	
	Horizontal 10 ft (3.1 m)	Horizontal 10 ft (3.0 m)					
	Vertical 20 ft (6.1 m)	Vertical 20 ft (6.1 m)	16.3.1.3.1.1(A)(i)	No	0.35	14.2	
	Horizontal 5 ft (1.5 m)	Horizontal 5 ft (1.5 m)					
I, II, III, IV	Horizontal barriers at 15 ft (4.6 m)		Higher than 25 ft (7.6 m)		2000	186	
	Vertical intervals — two lines of sprinklers under barriers — maximum horizontal spacing 10 ft (3.0 m), staggered	-	16.3.1.3.1.1(A)(j)	Yes	0.35	14.2	

^a Minimum in-rack sprinkler discharge, 30 gpm (114 L/min).

^b Water shields required.

^c All in-rack sprinkler spacing dimensions start from the floor.

^d Install sprinklers at least 3 in. (75 mm) from uprights.

^e Face sprinklers shall not be required for a Class I commodity consisting of noncombustible products on wood pallets (without combustible containers), except for arrays shown in Figure 16.3.1.3.1.1(A)(g) and Figure 16.3.1.3.1.1(A)(j).

^f In Figure 16.3.1.3.1.1(A)(a) through Figure 16.3.1.3.1.1(A)(j), each square represents a storage cube that measures 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 48 in. to 10 ft (450 mm to 3.0 m). Therefore, there can be one load to six or seven loads between in-rack sprinklers that are spaced 10 ft (3.0 m) apart vertically.

^g For encapsulated commodity, increase density 25 percent.

Figure 25.9.2.2.1(a) In-Rack Sprinkler Arrangement, Class I, II, or III Commodities, Storage Height Over 25 ft (7.6 m) — Option 1.

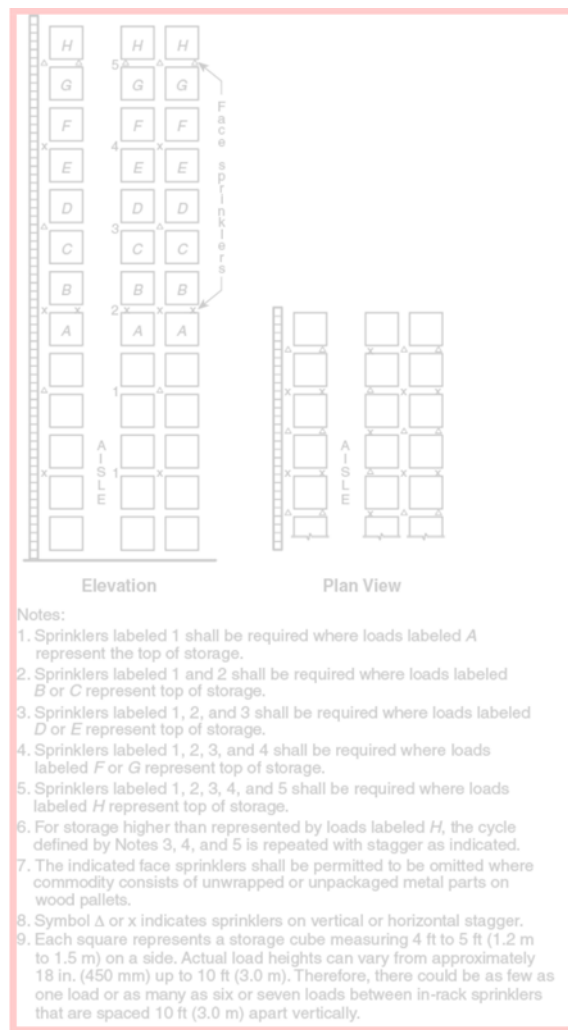


Figure 25.9.2.2.1(b) In-Rack Sprinkler Arrangement, Class I, II, or III Commodities, Storage Height Over 25 ft (7.6 m) — Option 2.

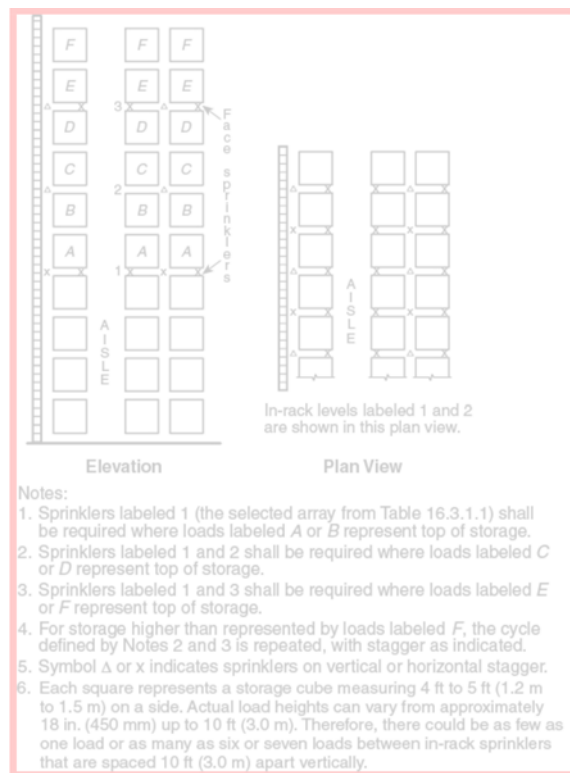


Figure 25.9.2.2.1(c) In-Rack Sprinkler Arrangement, Class I, II, or III Commodities, Storage Height Over 25 ft (7.6 m) — Option 3.

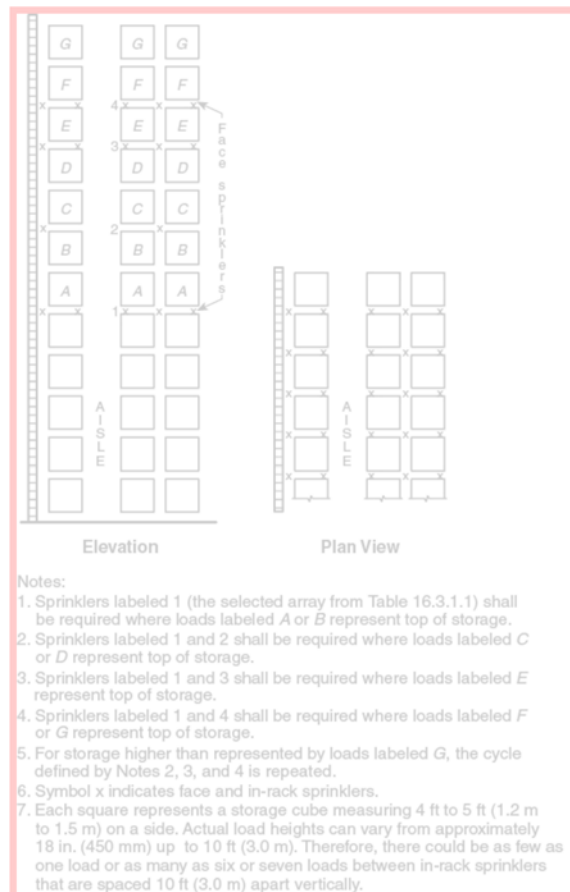


Figure 25.9.2.2.1(d) In-Rack Sprinkler Arrangement, Class I, II, or III Commodities, Storage Height Over 25 ft (7.6 m) — Option 4.

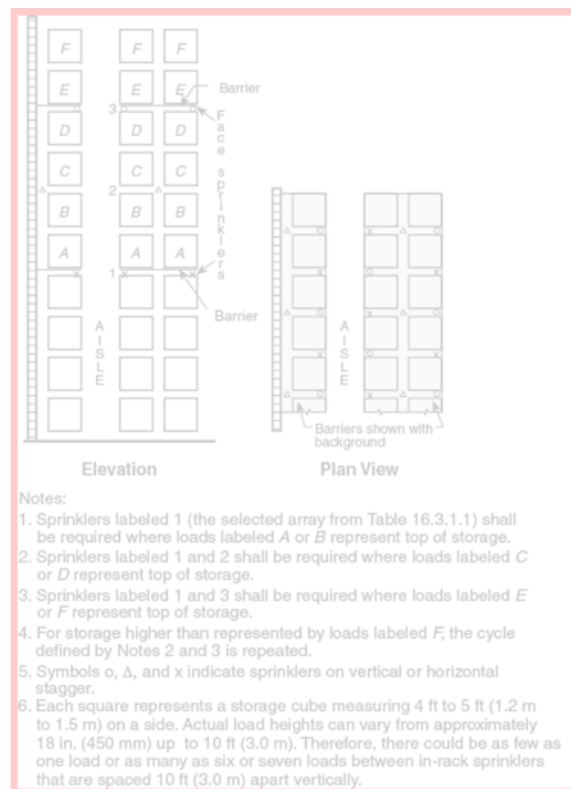


Figure 25.9.2.2.1(e) In-Rack Sprinkler Arrangement, Class I, II, III, or IV Commodities, Storage Height Over 25 ft (7.6 m) — Option 1.

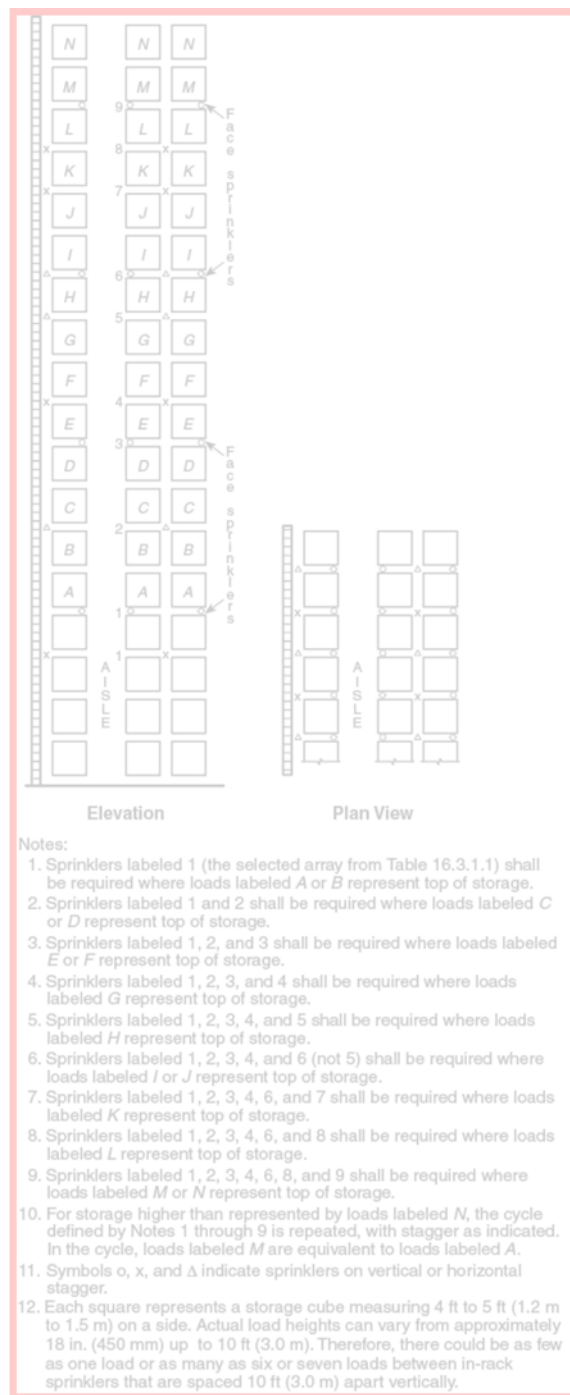


Figure 25.9.2.2.1(f) In-Rack Sprinkler Arrangement, Class I, II, III, or IV Commodities, Storage Height Over 25 ft (7.6 m) — Option 2.

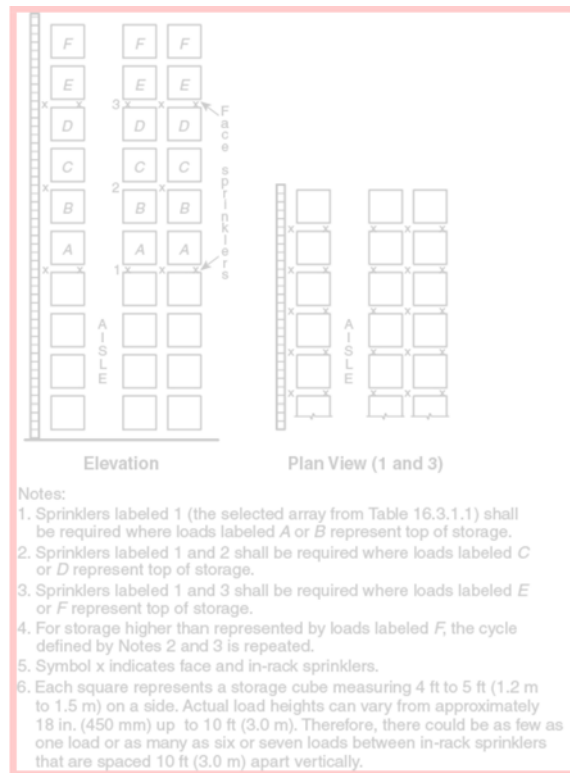
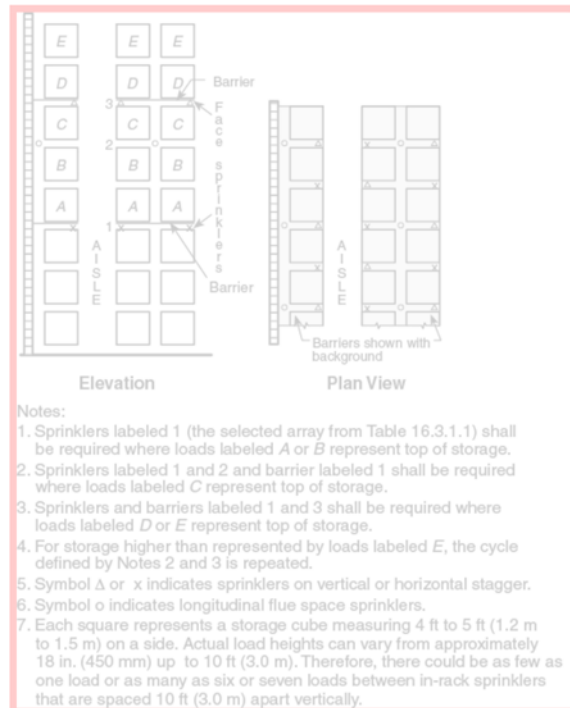


Figure 25.9.2.2.1(g) In-Rack Sprinkler Arrangement, Class I, II, III, or IV Commodities, Storage Height Over 25 ft (7.6 m) — Option 3.



25.9.2.3 Multiple-Row Racks.

25.9.2.3.1*

In multiple-row racks with a maximum of 10 ft (3.0 m) between the top of storage and the ceiling, in-rack sprinklers shall be in accordance with Table 25.9.2.3.1 and Figure 25.9.1.3.1(a) through Figure 25.9.2.3.1(c).

Table 25.9.2.3.1 Multiple-Row Racks of Class I Through Class IV Commodities Stored Over 25 ft (7.6 m) in Height

Commodity Class	Encapsulated	In-Rack Sprinklers ^{a,b,c}						Height Limit (ft)	Stagger	Figure	Maximum Spacing from Floor to Highest In-Rack Sprinkler	
		Maximum Vertical Spacing		Maximum Horizontal Spacing in A-Flue		Maximum Horizontal Spacing across Flue					ft	in
		ft	m	ft	m	ft	m					
I	No	20	6.1	12	3.7	10	3.0	None	Between adjacent flues	16.3.1.3.1.3(A)(a)	10	
	Yes											
I, II, and III	No	15	4.6	10	3.0	10	3.0			16.3.1.3.1.3(A)(b)	10	
	Yes											
I, II, III, and IV	No	10	3.1	10	3.0	10	3.0			16.3.1.3.1.3(A)(c)	5	
	Yes											

For SI units, °C = $\frac{5}{9}$ (°F-32); 1 gpm/ft² = 40.746 mm/min.

^a All four rack faces shall be protected by sprinklers located within the racks and no more than 18 in. (450 mm) from the faces, as indicated in Figure 16.3.1.3.1.3(A)(a) through Figure 16.3.1.3.1.3(A)(c). It shall not be required for each sprinkler level to protect all faces.

^b All in-rack sprinkler spacing dimensions start from the floor.

^c In Figure 16.3.1.3.1.3(A)(a) through Figure 16.3.1.3.1.3(A)(c), each square represents a storage cube measuring 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. to 10 ft (450 mm to 3.0 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.1 m) apart vertically.

Figure 25.9.2.3.1(a) In-Rack Sprinkler Arrangement, Class I Commodities, Storage Height 25 ft to Maximum 30 ft (7.6 m to Maximum 9.1 m).

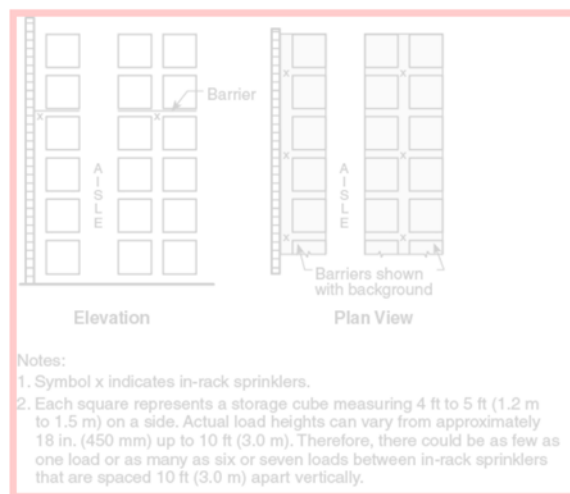


Figure 25.9.2.3.1(b) In-Rack Sprinkler Arrangement, Class I Commodities, Storage Height Over 25 ft (7.6 m).

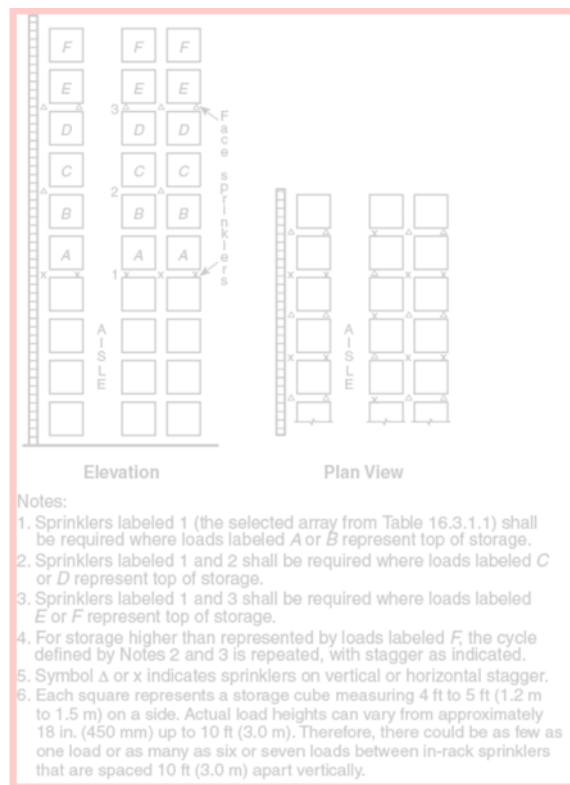
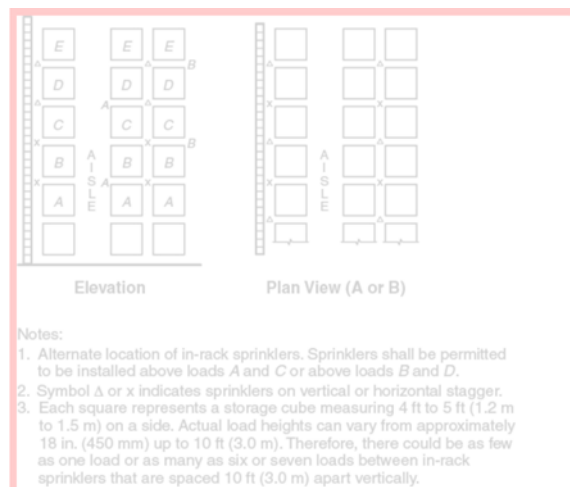


Figure 25.9.2.3.1(c) In-Rack Sprinkler Arrangement, Class I, II, or III Commodities, Storage Height 25 ft to Maximum 30 ft (7.6 m to Maximum 9.1 m).



25.9.3 Rack Storage of Group A Plastic Commodities Up to and Including 25 ft (7.6 m) in Height.

25.9.3.1

Where rack storage of cartoned Group A plastic commodities, encapsulated or nonencapsulated, having a clearance to ceiling up to and including 10 ft (3.1 m) require in-rack sprinklers, in-rack sprinkler arrangements shall be selected from Figure 25.9.3.1(a) through Figure 25.9.3.1(e).

Figure 25.9.3.1(a) In-Rack Sprinkler Arrangement, Cartoned Group A Plastic Storage Up to 15 ft (4.6 m) in Height with Up to 10 ft (3.0 m) Clearance to Ceiling.

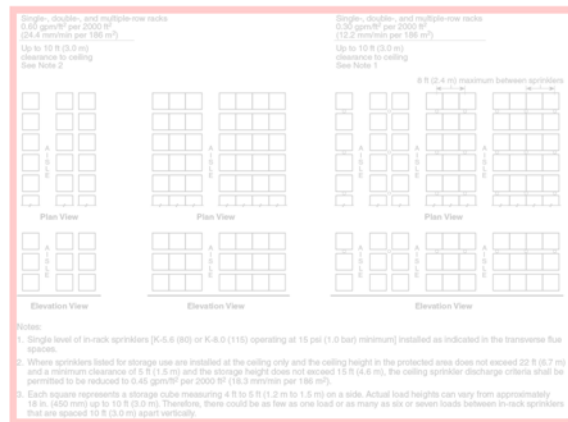


Figure 25.9.3.1(b) In-Rack Sprinkler Arrangement, Cartoned Group A Plastic Storage Up to Storage 20 ft (6.1 m) in Height with <5 ft (1.5 m) Clearance to Ceiling.

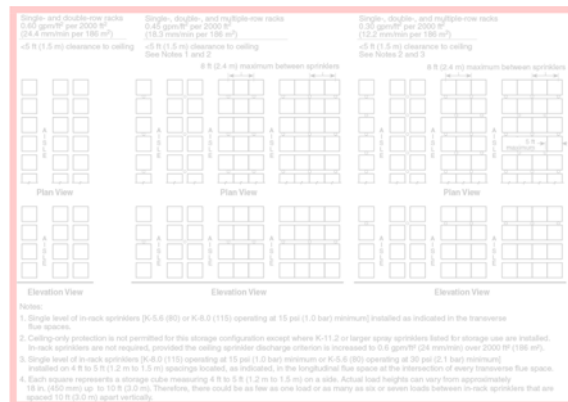


Figure 25.9.3.1(c) In-Rack Sprinkler Arrangement, Cartoned Group A Plastic Storage Up to Storage 20 ft (6.1 m) in Height with 5 ft to 10 ft (1.5 m to 3.0 m) Clearance to Ceiling.

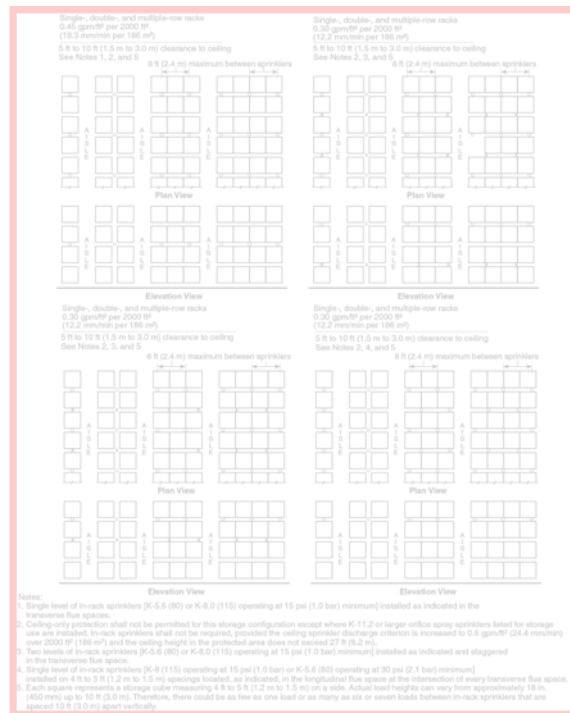


Figure 25.9.3.1(d) In-Rack Sprinkler Arrangement, Cartoned Group A Plastic Storage Up to Storage 25-ft (7.6 m) in Height with <5 ft (1.5 m) Clearance to Ceiling. (See Note 2.)

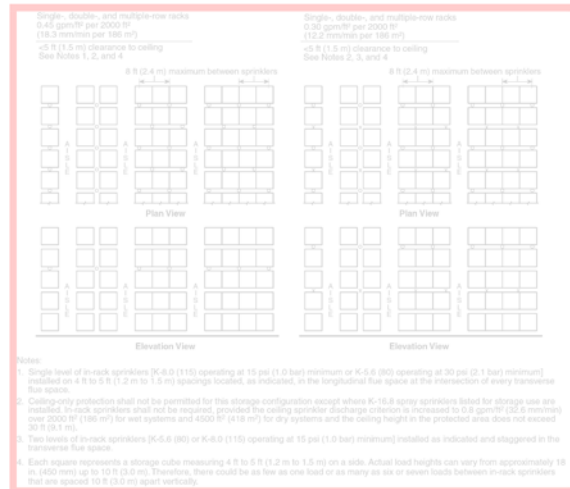
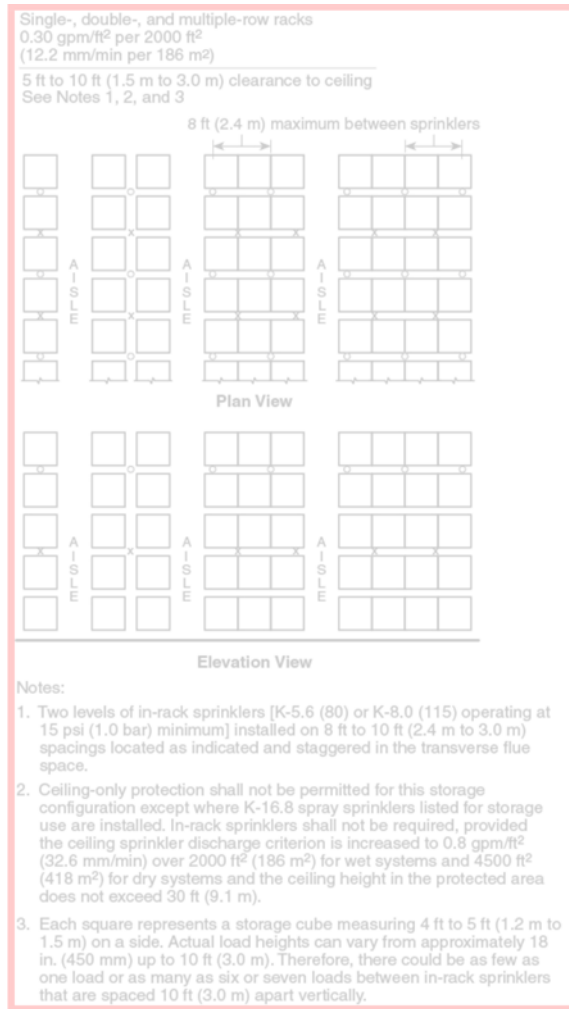


Figure 25.9.3.1(e) In-Rack Sprinkler Arrangement, Cartoned Group A Plastic Storage Up to Storage 25-ft (7.6 m) in Height with 5 ft to 10 ft (1.5 m to 3.0 m) Clearance to Ceiling. (See Note 2.)

**25.9.3.2***

~~Notes in each figure shall be permitted to clarify options or to present additional options not shown in the figures.~~

25.9.3.3*

Where rack storage of exposed nonexpanded Group A plastic commodities, encapsulated or nonencapsulated, require in-rack sprinklers, in-rack sprinkler arrangements shall be selected from Figure 25.9.3.3(a) through Figure 25.9.3.3(k).

Figure 25.9.3.3(a) In-Rack Sprinkler Arrangement, Exposed Nonexpanded Group A Plastic Commodities Up to 10 ft (3.0 m) in Height in Up to a 20 ft (6.1 m) High Building — Option 1.

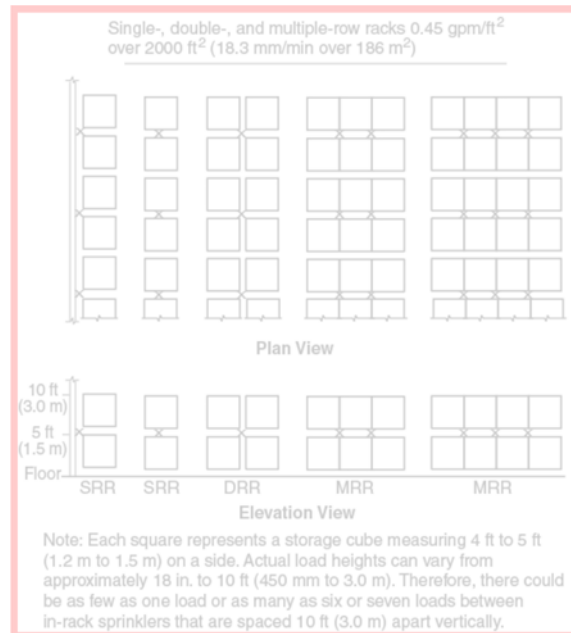


Figure 25.9.3.3(b) In-Rack Sprinkler Arrangement, Exposed Nonexpanded Group A Plastic Commodities Up to 10 ft (3.0 m) in Height in Up to a 20 ft (6.1 m) High Building — Option 2.

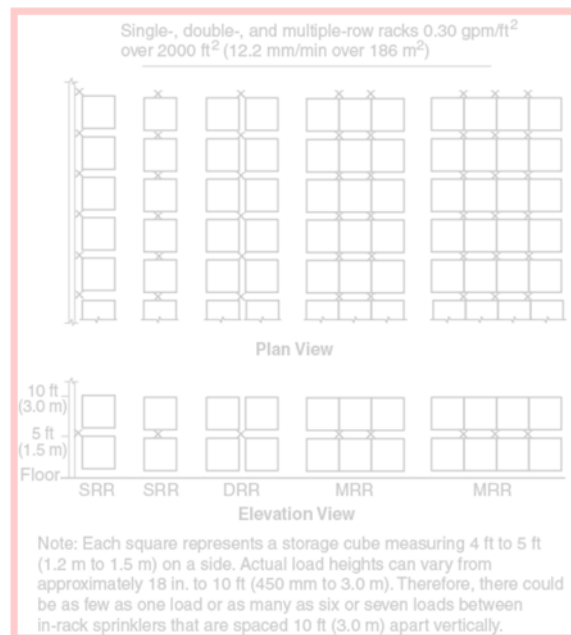


Figure 25.9.3.3(c) In-Rack Sprinkler Arrangement, Exposed Nonexpanded Group A Plastic Commodities Up to 15 ft (4.6 m) in Height in Up to a 25 ft (7.6 m) High Building — Option 1.

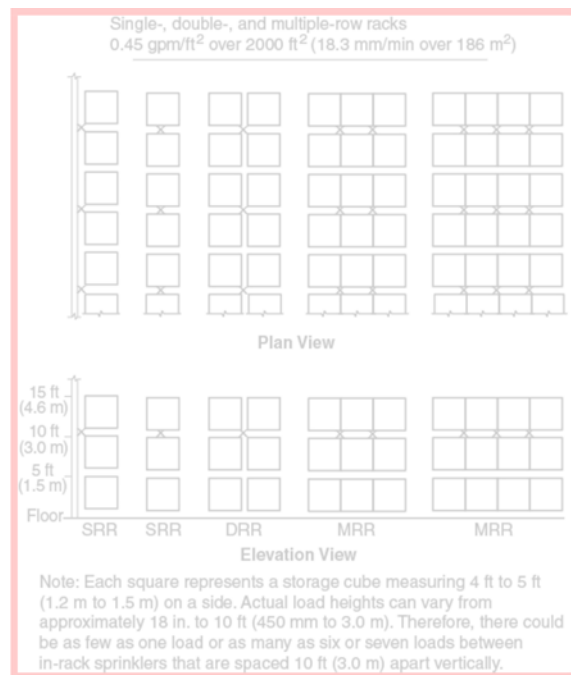


Figure 25.9.3.3(d) In-Rack Sprinkler Arrangement, Exposed Nonexpanded Group A Plastic Commodities Up to 15 ft (4.6 m) in Height in Up to a 25 ft (7.6 m) High Building — Option 2.

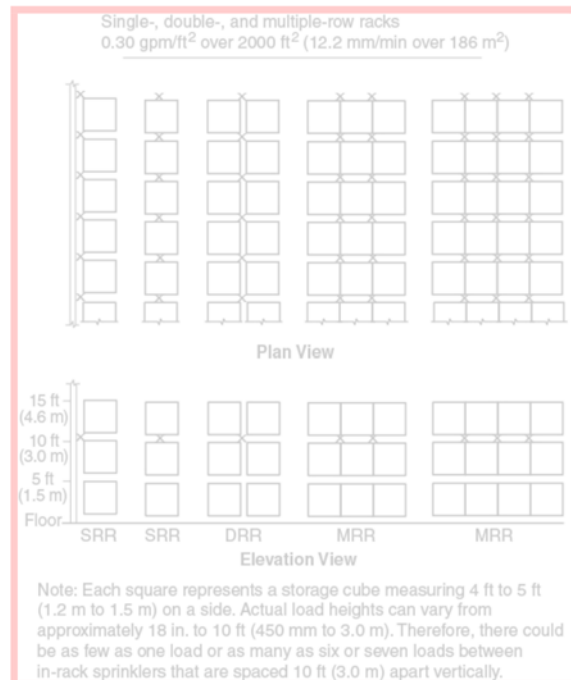


Figure 25.9.3.3(e) In-Rack Sprinkler Arrangement, Exposed Nonexpanded Group A Plastic Commodities Up to 20 ft (6.1 m) in Height in Up to a 25 ft (7.6 m) High Building — Option 1.

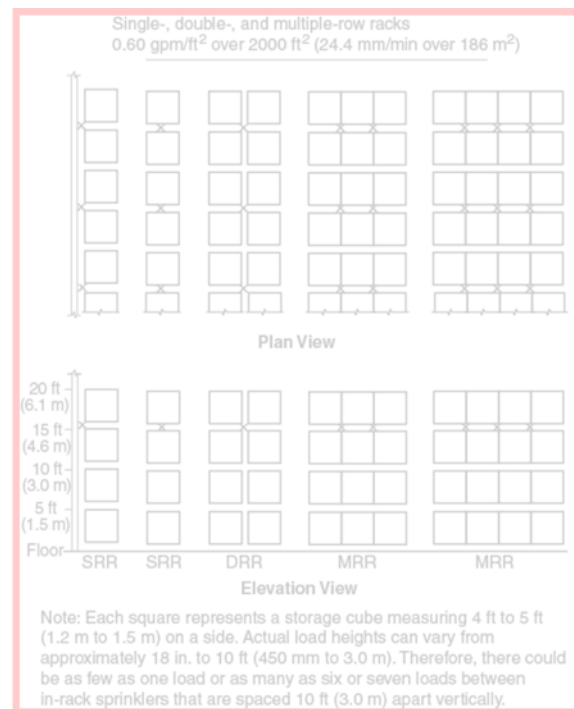


Figure 25.9.3.3(f) In-Rack Sprinkler Arrangement, Exposed Nonexpanded Group A Plastic Commodities Up to 20 ft (6.1 m) in Height in Up to a 25 ft (7.6 m) High Building — Option 2.

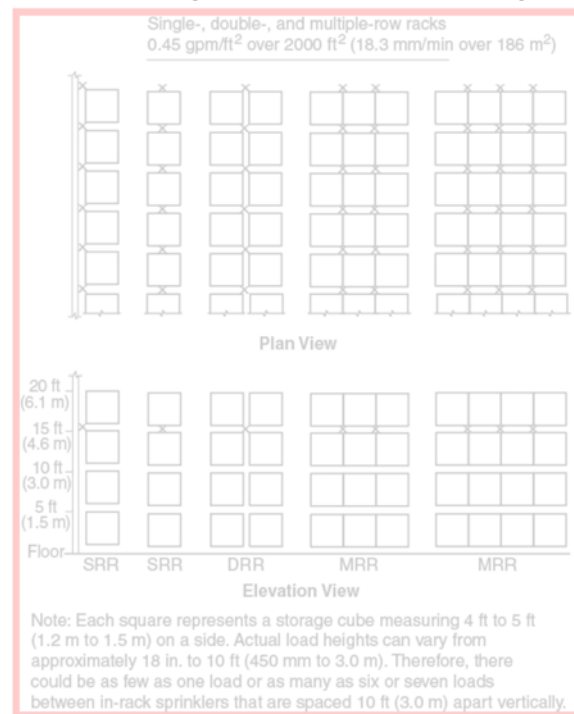


Figure 25.9.3.3(g) In-Rack Sprinkler Arrangement, Exposed Nonexpanded Group A Plastic Commodities Up to 20 ft (6.1 m) in Height in Up to a 30 ft (9.1 m) High Building — Option 1.

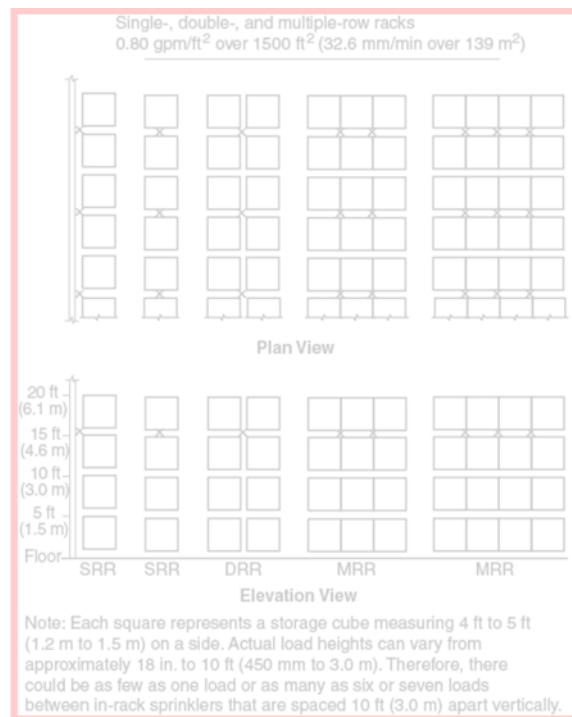


Figure 25.9.3.3(h) In-Rack Sprinkler Arrangement, Exposed Nonexpanded Group A Plastic Commodities Up to 20 ft (6.1 m) in Height in Up to a 30 ft (9.1 m) High Building — Option 2.

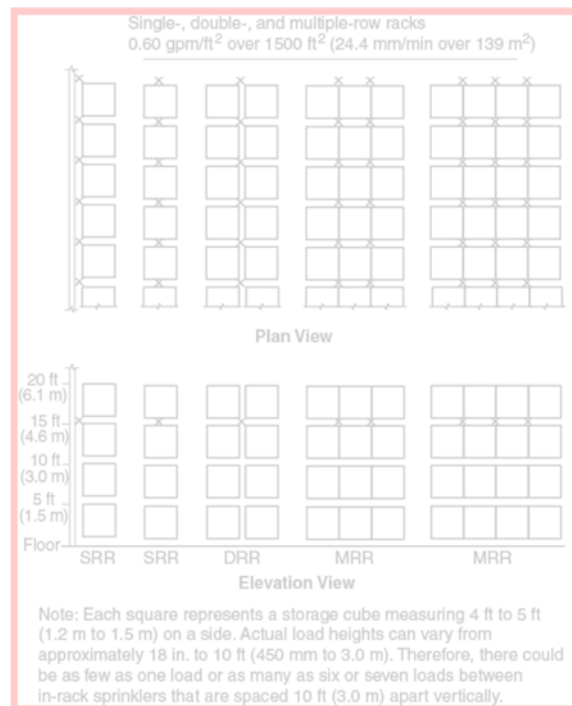


Figure 25.9.3.3(i) In-Rack Sprinkler Arrangement, Exposed Nonexpanded Group A Plastic Commodities Up to 20 ft (6.1 m) in Height in Up to a 30 ft (9.1 m) High Building — Option 3.

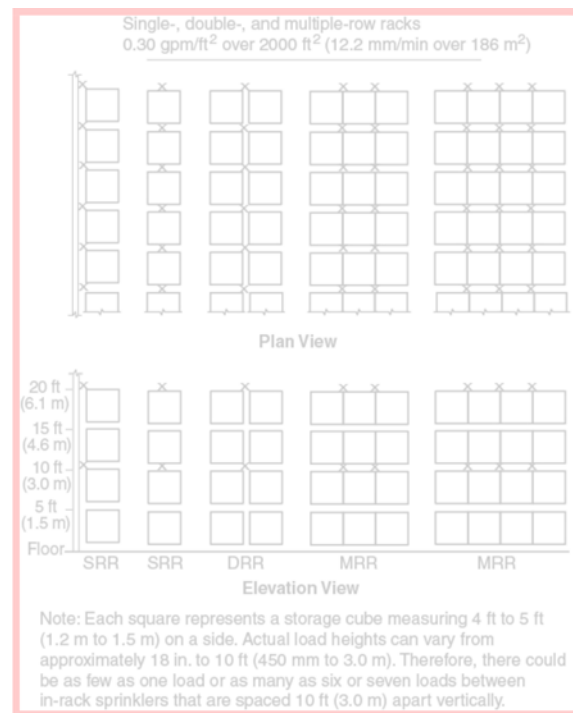


Figure 25.9.3.3(j) In-Rack Sprinkler Arrangement, Exposed Nonexpanded Group A Plastic Commodities Up to 25 ft (7.6 m) in Height in Up to a 35 ft (10.7 m) High Building — Option 1.

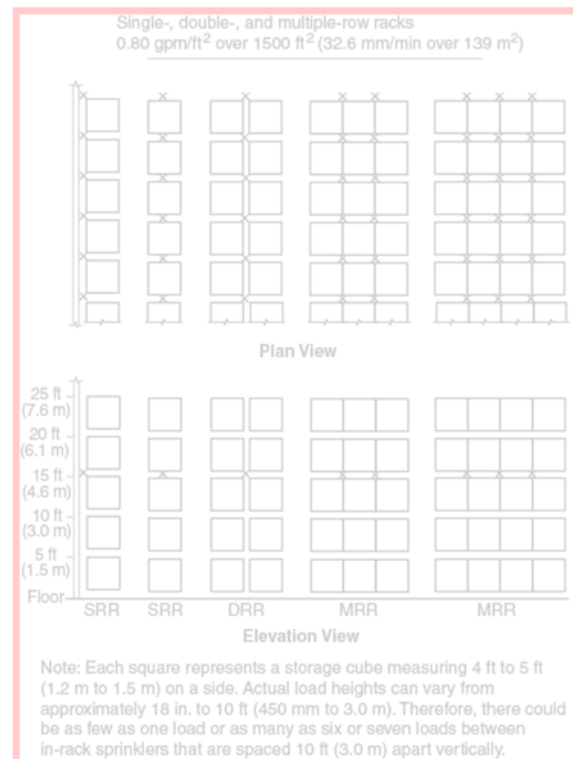
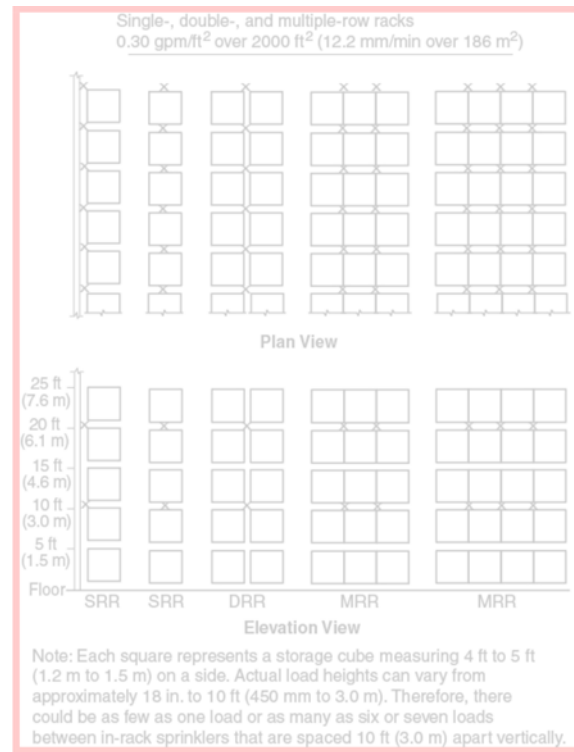


Figure 25.9.3.3(k) In-Rack Sprinkler Arrangement, Exposed Nonexpanded Group A Plastic Commodities Up to 25 ft (7.6 m) in Height in Up to a 35 ft (10.7 m) High Building — Option 2.



25.9.4 Rack Storage of Group A Commodities Over 25 ft (7.6 m) in Height.

25.9.4.1 Single-Row Racks.

25.9.4.1.1

Where single-row rack storage of cartoned Group A plastic commodities, expanded or nonexpanded, encapsulated or nonencapsulated, is over 25 ft (7.6 m) in height, in-rack sprinklers shall be arranged in accordance with one of the options in Figure 25.9.4.1.1(a) through Figure 25.9.4.1.1(d).

Figure 25.9.4.1.1(a) In-Rack Sprinkler Arrangement, Cartoned Group A Plastic Commodities, Single-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 1.

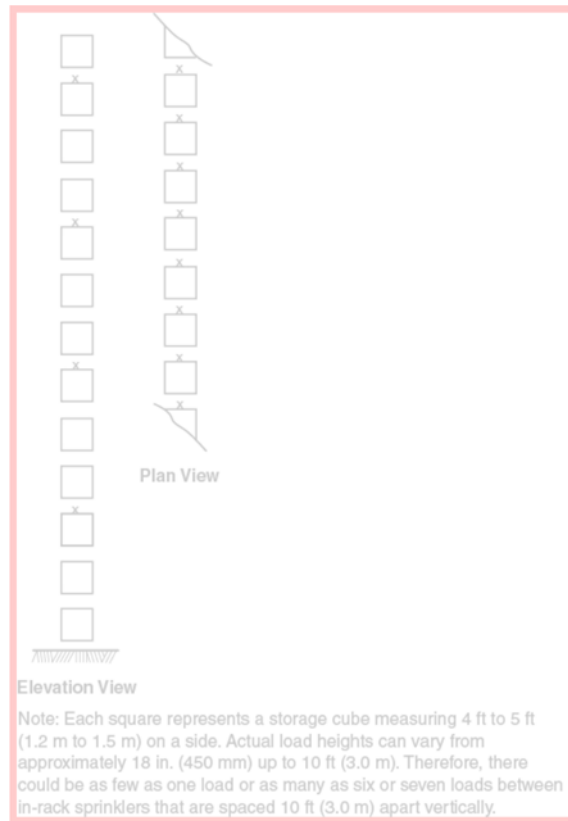


Figure 25.9.4.1.1(b) In-Rack Sprinkler Arrangement, Cartoned Group A Plastic Commodities, Single-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 2.

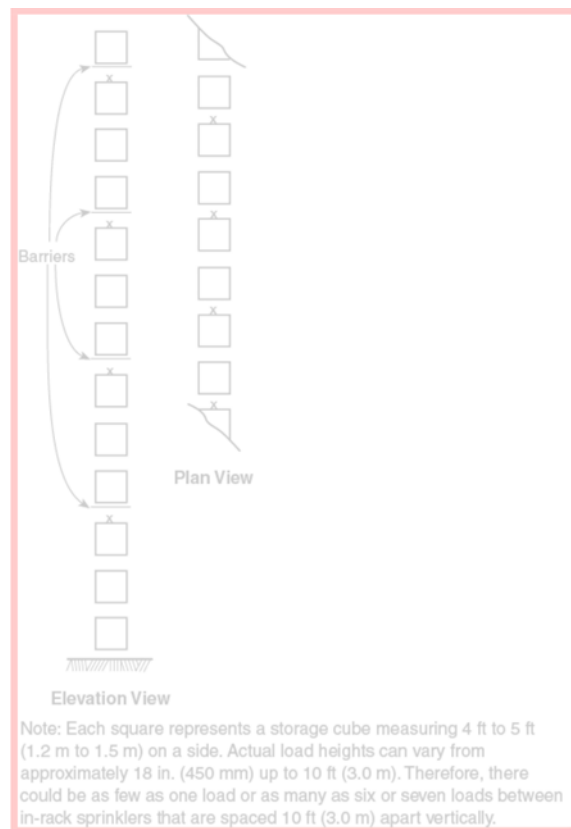


Figure 25.9.4.1.1(c) In-Rack Sprinkler Arrangement, Cartoned Group A Plastic Commodities, Single-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 3.

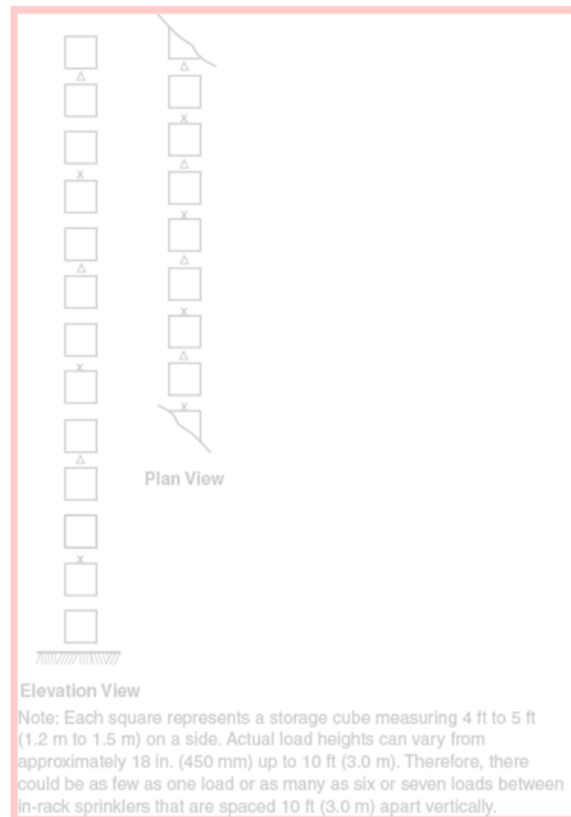


Figure 25.9.4.1.1(d) In-Rack Sprinkler Arrangement, Cartoned Group A Plastic Commodities, Single-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 4.

25.9.4.1.2

~~Where a single-row rack of cartoned Group A plastic commodities is located against a wall, the in-rack sprinkler arrangement shall be permitted to be in accordance with Figure 25.9.4.2(a) or Figure 25.9.4.2(b).~~

25.9.4.2 Double-Row Racks.

25.9.4.2.1

Where double-row rack storage of cartoned Group A plastic commodities, expanded or nonexpanded, encapsulated or nonencapsulated, is over 25 ft (7.6 m) in height, in-rack sprinklers shall be arranged in accordance with one of the options in Figure 25.3.5.2.1(a) through Figure 25.3.5.2.1(c).

Figure 25.9.4.2.1(a) In-Rack Sprinkler Arrangement, Cartoned Group A Plastic Commodities, Double-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 1.

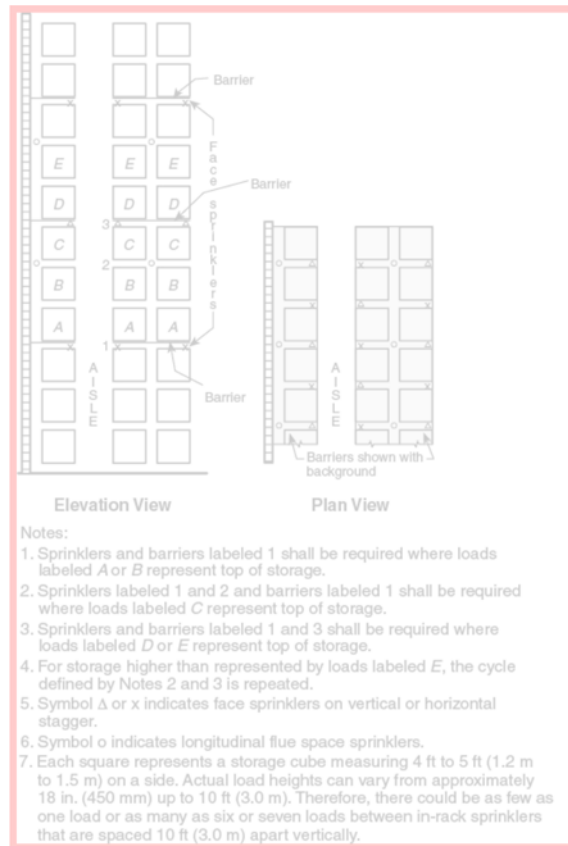


Figure 25.9.4.2.1(b) In-Rack Sprinkler Arrangement, Cartoned Group A Plastic Commodities, Double-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 2.

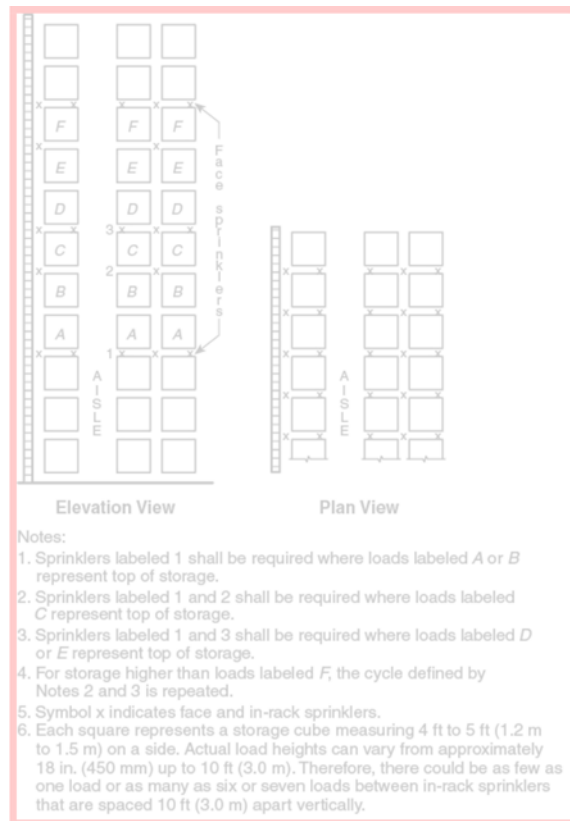
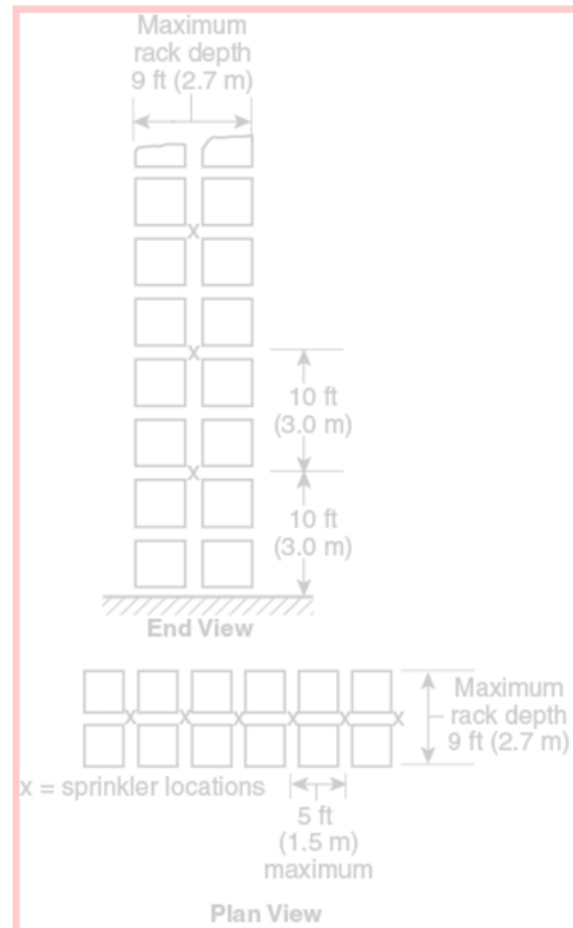


Figure 25.9.4.2.1(c) In-Rack Sprinkler Arrangement, Cartoned Group A Plastic Commodities, Double-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 3.

25.9.4.2.2*

Where double-row rack storage of exposed nonexpanded Group A plastic commodities, whether encapsulated or nonencapsulated, is over 25 ft (7.6 m) in height and has minimum 4 ft (1.2 m) wide aisles, in-rack sprinklers shall be arranged in accordance with Figure 25.9.4.2.2.

Figure 25.9.4.2.2 In-Rack Sprinkler Arrangement, Exposed Nonexpanded Group A Plastic Commodities, Double-Row Racks, Storage Height Over 25 ft (7.6 m).

**25.9.4.2.3**

Protection of Group A plastic commodities that are exposed and nonexpanded, whether encapsulated or nonencapsulated racks and with a clearance to ceiling up to and including 10 ft (3.1 m), shall be permitted only using in-rack sprinkler arrangements that are specifically permitted to be used with exposed nonexpanded plastic commodities.

25.9.4.3 Multiple-Row Racks.

25.9.4.3.1

Where multiple-row rack storage of exposed nonexpanded Group A plastic commodities, encapsulated or nonencapsulated, or cartoned Group A plastic commodities, expanded or nonexpanded, encapsulated or nonencapsulated, is over 25 ft (7.6 m) in height, in-rack sprinklers shall be arranged in accordance with one of the options in Figure 25.9.4.3.1(a) through Figure 25.9.4.3.1(f).

Figure 25.9.4.3.1(a) In-Rack Sprinkler Arrangement, Cartoned Group A Plastic and Exposed Nonexpanded Group A Plastic Commodities, Multiple-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 1 [10 ft (3.0 m) Maximum Spacing].

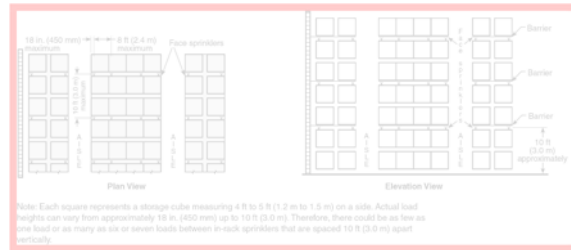


Figure 25.9.4.3.1(b) In-Rack Sprinkler Arrangement, Cartoned Group A Plastic and Exposed Nonexpanded Group A Plastic Commodities, Multiple-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 2 [10 ft (3.0 m) Maximum Spacing].

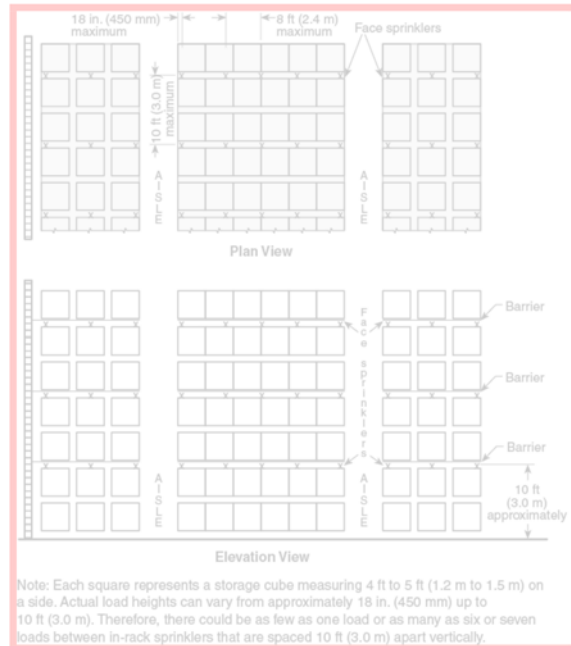


Figure 25.9.4.3.1(c) In-Rack Sprinkler Arrangement, Cartoned Group A Plastic and Exposed Nonexpanded Group A Plastic Commodities, Multiple-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 1 [5 ft (1.5 m) Maximum Spacing].

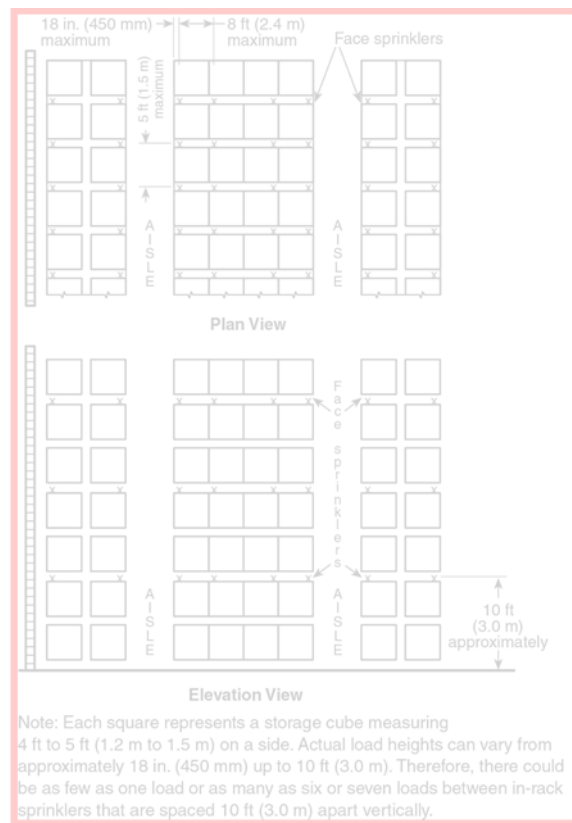


Figure 25.9.4.3.1(d) In-Rack Sprinkler Arrangement, Cartoned Group A Plastic and Exposed Nonexpanded Group A Plastic Commodities, Multiple-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 2 [5 ft (1.5 m) Maximum Spacing].

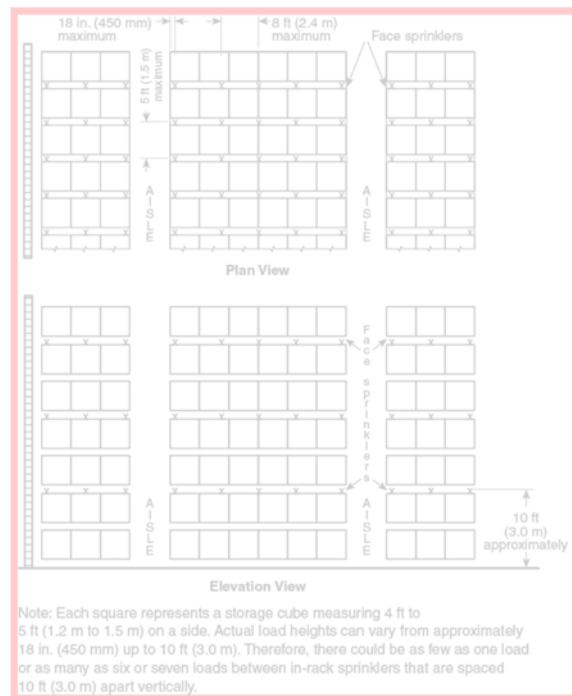


Figure 25.9.4.3.1(e) In-Rack Sprinkler Arrangement, Cartoned Group A Plastic and Exposed Nonexpanded Group A Plastic Commodities, Multiple-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 3 [5 ft (1.5 m) Maximum Spacing].

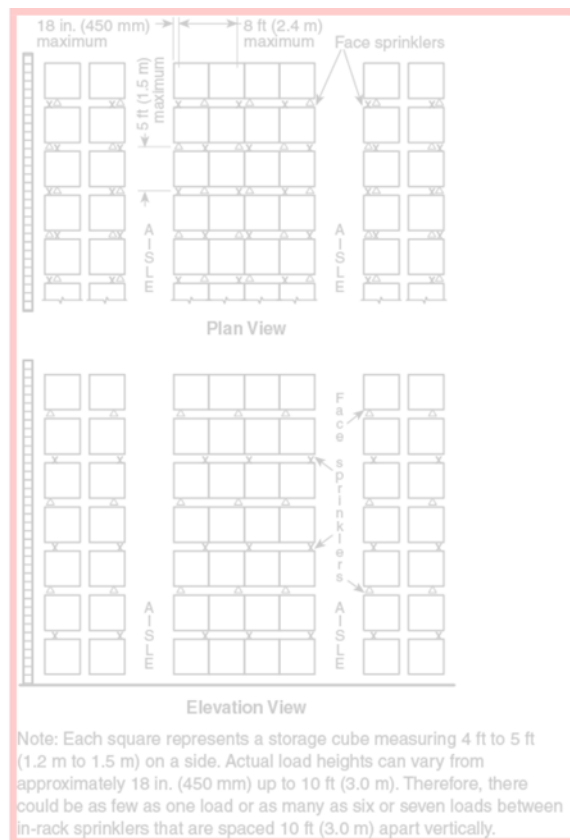
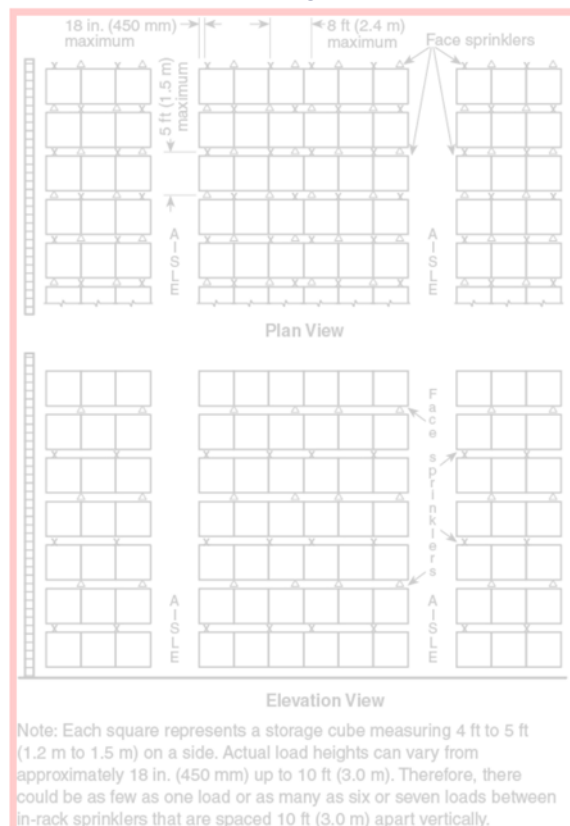


Figure 25.9.4.3.1(f) In-Rack Sprinkler Arrangement, Cartoned Group A Plastic and Exposed Nonexpanded Group A Plastic Commodities, Multiple-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 4 [5 ft (1.5 m) Maximum Spacing].



25.9.5 In-Rack Sprinkler Arrangements Due to Excessive Clearance.

25.9.5.1

Where the clearance to ceiling for rack storage of Class I through Class IV commodities up to and including 25 ft (7.6 m) in height protected by CMDA ceiling-level sprinklers exceeds 20 ft (6.1 m) and the ceiling-level protection is not capable of providing the protection needed for the storage height that would result in a clearance to ceiling of 20 ft (6.1 m), one level of supplemental, quick-response in-rack sprinklers located directly below the top tier of storage and at every flue space intersection shall be installed.

25.9.5.2

Where the clearance to ceiling for rack storage of plastic commodities up to and including 25 ft (7.6 m) in height protected by CMDA ceiling-level sprinklers exceeds 10 ft (3.0 m), and the ceiling-level protection is not capable of providing the protection needed for the storage height that would result in a clearance to ceiling of 10 ft (3.0 m) one level of supplemental, quick-response in-rack sprinklers located directly below the top tier of storage and at every flue space intersection shall be installed.

25.9.5.3

Where the clearance to ceiling exceeds 10 ft (3.0 m) for rack storage over 25 ft (7.6 m) in height, and the ceiling-level protection is not capable of providing the protection needed for the storage height that would result in a clearance to ceiling of 10 ft (3.0 m) one level of supplemental, quick-response in-rack sprinklers located directly below the top tier of storage and at every flue space intersection shall be installed.

25.9.5.4

Where the supplemental in-rack sprinkler protection has been installed in accordance with this section, the ceiling-level sprinkler system design shall be based upon the storage height that results in an acceptable clearance to ceiling.

25.9.5.5

Where in-rack sprinklers are required for the actual storage height based on a theoretical acceptable clearance to ceiling, in-rack sprinklers shall be installed as indicated by that criteria and supplemented as outlined in this section.

25.9.6 Rack Storage of Rubber Tires Up to and Including 20 ft (6.1 m) in Height.

The in-rack arrangements for rack storage of rubber tires, either on-side or on-tread, up to and including 20 ft (6.1 m) in height shall be in accordance with the guidelines outlined in 25.4 through 25.7 as applicable.

25.10 In-Rack Sprinkler Arrangements in Combination with CMSA Sprinklers at Ceiling Level.**25.10.1* Rack Storage of Class I Through Class IV and Group A Plastic Commodities.**

The in-rack arrangements for rack storage of Class I through Class IV and Group A plastic commodities protected by CMSA sprinklers at ceiling level shall be in accordance with the guidelines outlined in Section 25.4 through 25.7 as applicable.

25.11 In-Rack Sprinkler Arrangements in Combination with ESFR Sprinklers at Ceiling Level.**25.11.1 Rack Storage of Class I Through Class IV and Group A Plastic Commodities.**

The in-rack arrangements for rack storage of Class I through Class IV and Group A plastic commodities protected by ESFR sprinklers at ceiling level shall be in accordance with the guidelines outlined in Section 25.4 through 25.7 as applicable.

25.12 Design Criteria for In-Rack Sprinklers in Combination with Ceiling-Level Sprinklers.**25.12.1 General.****25.12.1.1**

In-rack sprinkler design criteria for Group A plastic commodities shall be permitted for the protection of the same storage height and configuration of Class I, II, III, and IV commodities.

25.12.1.2

Pipe sizing of an in-rack sprinkler system shall be permitted to be based on hydraulic calculations and not restricted by any pipe schedule.

25.12.1.3

Where in-rack sprinklers are being installed to protect a storage rack and, due to the length of the rack, fewer in-rack sprinklers will be installed than the number of in-rack sprinklers specified in the in-rack design, the in-rack sprinkler design shall be based on only those in-rack sprinklers installed within the protected rack.

25.12.1.4

Where in-rack sprinkler arrangements have been installed in accordance with Section 25.10, Section 25.11 or Section 25.12, the flow and pressure requirements of both the ceiling and in-rack sprinkler systems over the same protected area shall be hydraulically balanced together to the higher sprinkler system pressure requirement at their point of connection.

25.12.1.5

The minimum water supply requirements for a hydraulically designed occupancy hazard automatic in-rack sprinkler system shall be determined by adding the hose stream allowance from Table 20.12.2.6 to the water supply for ceiling-level sprinklers determined in Section 25.2, unless indicated otherwise.

25.12.2 Number of Operating In-Rack Sprinklers.**25.12.2.1** In-Rack Design Based on 4 In-Rack Sprinklers.

Where in-rack sprinklers have been installed to protect miscellaneous storage, the number of in-rack sprinklers to account for in the design shall be based on the simultaneous operation of the most hydraulically remote four in-rack sprinklers.

25.12.2.2 In-Rack Design Based on 6 In-Rack Sprinklers.**25.12.2.2.1**

Where in-rack sprinklers have been installed on one level to protect the following commodities and storage arrangements, the number of in-rack sprinklers to account for in the design shall be based on the simultaneous operation of the most hydraulically remote six in-rack sprinklers:

Class I through Class III commodities stored in racks with solid shelves.

Class I through Class III commodities stored in racks protected by CMDA sprinklers at ceiling level.

25.12.2.3 In-Rack Design Based on 8 In-Rack Sprinklers.**25.12.2.3.1**

Where in-rack sprinklers have been installed on one level to protect the following commodities and storage arrangements, the number of in-rack sprinklers to account for in the design shall be based on the simultaneous operation of the most hydraulically remote eight in-rack sprinklers:

Class IV and Group A plastic commodities stored in racks with solid shelves.

Class IV and Group A plastic commodities stored in racks protected by CMDA sprinklers at ceiling level.

Class I through Class IV commodities stored in racks protected by CMSA sprinklers at ceiling level.

Group A plastic commodities stored in racks up to and including 25 ft (7.6 m) in height protected by CMSA sprinklers at ceiling level.

Class I through Class IV commodities stored in racks protected by ESFR sprinklers at ceiling level.

25.12.2.4 In-Rack Design Based on 10 In-Rack Sprinklers.

25.12.2.4.1

Where in-rack sprinklers have been installed on more than one level to protect the following commodities and storage arrangements, the number of in-rack sprinklers to account for in the design shall be based on the simultaneous operation of the most hydraulically remote ten in-rack sprinklers (five on each of the top two levels):

Class I through Class III commodities stored in racks with solid shelves.

Class I through Class III commodities stored in racks over 25 ft (7.6 m) in height protected by CMDA sprinklers at ceiling level.

Class IV commodities stored in racks up to and including 25 ft (7.6 m) in height protected by CMDA sprinklers at ceiling level.

25.12.2.5 In-Rack Design Based on 12 In-Rack Sprinklers.

Where in-rack sprinklers have been installed on one level to protect rack storage of rubber tires, the number of in-rack sprinklers to account for in the design shall be based on the simultaneous operation of the most hydraulically remote twelve in-rack sprinklers.

25.12.2.6 In-Rack Design Based on 14 In-Rack Sprinklers.**25.12.2.6.1**

Where in-rack sprinklers have been installed on more than one level to protect the following commodities and storage arrangements, the number of in-rack sprinklers to account for in the design shall be based on the simultaneous operation of the most hydraulically remote fourteen in-rack sprinklers (seven on each of the top two levels):

Class IV and Group A plastic commodities stored in racks with solid shelves.

Class IV and Group A plastic commodities stored in racks protected by CMDA sprinklers at ceiling level.

25.12.3 In-Rack Sprinkler Flow/Pressure.**25.12.3.1 In-Rack Design Based on 15 psi (1.0 bar).****25.12.3.1.1**

Where in-rack sprinklers have been installed to protect the following commodities and storage arrangements, the minimum allowable design pressure at the hydraulically most remote in-rack sprinkler shall be 15 psi (1.0 bar). (See Section C.19.)

Miscellaneous storage.

Class I through Class IV commodities stored in racks up to and including 25 ft (7.6 m) in height protected by CMDA sprinklers at ceiling level.

Class I through Class IV commodities stored in racks protected by CMSA sprinklers at ceiling level.

Group A plastic commodities stored in racks up to and including 25 ft (7.6 m) in height protected by CMDA sprinklers at ceiling level.

Group A plastic commodities stored in racks up to and including 25 ft (7.6 m) in height protected by CMSA sprinklers at ceiling level.

25.12.3.2 In-Rack Design Based on 30 psi (2.1 bar).

Where in-rack sprinklers have been installed to protect rack storage of rubber tires, the minimum allowable design pressure at the hydraulically most remote in-rack sprinkler shall 30 psi (2.1 bar).

25.12.3.3 In-Rack Design Based on 30 gpm (115 L/min).



Second Revision No. 1020-NFPA 13-2017 [Chapter 26]

Chapter 26 Special Occupancy Requirements

26.1 General.

26.1.1 Application.

26.1.1.1

In addition to the requirements of Chapter 8, Chapters 11 through 22, and Chapter 23, the following special occupancy requirements shall apply.

26.1.1.1.1

All provisions of design criteria in this standard, including design area increases and reductions, shall also apply to these special occupancy requirements.

26.1.1.2

Where the requirements of the reference standard differ from the requirements of this standard, the reference standard shall take precedence.

26.1.2 Definitions.

For terms not defined in Chapter 3, the definitions of the reference standard shall apply.

26.2 Flammable and Combustible Liquids.

26.2.1 Design Requirements.

Sprinkler system discharge criteria for the protection of flammable and combustible liquids shall comply with NFPA 30.

26.2.2 Installation Requirements. (Reserved)

26.3 Aerosol Products.

26.3.1 Design Requirements.

Sprinkler system discharge criteria for the protection of aerosol products shall comply with NFPA 30B.

26.3.2 Installation Requirements. (Reserved)

26.4 Spray Application Using Flammable or Combustible Materials.

26.4.1 Design Requirements.

26.4.1.1*

The automatic sprinkler system shall be a wet pipe system, a dry pipe system, a preaction system, or an open-head deluge system, whichever is most appropriate for the portion of the spray operation being protected. [33:9.4.4 9.6.1]

A.26.4.1.1

Spray application operations should be located only in buildings that are completely protected by an approved system of automatic sprinklers. If the operations are located in unsprinklered buildings, sprinklers should be installed to protect spray application processes where practical. Because of the rapidity and intensity of fires that involve spray operations, the available water should be ample to simultaneously supply all sprinkler heads likely to open in one fire without depleting the available water for use by hose streams. Noncombustible draft curtains can be used to limit the number of sprinklers that will open. Subsection 9.6.1 of NFPA 33 lists four types of automatic sprinkler systems and requires that the one "most appropriate for the portion of the spray area being protected" be used. Generally, an open-head deluge system provides the highest level of protection, given that all sprinklers in the protected area flow simultaneously. This type of system is most appropriate for large, downdraft, water-wash spray booths when protecting automatic electrostatic spray application zones. [33: A.9.6.1]

Even when areas adjacent to coating operations are considered under reasonably positive fire control by adequate automatic sprinkler protection, damage is possible if operations are conducted on floors above those containing contents that are highly susceptible to water damage. Waterproofing and drainage of spray room floors can assist in reducing water damage on floors below. Proper drainage of the large volume of water frequently necessary to extinguish spray finishing room fires often presents considerable difficulty. [33: A.9.4] Wet pipe automatic sprinkler systems are appropriate for protecting spray booths that utilize nonelectrostatic application processes or operations using listed electrostatic application processes. Wet pipe systems are also generally used to protect exhaust plenums (eliminator or scrubber sections), exhaust ducts, and air recirculation filter houses. [33: A.9.6.1]

Automatic sprinklers in spray areas, including the interior of spray booths and exhaust ducts, should be wet pipe, preaction, or deluge system so that water can be placed on the fire in the shortest possible time. Automatic sprinklers in spray booths and exhaust ducts should be of the lowest practical temperature rating. The delay in application of water with ordinary dry pipe sprinklers can permit a fire to spread so rapidly that final extinguishment is difficult without extensive resulting damage. Dry pipe systems have been included because some exhaust duct designs include sections that are subject to freezing. [33: A.9.6.1]

The location of the sprinkler heads inside spray booths should be selected with care in order to avoid heads being placed in the direct path of spray and yet afford protection for the entire booth interior. When sprinkler heads are in the direct path of spray, even one day's operation can result in deposits on the sprinkler heads that insulate the fusible link or choke open head orifices to the extent that sprinklers cannot operate efficiently. Praction systems have been included because some spray application processes and equipment can be damaged by unwanted water discharge. This damage can be disruptive and costly. Powder spray booths and solvent concentrator (air pollution abatement) systems are examples of systems where it is appropriate to use a preaction system. [33: A.9.6.1]

Automatic sprinklers should also be located so that areas subject to substantial accumulations of overspray residue are protected. Generally, sprinklers are located no more than 4 ft (1.2 m) from side walls of booths and rooms and from dry overspray collectors (where applicable). Sprinklers in booths or rooms should be on Extra Hazard Occupancy spacing of 90 ft² (8.4 m²).

All sprinklers in spray areas should be controlled by an accessible control valve, preferably an outside stem and yoke (OS&Y) valve. [33: A.9.4]

26.4.1.2

The automatic sprinkler system shall be designed for Extra Hazard (Group 2) occupancies as defined in NFPA 13, as follows:

- (1) For spray application of styrene cross-link thermoset resins, ~~Section 17.3 of NFPA 33 shall apply.~~ resin application areas, sprinklers shall be designed for Ordinary Hazard (Group 2) as defined in this standard.
- (2) ~~Automatic sprinkler systems for~~ For powder coating operations, sprinklers shall be designed for Ordinary Hazard (Group 2), as defined in NFPA 13 this standard.
- (3) For all other spray areas, sprinklers shall be designed for Extra Hazard (Group 2) as defined in this standard.

[33:9.4.2 9.6.2]

Exception No. 1: For spray application of styrene cross-link thermoset resins, Section 17.3 of NFPA 33 shall apply.

Exception No. 2: Automatic sprinkler systems for powder coating operations shall be designed for Ordinary Hazard (Group 2), as defined in NFPA 13. [33: 9.4.2]

26.4.1.3

The sprinkler design area shall not be required to exceed the area of the booth or room in which spraying or resin application is conducted. [33: 9.6.2.1]

26.4.1.4

The water supply shall be sufficient to supply all sprinklers likely to open in any one fire incident without depleting the available water for use in hose streams. [33:9.4.3 9.6.3]

26.4.1.5

Where sprinklers are installed to protect spray areas and mixing rooms only, water shall be permitted to be supplied from domestic water systems, provided the domestic supply can meet the design criteria of 26.4.1.2. [33:9.4.4 9.6.4]

26.4.1.6

The sprinkler system shall be controlled by a separate, listed indicating valve(s), operable from floor level. [33:9.4.5 9.6.5]

26.4.1.7

Automated liquid electrostatic spray application equipment that is unlisted shall be protected further by the following:

- (1) In addition to meeting the requirements in 9.8.1 9.9.1 of NFPA 33, the optical flame detection system shall also activate one of the following over each zone in which fire has been detected:
 - (a) An open head deluge system designed to discharge a minimum density of 24.4 mm/min (0.6 gpm/ft²)
 - (b) A carbon dioxide extinguishing system
 - (c) A dry chemical extinguishing system
 - (d) A gaseous agent extinguishing system
 - (e) A water mist fire protection system

[33:9.8.2(1) 9.9.2(1)]

- (2) A wet pipe sprinkler system shall also be provided throughout the spray booth. This system shall meet all the applicable requirements of this standard for Extra Hazard (Group 2) occupancies.

[33:9.8.2(3) 9.9.2(3)]

26.4.2 Installation Requirements.**26.4.2.1***

Sprinkler systems protecting stacks or ducts with widths or diameters equal to or greater than 10 in. (0.25 m) but less than 12 ft (3.7 m) shall meet all of the following requirements:

~~Sprinklers shall be spaced no more than 3.7 m (12 ft) apart.~~

- (1) One sprinkler shall be located at the top of each vertical riser and at the midpoint of each offset. Additional sprinklers shall be spaced on 24 ft (7.3 m) centers if the rise is greater than 24 ft (7.3 m).
- (2) Horizontal exhaust ducts shall have sprinklers located on 12 ft (3.7 m) centers beginning no more than 6 ft (1.7 m) from the duct entrance.
- (3) If exhaust ducts are manifolded, a sprinkler shall be located in the manifold at the junction of each exhaust duct with the manifold.
- (4) Sprinklers shall provide a minimum flow of 30 gpm (114 L/min) per head at a minimum of 15 psi (1 bar) pressure.
- (5) Sprinklers shall be ordinary temperature rated, unless required to be higher due to operating temperatures measured in the ducts, in which case the operating temperature shall be at least 50°F (28°C) above the inside temperature of the duct.
- (6)* The system demand shall include the discharge from the hydraulically most remote adjacent sprinklers in a common 100 linear ft (30.5 m) area of duct (horizontal and/or vertical).
- (7)* The supply line to the duct sprinklers, if taken from the ceiling sprinkler system, shall be equipped with an accessible listed control valve.

[33:9.4.6 9.6.6]

A.26.4.2.1

Subsection 26.4.1.1 lists four types of automatic sprinkler systems and requires that the one “most appropriate for the portion of the spray area being protected” be used. Generally, an open-head deluge system provides the highest level of protection, given that all sprinklers in the protected area flow simultaneously. This type of system is most appropriate for large, downdraft, water-wash spray booths when protecting automatic electrostatic spray application zones. Water supply requirements for most industrial paint spray operations should be adequate to supply all automatic sprinklers in the spray area. Loss experience has shown that fires starting in the exhaust duct can spread to the spray booth and that fires starting in the booth can spread to the exhaust duct. [33: A.9.6.6]

Wet pipe automatic sprinkler systems are appropriate for protecting spray booths that utilize nonelectrostatic application processes or operations using listed electrostatic application processes. Wet pipe systems are also generally used to protect exhaust plenums (eliminator or scrubber sections), exhaust ducts, and air recirculation filter houses. Sprinklers or sprinkler systems protecting stacks or ducts should be of a type not subject to freezing. Automatic systems are preferred, but manual systems are also acceptable. Nonfreeze or dry-type sprinkler systems can be used in ducts subject to freezing. For some industries, such as the automotive industry, manually operated open-head systems have proved to be effective protection for ducts and stacks. [33: A.9.6.6]

Dry pipe systems have been included because some exhaust duct designs include sections that are subject to freezing. Ductwork in powder coating applications does not require fire protection. Based on design duct velocity, there is no accumulation of residual powder. [33: A.9.6.6]

Preaction systems have been included because some spray application processes and equipment can be damaged by unwanted water discharge. This damage can be disruptive and costly. Powder spray booths and solvent concentrator (air pollution abatement) systems are examples of systems where it is appropriate to use a preaction system. [33: A.9.4.1]

Water supply requirements for most industrial paint spray operations should be adequate to supply all automatic sprinklers in the spray area. Loss experience has shown that fires starting in the exhaust duct can spread to the spray booth and that fires starting in the booth can spread to the exhaust duct.

Sprinklers or sprinkler systems protecting stacks or ducts should be of a type not subject to freezing. Automatic systems are preferred, but manual systems are also acceptable. For some industries, such as the automotive industry, manually operated open-head systems have proved to be effective protection for ducts and stacks. [33: A.9.4.6]

26.4.2.1.1

Stacks and exhaust ducts shall be provided with access openings for inspection and cleaning of sprinklers. [33:9.4.6.1 9.6.6.1]

26.4.2.1.2

Sprinkler systems protecting stacks and ducts that are subject to freezing shall be of a nonfreezing type or be a manually controlled open-head system. [33:9.4.6.2 9.6.6.2]

26.4.2.2

Sprinklers shall be protected against overspray residue, either by location or covering, so that they will operate quickly in event of fire. [33:9.4.7 9.6.7]

26.4.2.2.1

Sprinklers shall be permitted to be covered only by cellophane bags having a thickness of 0.003 in. (0.08 mm) or less or by thin paper bags. These coverings shall be replaced frequently so that heavy deposits of residue do not accumulate. [33:9.4.7.1 9.6.7.1]

26.4.2.2.2

Sprinklers that have been painted or coated by overspray or residues shall be replaced with new sprinklers. [33:9.4.7.2 9.6.7.2]

26.5 Solvent Extraction Plants. [NFPA 36]**26.5.1* Design Requirements.****A.26.5.1**

Water spray or deluge systems that are used to protect solvent extraction process equipment or structures should be designed to provide a density of not less than 0.25 gpm/ft² (10.3 mm/min) of protected surface area. (~~See NFPA 13 and NFPA 15, for additional information.~~) See this standard and NFPA 15 for additional information. Foam-water sprinkler or deluge systems that are used for the same purposes should be designed to provide a density of not less than 0.16 gpm/ft² (6.5 mm/min) of protected surface area. (~~See NFPA 13 and NFPA 16 for additional information.~~) See this standard and NFPA 16 for additional information. Preparation buildings should be protected with automatic sprinkler systems designed for ordinary hazard (Group 2), ~~in accordance with NFPA 13.~~ Ordinary Hazard (Group 2), in accordance with this standard. [36:A.4.8 A.4.9]

26.5.2 Installation Requirements. (Reserved)**26.6 Installation and Use of Stationary Combustion Engines and Gas Turbines.****26.6.1* Design Requirements.**

Automatic sprinkler systems shall be designed to provide for a density of 0.3 gpm/ft² (12.2 mm/min) over the most remote 2500 ft² (230 m²). [37:11.4.5.1]

26.6.2 Installation Requirements.**26.6.2.1**

Sprinklers and spray nozzles shall be spaced at a 100 ft² (9 m²) maximum area of coverage per sprinkler or spray nozzle. [37:11.4.5.1.1]

26.6.2.2

Sprinkler and water spray system coverage shall be provided to all areas within the enclosure located within 20 ft (6 m) of the following:

- (1) The engine
- (2) The lubricating oil system
- (3) The fuel system

[37:11.4.5.1.2]

26.6.2.3

Sprinklers and water spray nozzles shall not be directed at engine components that are susceptible to thermal shock or deformation. [37:11.4.5.2]

26.7 Nitrate Film.**26.7.1 Design Requirements.****26.7.1.1**

Every room, except projection booths and rewinding rooms, where nitrate film is stored or handled in quantities greater than 51 lb (23 kg), or ~~40 standard rolls~~ 10,000 ft (3050 m), shall be protected by an automatic sprinkler system that is installed in accordance with the requirements for Group II extra hazard occupancies. [40:5.1.2]

26.7.1.2

Water supplies for automatic sprinklers shall be based on 20 gpm (1.26 L/sec) per sprinkler for 20 minutes for the total number of sprinklers in one vault plus 25 percent of the sprinklers in the communicating fire area. [40:5.2.2]

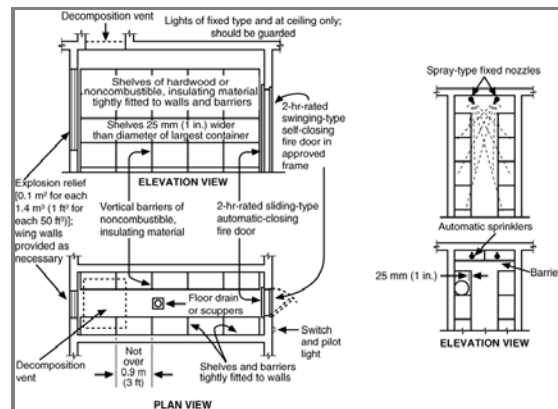
26.7.1.3* Vaults Other Than Extended Term Storage Vaults.

[40:6.3] (See Figure A.26.7.1.3.) Fire protection in vaults shall be provided by a deluge system with directional nozzles meeting the criteria in 26.7.1.4. [40:6.3.7]

A.26.7.1.3

See Figure A.26.7.1.3. The illustration shows the location of ~~sprinkler heads~~ sprinklers and the decomposition vent. [40:A.6.3]

Figure A.26.7.1.3 Standard Film Vault (for Other Than Extended Term Storage Film). [40:Figure A.6.3]

**26.7.1.4**

For extended term storage vaults in accordance with Section 6.5.5 of NFPA 40, fire protection shall be provided by a deluge system with directional nozzles installed in accordance with NFPA 15 and meeting the criteria in 26.7.1.4.1 through 26.7.1.4.9. [40:6.5.6]

26.7.1.4.1

Sprinkler systems in existing extended term storage vaults that were in compliance with the provisions of this standard at the time of installation shall be permitted to be continued in use. [40:6.5.6.1]

26.7.1.4.2

High-velocity open head ~~water spray~~ water spray nozzles each capable of providing a discharge rate of 20 gpm (1.26 L/sec) at a gauge pressure of 50 psi (345 kPa) shall be installed. [40:6.5.6.2]

26.7.1.4.3

The design shall be based on a discharge density of ~~28 mm/min (0.68 gpm/ft²)~~ 0.68 gpm/ft² (28 mm/min) over each face of storage racks. [40:6.5.6.3]

26.7.1.4.4*

The nozzles shall have a combined spray pattern capable of covering the face of the film storage racks.
[40:6.5.6.4]

26.7.1.4.5

The nozzles shall be installed at the top of the storage shelf array, aimed at the opposite shelf array.
[40:6.5.6.5]

26.7.1.4.6*

Nozzles shall be installed on opposite faces of the storage shelf array in a staggered pattern such that no nozzles are directly opposite one another. [40:6.5.6.6]

26.7.1.4.7

The water supply duration shall be a minimum of 20 minutes. [40:6.5.6.7]

26.7.1.4.8

The deluge system shall be activated by a signal from one of the following:

- (1) An air sampling-type smoke detection system
- (2) A fixed temperature heat sensitive cable

[40:6.5.6.8]

26.7.1.4.9

Full water flow shall be discharged from the water spray nozzles within 10 seconds of reaching the set point actuation of the detection system [40:6.5.6.9.6]

26.7.2 Installation Requirements.**26.7.2.1**

In areas or rooms where nitrate film is handled, the area that is protected per sprinkler head shall not exceed 64 ft² (6 m²) with sprinklers not being more than 8 ft (2.4 m) apart. [40:5.1.4]

26.7.2.2 Cabinet Protection.

[40:6.2.5]

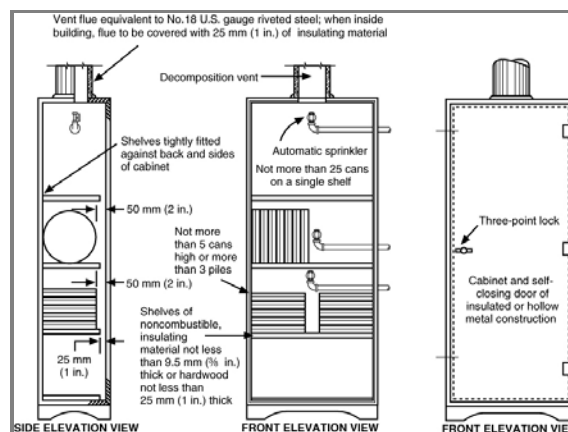
26.7.2.2.1

Cabinets having a capacity of more than 34 kg (75 lb), or 15 standard rolls, 75 lb (34 kg), or 15,000 ft (4575 m), of film shall be provided with at least one automatic sprinkler head. [40:6.2.5.1]

26.7.2.2.2

Where cans are stored on more than one shelf, as shown in Figure 26.7.2.2.2 and as described in 6.2.6.2 or 6.2.6.3 of NFPA 40, one sprinkler shall be provided for each shelf. [40:6.2.5.2]

Figure 26.7.2.2.2 Standard Film Cabinet for Other Than Extended Term Storage Film. [40:Figure 6.2.1]



26.7.2.3 Motion Picture Film Laboratories.

In all cases, sprinklers shall be arranged so that not more than two machines are protected by any one sprinkler head. [40:9.2.5.2]

26.8 Laboratories Using Chemicals.

26.8.1 Design Requirements.

Automatic sprinkler system protection shall be required for all new laboratories in accordance with the following:

- (1) Automatic sprinkler system protection for Class A and Class B laboratories shall be in accordance with NFPA 43 this standard for ordinary hazard (Group 2) occupancies.
- (2) Automatic sprinkler system protection for Class C and Class D laboratories shall be in accordance with NFPA 43 this standard for ordinary hazard (Group 1) occupancies.

[45:6.1.1.1]

26.8.2 Installation Requirements.

Fire sprinklers in laboratory units shall be the quick response (QR) sprinkler type installed in accordance with NFPA 43 this standard. [45:6.1.1.2]

26.9 Oxygen-Fuel Gas Systems for Welding, Cutting, and Allied Processes.

26.9.1 Design Requirements.

26.9.1.1

Oxygen cylinders connected to one manifold shall be limited to a total gas capacity of 6500 ft³ (184 m³). [51:5.2.5]

26.9.1.1.1

Two such manifolds with connected cylinders shall be permitted to be located in the same room, provided the building is protected throughout with an approved automatic sprinkler system designed in accordance with this standard, furnishing a sprinkler discharge density of at least 0.25 gpm/ft² (10.2 mm/min) over a minimum operating area of at least 3000 ft² (279 m²) with sprinklers located not more than 20 ft (6.1 m) above the floor where the manifolds are located. [51:5.2.5.1]

26.9.1.2

~~For mobile acetylene trailer systems, a~~ An automatic deluge sprinkler system shall be provided for MATS fire areas used as indoor and outdoor discharging stations. [51:10.5.8.1.1]

26.9.1.3

~~Deluge~~ Automatic deluge sprinkler systems shall ~~provide~~ be designed in accordance with the requirements of this standard using Extra Hazard Group 1 with a minimum density of 0.3 gpm/ft² (12.2 mm/min) over design area of 2500 ft² (232 m²) for the entire MATS fire area being protected. [51:10.5.8.1.2]

26.9.1.4

~~The automatic deluge system shall be identified and marked with a sign and shall be able to be activated automatically by a fast-acting fire detection system and also by a~~ at least one manual actuator pull station in an accessible location at a minimum of 25 ft (7.6 m) from the MATS fire area. [51:10.5.8.1.3]

26.9.1.5

The requirements of 26.9.1.2, 26.9.1.3, and 26.9.1.4 shall not apply to existing indoor or outdoor facilities, equipment, structures, or installations where MATS are charged or discharged that existed or were approved for construction or installation prior to the effective date of this standard, provided ~~providing~~ the MATS are fire area is protected with an automatic sprinkler or deluge system with a minimum design density of not less than 0.25 gpm/ft² (10.2 10.1 mm/min). [51:10.5.8.1.4.1]

26.9.2 Installation Requirements.

26.9.2.1

In buildings protected by an automatic sprinkler system and water supply designed in accordance with this standard for an Ordinary Hazard Group 2 or more hazardous occupancy, where the occupancy other than the cylinder storage is not more hazardous than ordinary hazard as defined in this standard, the distance between designated storage areas shall be permitted to be reduced to ~~45.2 m (50 ft)~~ 50 ft (15.2 m). [51:4.3.4.1].

26.9.2.2

If the occupancy in such protected buildings between the designated storage areas is free of combustible material, the distance shall be permitted to be reduced to 25 ft (7.6 m). [51:4.3.4.2].

26.10 Acetylene Cylinder Charging Plants.**26.10.1 Design Requirements.****26.10.1.1**

~~When sprinkler protection is provided, the area in which flammable compressed gases are stored or used shall be protected with a sprinkler system designed to be not less than that required by NFPA 13 for Extra Hazard Group 1 with a minimum design area of 2500 ft² (232.26 m²). [51A: 11.2.1.2] An automatic deluge sprinkler system shall be provided for MATS fire areas used as indoor and outdoor charging and discharging stations. [55: 15.3.9.1.1]~~

26.10.1.2

~~At mobile acetylene trailer systems (MATS) at mobile acetylene charging plants, a fire sprinkler system in accordance with this standard, Extra Hazard Group 1 shall be installed in the areas occupied by trailers in charging or discharging stations. [51A: 11.2.1.3] Automatic deluge sprinkler systems shall be designed in accordance with the requirements of this standard using Extra Hazard Group 1 with a minimum design area of 2500 ft² for the entire MATS fire area. [55: 15.3.9.1.2]~~

26.10.1.3

~~The automatic deluge system shall be able to be activated automatically by a fast-acting fire detection system and also by at least one manual pull station in an accessible location at a minimum of 25 ft (7.6 m) from the MATS fire area. [55: 15.3.9.1.3]~~

26.10.2 Installation Requirements. (Reserved)**26.11 Compressed Gases and Cryogenic Fluids Code.****26.11.1 Design Criteria.****26.11.1.1**

When sprinkler protection is required, the area in which compressed gases or cryogenic fluids are stored or used shall be protected with a sprinkler system designed to be not less than that required by NFPA 13 19.3.3.1.1 for Ordinary Hazard Group 2: density/area curve. [55:6.10.2.1 6.11.2.1]

26.11.1.2

~~When~~ Where sprinkler protection is required, the area in which the flammable or pyrophoric compressed gases or cryogenic fluids are stored or used shall be protected with a sprinkler system designed to be not less than that required by NFPA 13 19.3.3.1.1 for Extra Hazard Group 1 density/area curve. [55:6.10.2.2 6.11.2.2]

26.11.2 Installation Requirements. (Reserved)**26.12 Utility LP-Gas Plants.****26.12.1 Design Requirements.****26.12.1.1**

The design of fire water supply and distribution systems, where used, shall provide for the simultaneous supply of those fixed fire protection systems involved in the maximum single incident expected in the plant, including monitor nozzles, at their design flow and pressure. [59:13.4.2]

26.12.1.2

An additional supply of 1000 gal/min (63 L/sec) shall be available for hand hose streams for a period of not less than 2 hours. [59:13.4.2.1]

26.12.1.3

Manually actuated monitors shall be permitted to be used to augment hand hose streams. [59:13.4.2.2]

26.12.2 Installation Requirements. (Reserved)**26.13** Production, Storage, and Handling of Liquefied Natural Gas (LNG).**26.13.1** Design Requirements.

The fire water supply and distribution systems, if provided, shall simultaneously supply water to fixed fire protection systems, including monitor nozzles, at their design flow and pressure, involved in the maximum single incident expected in the plant plus an allowance of 1000 gpm (63 L/sec) for hand hose streams for not less than 2 hours. [59A:12.5.2]

26.13.2 Installation Requirements. (Reserved)**26.14** Protection of Information Technology Equipment.**26.14.1** Design Requirements. (Reserved)**26.14.2** Installation Requirements.**26.14.2.1**

~~Information technology equipment ITE~~ rooms and ~~information technology equipment ITE~~ areas located in a sprinklered building shall be provided with an automatic sprinkler system. [75:9.1.1]

26.14.2.1.1

ITE rooms and ITE areas located in a nonsprinklered building shall be provided with one or more automatic fire suppression systems as permitted by Chapter 9 of NFPA 75 .

26.14.2.2

Sprinkler systems protecting ~~information technology equipment ITE~~ areas shall be valved separately from other sprinkler systems. [75:9.1.3]

26.14.2.3

The requirement of 9.1.1.1 of NFPA 75 shall be permitted to be evaluated as part of the fire risk assessment as outlined in Chapter 4 of NFPA 75 . [75: 9.1.1.2]

26.14.2.4*

~~An automatic sprinkler fire suppression system or a gaseous fire extinguishing system , as permitted by Chapter 9 of NFPA 75 , shall be provided for the protection of the area below a raised floor in an information technology equipment room or information technology equipment ITE room or ITE area where the area below the raised floor contains combustible material other than what is permitted in 26.14.2.5 . [75: 9.1.1.3] when one or more of the following exist:~~

~~There is a critical need to protect data in the process, reduce equipment damage, and facilitate return to service.~~

~~The area below the raised floor contains combustible material.~~

[75: 9.1.1.2]

A.26.14.2.4

The use of carbon dioxide systems for the protection of spaces beneath raised floors is discussed in Section B.5 of NFPA 12 wherein it is pointed out that the design of such systems requires compensation for leakage and provision for a soft discharge to minimize turbulence and agent loss through perforated tiles. These same concerns exist for other inert gas clean agent systems installed in accordance with NFPA 2001. Since these spaces are usually of a very limited height, this type of fire suppression system may be easier to design and install than sprinklers. [75:A-8.1.1.2 A.9.1.1.3]

The use of halocarbon agents for protection of the spaces under a raised floor where the room is not simultaneously protected is not recommended. However, where a room is protected by a halocarbon system, the space beneath its raised floor needs to be included in the system coverage. [75: A.9.1.1.3]

26.14.2.5

An automatic fire suppression system shall not be required for the protection of the area below a raised floor in an ITE room or ITE area where combustible material under the floor is limited to the following:

- (1) Cables listed for plenum use
- (2) Listed plenum communications raceways
- (3) Listed equipment power cords up to 15 ft (4.6 m) each
- (4) Cables installed in metallic raceways
- (5) Installations in compliance with Section 300.22(C) of NFPA 70
- (6) Listed cooling hoses

[75: 9.1.1.4]

26.15 Standard on Incinerators, and Waste and Linen Handling Systems and Equipment.

26.15.1 Design Requirements. (Reserved)

26.15.2 Installation Requirements.

26.15.2.1

Automatic sprinklers shall be provided in incinerator rooms in accordance with this standard. [82:5.2.7.3]

26.15.2.2* Waste and Linen Chutes and Transport Systems.

[82:Chapter 6]

26.15.2.2.1 Gravity Waste or Linen Chutes.

[82:6.2]

26.15.2.2.1.1

~~Lined metal chutes shall be protected internally by automatic sprinklers unless they are lined in accordance that comply with 6.2.2.6.1 in of NFPA 82.~~ shall not require automatic sprinkler protection. [82:6.2.2.6.2]

26.15.2.2.1.2

~~This protection requires that a A sprinkler shall be installed at or above the top service opening chute intake of the chute.~~ [82:6.2.6.1.2]

26.15.2.2.1.3 Chute Sprinkler Protection.

Automatic sprinklers installed in gravity chute ~~service openings~~ intakes shall be recessed out of the chute area through which the material travels. [82:6.2.6.1.3]

26.15.2.2.1.4

~~In addition, a A sprinkler shall be installed within the chute at alternate floor levels in buildings over chutes connecting more than two stories in height , with a mandatory sprinkler located at the lowest service level.~~ [82:6.2.6.1.4]

26.15.2.2.1.5

Gravity chutes shall be protected internally by automatic sprinklers unless ~~they are lined~~ the chute is in accordance with ~~6.2.2.6.1 in 6.2.2.5 or 6.2.2.6 of NFPA 82.~~ [82:6.2.6.1.1]

26.15.2.2.1.6 Chute Room Automatic Sprinklers.

Automatic sprinklers shall be installed in chute ~~terminal~~ discharge rooms. [82:6.2.6.2.1]

26.15.2.2.2 Full Pneumatic Waste and Linen Conveying Systems.

[82:6.3]

26.15.2.2.2.1

Full pneumatic-type risers shall be protected internally by automatic sprinklers. [82:6.3.4.1]

26.15.2.2.2.2

A sprinkler shall be required at or above the top loading station chute intake door and at alternate floor levels in buildings over two stories in height, with a mandatory sprinkler located at the lowest loading station chute intake door. [82:6.3.4.2]

26.15.2.2.2.3

Sprinklers shall be recessed out of the station area through which the material travels. [82:6.3.4.3]

26.15.2.2.3 Gravity Pneumatic Trash or Linen Conveying Systems.

[82:6.4]

26.15.2.2.3.1 Chute Automatic Sprinklers.

Where material is to be stored at the bottom of the chute and above the riser discharge damper (above the transport tee), automatic sprinklers shall be installed below the last service door on the chute.

[82:6.4.2.3]

26.15.2.2.3.2

Automatic sprinklers shall be installed in chute discharge rooms. [82:6.4.2.4.3]

26.15.2.3 Other Waste Handling Systems: Automatic Sprinklers. [82:7.4]**26.15.2.3.1**

Automatic sprinklers shall be installed in rooms where waste handling systems and equipment are used to transport waste from interim storage areas to waste processing equipment, such as incinerators.

[82:7.4.1]

26.15.2.3.2

In locations or rooms where waste handling systems and equipment are used for interim storage of waste only, the rooms shall be sprinklered in accordance with requirements specified in 26.15.2.4. [82:7.4.2]

26.15.2.4 Waste Compactors. [82:Chapter 8]**26.15.2.4.1**

All chute-fed compactors shall have an automatic sprinkler with a minimum ½ in. (13 mm) orifice installed in the hopper of the compactor. [82:8.2.1]

26.15.2.4.2

Sprinklers shall be ordinary temperature-rated sprinklers. [82:8.2.1.1]

26.15.2.4.3

Sprinklers shall be supplied by a minimum of 1 in. (25.4 mm) ferrous piping or ¾ in. (19 mm) copper tubing line from the domestic cold water supply or by the building fire sprinkler system. [82:8.2.1.2]

26.15.2.4.4

Sprinkler water pipe shall be protected from freezing in outdoor installations. [82:8.2.1.3]

26.15.2.4.5

Hand-fed compactors located within a building and not operated in conjunction with a chute shall not require installation of an automatic sprinkler in the hopper. [82:8.2.2]

26.15.2.5

Waste and recyclables storage rooms shall be provided with automatic sprinklers in accordance with this standard. [82:9.3]

26.15.2.6

Rooms in which waste processing equipment is located shall be installed with automatic sprinklers. [82:10.4.1]

26.16 Standard for Ovens and Furnaces.**26.16.1 Design Requirements.** (Reserved)**26.16.2 Installation Requirements.**

26.16.2.1*

Where automatic sprinklers are provided, they shall be installed in accordance with NEPA-13, this standard unless otherwise permitted by 26.16.2.2. [86:9.2.1]

26.16.2.2

Where sprinklers that protect only ovens are installed and connection to a reliable fire protection water supply is not feasible, a domestic water supply connection shall be permitted to supply these sprinklers subject to the approval of the authority having jurisdiction. [86:9.2.2]

26.16.2.3

Where sprinklers are selected for the protection of ovens, furnaces, or related equipment, ~~the use of closed-head sprinkler systems~~ with only open sprinklers shall be ~~prohibited and only deluge sprinkler systems shall be used~~ installed where the following conditions exist:

- (1) In equipment where temperatures can exceed 625°F (329°C)
- (2) Where flash fire conditions can occur

[86:9.3.3]

26.16.2.4

Furnaces shall be located so as to minimize exposure to power equipment, process equipment, and sprinkler risers. [86:5.1.3.1]

26.16.2.5

Where water from a fixed protection system could come in contact with molten materials, such as molten salt or molten metal, shielding shall be provided to prevent water from contacting the molten material. [86:9.3.1]

26.16.2.6*

Galvanized pipe shall not be used in sprinkler or water spray systems in ovens, furnaces, or related equipment. [86:9.3.2]

26.17 Health Care Facilities Code, Class A Hyperbaric Chambers.**26.17.1 Design Requirements.****26.17.1.1**

A fixed water deluge extinguishing system shall be installed in all chamber compartments that are designed for manned operations. [99:14.2.5.2 14.2.6.2]

26.17.1.2

In chambers that consist of more than one chamber compartment (lock), the design of the deluge system shall meet the requirements of 26.17.1.1 when the chamber compartments are at different depths (pressures). [99:14.2.5.2.1 14.2.6.2.1]

26.17.1.3

The deluge system in different compartments (locks) shall operate independently or simultaneously. [99:14.2.5.2.2 14.2.6.2.2]

26.17.1.4

Fixed deluge systems shall not be required in chamber compartments that are used strictly as personnel transfer compartments (locks) and for no other purposes. [99:14.2.5.2.3 14.2.6.2.3]

26.17.1.5*

Manual activation and deactivation deluge controls shall be located at the operator's console and in each chamber compartment (lock) containing a deluge system. [99:14.2.5.2.4 14.2.6.2.4]

26.17.1.6

Controls shall be designed to prevent unintended activation. [99:14.2.5.2.4.1 14.2.6.2.4.1]

26.17.1.7

Water shall be delivered from the fixed discharge nozzles as specified in 26.17.1.9 within 3 seconds of activation of any affiliated deluge control. [99:14.2.5.2.5 14.2.6.2.5]

26.17.1.8*

Average spray density at floor level shall be not less than 2 gpm/ft² (81.5 L/min/m²), with no floor area larger than 10.76 ft² (1 m²) receiving less than 1 gpm/ft² (40.75 L/min/m²). [99:14.2.5.2.6 14.2.6.2.6]

26.17.1.9

Water shall be available in the deluge system to maintain the flow specified in 26.17.1.8 simultaneously in each chamber compartment (lock) containing the deluge system for 1 minute. [99:14.2.5.2.7 14.2.6.2.7]

26.17.1.10

The limit on maximum extinguishment duration shall be governed by the chamber capacity (bilge capacity also, if so equipped) or its drainage system, or both. [99:14.2.5.2.7.1 14.2.6.2.7.1]

26.17.1.11

The deluge system shall have stored pressure to operate for at least 15 seconds without electrical branch power. [99:14.2.5.2.8 14.2.6.2.8]

26.17.2 Installation Requirements. (Reserved)**26.18** Fixed Guideway Transit and Passenger Rail Systems.**26.18.1** Design Requirements.**26.18.1.1**

Other fire suppression systems, if approved, shall be permitted to be substituted for automatic sprinkler systems in the areas listed in 26.18.2.1. [130:5.7.3.4 5.4.4.5]

26.18.2 Installation Requirements.**26.18.2.1**

An automatic sprinkler protection system shall be provided in areas of stations used for concessions, in storage areas, in trash rooms, and in the steel truss area of all escalators and other similar areas with combustible loadings, except trainways. [130:5.7.3.1 5.4.4.1]

26.18.2.2

Sprinkler protection shall be permitted to be omitted in areas of open stations remotely located from public spaces. [130:5.7.3.1.1 5.4.4.2]

26.18.2.3

Installation of sprinkler systems shall comply with NFPA-13 this standard or applicable local codes as required. [130:5.7.3.2 5.4.4.3]

26.18.2.4

A sprinkler system waterflow alarm and supervisory signal service shall be installed. [130:5.7.3.3 5.4.4.4]

26.19 Motion Picture and Television Production Studio Soundstages, Approved Production Facilities, and Production Locations.**26.19.1** Design Requirements. (Reserved)**26.19.2** Installation Requirements.**26.19.2.1**

The requirements of NFPA-13 this standard prohibiting obstructions to sprinkler discharge shall not be applicable if approved mitigation is employed. [140:4.11.1.3.1]

26.19.2.2

The requirements of NFPA-13 this standard prohibiting obstructions to sprinkler discharge shall not be applicable if the building sprinkler system meets the design criteria for Extra Hazard, Group 2. [140:4.11.1.3.2]

26.19.2.3

In any production location building protected by an existing automatic sprinkler system, where solid- or hard-ceiling sets or platforms are introduced and create an obstruction to sprinkler discharge, the provisions of 26.19.2.4 or 26.19.2.5 shall be met. [140:5.11.3]

26.19.2.4*

The requirements of NFPA-13 this standard prohibiting obstructions to sprinkler discharge shall not be applicable if approved mitigation is employed. [140:5.11.4]

A.26.19.2.4

Paragraphs 4.11.1.3.1 and 4.11.1.3.2 of NFPA 140 recognize motion picture and television industry practices that require sets to change constantly and that sets are “temporary” construction not subject to building codes or standards. Solid ceilings that obstruct the stage sprinklers are “flown” (moved) in or out to permit special shooting angles or lighting requirements, often on a scene-by-scene basis. With temporary walls and ceilings, it would be impractical to install a sprinkler system in a constantly changing structure. Therefore, one or more of the following mitigation techniques should be used to compensate for the areas shielded from sprinkler spray by solid or hard ceilings or platforms:

- (1) Approved and listed heat detectors or smoke detectors can be installed beneath such solid or hard ceilings in excess of 600 ft² (55.7 m²) in area and platforms in excess of 600 ft² (55.7 m²) in area and 3 ft (900 mm) (0.9 m) in height. Detectors should be connected to an approved and listed central, proprietary, or remote station service or to a local alarm that will provide an audible signal (i.e., a bell or horn) at a constantly attended location. The detector system, including the alarm panel, is defined as a portable system because it is intended to be reinstalled when platforms or sets are changed. The detectors that are secured to standard outlet boxes and the listed fire alarm panels can be temporarily supported by sets, platforms, or pedestals. Spacing of detectors should be per manufacturers’ requirements.
- (2) The ceiling can be positioned to allow for the operation of the building’s automatic fire sprinkler system after videotaping, filming, or broadcasting of programs has been completed for the day.
- (3) A fire watch should be provided when the set is not in use.
- (4) No combustible materials should be stored under any platforms. Consideration should be given to secure such covered areas with screen wire or other materials that will permit visual inspection and emergency access.
- (5) Approved/listed fire retardants can be applied beneath combustible platforms.
- (6) Approved/listed fire retardants can be applied to scenery, props, framework and deck of combustible platforms, and the hard ceilings of combustible sets.

[140: A.4.11.1.3.1]

26.19.2.5*

The requirements of NFPA-13 this standard prohibiting obstructions to sprinkler discharge shall not be applicable if the building sprinkler system meets the design criteria for Extra Hazard, Group 2. [140:5.11.5]

26.20 Animal Housing Facilities.**26.20.1 Design Requirements. (Reserved)****26.20.1.1 (Reserved)****26.20.2 Installation Requirements. (Reserved)****26.20.2.1**

Quick-response sprinklers shall be utilized in animal housing facilities. [150:9.2.3]

26.21 Water Cooling Towers.**26.21.1 Design Requirements.****26.21.1.1 Types of Systems.****26.21.1.1.1***

~~Because the counterflow tower design lends itself to either closed- or open-head systems, the~~ The following fire protection systems shall be permitted to be used in counterflow cooling towers :

- (1) Wet pipe sprinkler system
- (2) Dry pipe sprinkler system
- (3) Preaction sprinkler system
- (4) Deluge sprinkler system

[214:5.2.2.1]

A.26.21.1.1.1

Counterflow design configurations lend themselves to use of open- or closed-orifice fire protection systems. A deluge system provides a higher degree of protection where water supplies are adequate. In climates that are subject to freezing temperatures, ~~a a dry pipe, preaction, or~~ deluge system minimizes the possibility of failure due to pipes freezing. [214: A.5.2.2.1]

26.21.1.1.2*

~~The open-head A~~ A deluge sprinkler system shall be used in crossflow towers to maximize the water distribution and heat detection activation . [214:5.2.2.2]

A.26.21.1.1.2

The crossflow design is such that it is difficult to locate sprinklers in the most desirable spots for both water distribution and heat detection. This situation ~~can be solved by separating these two functions and using separate water discharge and detection systems~~ is best addressed by using a deluge system . [214: A.5.2.2.2]

26.21.1.2 Minimum Rate of Application.

[214:5.2.3]

26.21.1.2.1

Under the fan decks of counterflow towers, the rate of application of water shall be 0.5 gpm/ft² (20.4 mm/min), including fan opening. [214:5.2.3.1]

26.21.1.2.2

Under the fan decks of crossflow towers, the rate of application of water shall be 0.33 gpm/ft² (13.45 mm/min), including fan opening. [214:5.2.3.2]

26.21.1.2.3

Over the fill areas of crossflow towers, the rate of application of water shall be 0.5 gpm/ft² (20.4 mm/min). [214:5.2.3.3]

26.21.1.3 Extended Fan Decks.

On towers having extended fan decks that completely enclose the distribution basin, the discharge outlets protecting the fill area shall be located over the basin, under the extension of the fan deck. [214:5.2.4.3]

26.21.1.3.1

These discharge outlets shall be open directional spray nozzles or other approved spray devices arranged to discharge 0.35 gpm/ft² (14.26 mm/min) directly on the distribution basin and 0.15 gpm/ft² (6.11 mm/min) on the underside of the fan deck extension. [214:5.2.4.3.1]

26.21.1.3.2

On towers having extended fan decks that do not completely enclose the hot-water basin, outlets protecting the fill shall be located under the distribution basin in accordance with 5.2.4.2.2 of NFPA 214. [214:5.2.4.3.2]

26.21.1.4 Combustible Fan Decks.

For deluge systems using directional spray nozzles in the pendant position, provisions shall be made to protect the underside of a combustible fan deck at a minimum of 0.15 gpm/ft² (6.11 mm/min), which shall be included as part of the application rate specified in 5.2.3 of NFPA 214. [214:5.2.4.4]

26.21.1.5* Water Basin Covers.

On film-filled towers that have solid, hot-water basin covers over the complete basin, the discharge outlets protecting the fill area shall be permitted to be located under the basin covers. [214:5.2.4.5]

26.21.1.5.1

These discharge outlets shall be open directional spray nozzles or other approved devices arranged to discharge 0.50 gpm/ft² (20.4 mm/min) into the distribution basin horizontally, with some of the spray splashing up and on the underside of the water basin covers. [214:5.2.4.5.1]

26.21.1.6 Exterior Exposure Protection.

[214:5.2.10]

26.21.1.6.1

Where any combustible exterior surfaces of a tower, including the fan deck and distribution basins, are less than 100 ft (30.5 m) from significant concentrations of combustibles such as structures or piled material, the combustible exposed surfaces of the tower shall be protected by an automatic water spray system. [214:5.2.10.1]

26.21.1.6.2

Systems for exterior protection shall be designed with the same attention and care as interior systems. [214:5.2.10.2]

26.21.1.6.2.1

Pipe sizing shall be based on hydraulic calculations. [214:5.2.10.2.1]

26.21.1.6.2.2

Water supply and discharge rate shall be based on a minimum 0.15 gpm/ft² (6.11 mm/min) for all protected surfaces. [214:5.2.10.2.2]

26.21.1.7 Sprinkler System Water Supply.**26.21.1.7.1 Deluge Systems.****26.21.1.7.1.1***

Where all cells of a cooling tower are protected by a single deluge system, the water supply shall be adequate to supply all discharge outlets on that system. [214:5.6.1.1]

26.21.1.7.1.2

Where two or more deluge systems are used to protect a cooling tower and fire-resistant partitions are not provided between the deluge systems, the water supply shall be adequate to supply all discharge outlets in the two most hydraulically demanding adjacent systems. [214:5.6.1.2]

26.21.1.7.1.3*

Where two or more deluge systems are separated by fire-resistant partitions, the water supply shall be adequate to supply all discharge outlets in the single most hydraulically demanding system. [214:5.6.1.3]

26.21.1.7.2 Wet, Dry, and Preaction Systems.**26.21.1.7.2.1***

Where each cell of the cooling tower is separated by a fire-resistant partition, the water supply shall be adequate to supply all discharge outlets in the hydraulically most demanding single cell. [214:5.6.2.1]

26.21.1.7.2.2*

Where fire-resistant partitions are not provided between each cell of a cooling tower, the water supply shall be adequate to supply all discharge outlets in the two most hydraulically demanding adjoining cells. [214:5.6.2.2]

26.21.1.7.3 Hose Streams.

Water supplies shall be sufficient to include a minimum of 500 gpm (1892.5 L/min) for hose streams in addition to the sprinkler requirements. [214:5.6.3]

26.21.1.7.4 Duration.

A water supply adequate for at least a 2-hour duration shall be provided for the combination of the water supply specified in 5.6.1 or 5.6.2 of NFPA 214, plus the hose stream demand specified in 26.21.1.7.3. [214:5.6.4]

26.21.2 Installation Requirements.**26.21.2.1*** Counterflow Towers.

[214:5.2.4.1]

26.21.2.1.1

The discharge outlets shall be located under the fan deck and fan opening. [214:5.2.4.1.1]

26.21.2.1.2

Except under the fan opening, all discharge outlets shall have deflector distances installed in accordance with Section 9.5 of NFPA-13 this standard . [214:5.2.4.1.2]

26.21.2.1.3

Closed-head discharge outlets for dry-pipe and preaction systems shall be installed in the upright position only. [214:5.2.4.1.3]

26.21.2.2* Crossflow Towers.

[214:5.2.4.2]

26.21.2.2.1

The discharge outlets protecting the plenum area shall be located under the fan deck and in the fan opening. [214:5.2.4.2.1]

26.21.2.2.2

Discharge outlets protecting the fill shall be located under the distribution basin on either the louver or drift eliminator side, discharging horizontally through the joist channels. [214:5.2.4.2.2]

26.21.2.2.3

Towers with an air travel dimension longer than the maximum allowable for the discharge device being used shall have discharge devices placed on both sides of the fill area in each joist channel. [214:5.2.4.2.3.1]

26.21.2.2.4

The pressure at each discharge device shall be adequate to provide protection for half of the length of the fill measured along the air travel. [214:5.2.4.2.3.2]

26.21.2.2.5

Where joist channels are wider than 2 ft (0.6 m), more than one discharge device shall be required per joist channel. [214:5.2.4.2.4.1]

26.21.2.2.6

If the discharge device being used is listed for the width of the joist channel being protected, one discharge device per joist channel shall be permitted to be used. [214:5.2.4.2.4.2]

26.21.2.3* Extended Fan Decks.

On towers having extended fan decks that completely enclose the distribution basin, the discharge outlets protecting the fill area shall be located over the basin, under the extension of the fan deck. [214:5.2.4.3]

26.21.2.4* Water Basin Covers.

On film-filled towers that have solid, hot-water basin covers over the complete basin, the discharge outlets protecting the fill area shall be permitted to be located under the basin covers. [214:5.2.4.5]

26.21.2.5 Valves.

[214:5.2.6]

26.21.2.5.1

Shutoff valves and automatically operated water control valves, if provided, shall be located as follows:

- (1) Outside the fire-exposed area
- (2) As close to the cooling tower as possible to minimize the amount of pipe to the discharge device
- (3) Where they will be accessible during a fire emergency

[214:5.2.6.1.2]

26.21.2.5.2 Manual Release Valve.

[214:5.2.6.2]

26.21.2.5.2.1

Remote manual release valves, where required, shall be conspicuously located and accessible during a fire emergency. [214:5.2.6.2.1]

26.21.2.5.2.2

Where remote manual release valves are not required, an inspector's test valve shall be provided for each pilot-head-operated system. [214:5.2.6.2.2]

26.21.2.6 Strainers.

Strainers shall be required for systems utilizing discharge devices with waterways of less than $\frac{3}{8}$ in. (9.5 mm) diameter. [214:5.2.7]

26.21.2.7 Heat Detectors.

Where deluge or preaction systems are used, heat detectors shall be installed and shall be selected from either of the types in 5.2.8.1 or 5.2.8.2 of NFPA 214. [214:5.2.8]

26.21.2.7.1

In mechanical-draft towers, pilot line detectors shall be located under the fan deck at the circumference of the fan opening and under the fan opening where necessary to comply with the spacing requirements in 26.21.2.7.1.1. (*For extended fan decks, see 5.2.8.2.3 in NFPA 214.*) [214:5.2.8.1.2.1(A)]

26.21.2.7.1.1

Pilot line detectors shall be spaced not more than 8 ft (2.4 m) apart in any direction including the fan opening. Temperature ratings shall be selected in accordance with operating conditions, but shall be no less than intermediate. [214:5.2.8.1.2.1(B)]

26.21.2.7.2

On towers having extended fan decks that completely enclose the distribution basin, electrical heat detectors shall be located under the fan deck extension in accordance with standard, indoor-spacing rules for the type detectors used in accordance with NFPA 72. [214:5.2.8.2.3]

26.21.2.7.2.1

Where the fan deck extension is 16 ft (4.9 m) or less and this dimension is the length of the joist channel, then only one row of detectors centered on and at right angles to the joist channels shall be required. Spacing between detectors shall be in accordance with NFPA 72. [214:5.2.8.2.3.1]

26.21.2.7.2.2

On towers having extended fan decks that do not completely enclose the hot-water basin, electrical heat detectors shall not be required under the fan deck extension. [214:5.2.8.2.3.2]

26.21.2.7.3

Where electrical heat detectors are inaccessible during tower operation, an accessible test detector shall be provided for each detection zone. [214:5.2.8.3]

26.21.2.7.4

Electrical heat detector components exposed to corrosive vapors or liquids shall be protected by materials of construction or by protective coatings applied by the equipment manufacturer. [214:5.2.8.4]

26.21.2.8 Protection for Fan Drive Motor.

[214:5.2.9]

26.21.2.8.1

A sprinkler or spray nozzle shall be provided over each fan drive motor where the motor is located so that it is not within the protected area of the tower. [214:5.2.9.1]

26.21.2.8.2

Where a preaction or deluge system is used, the detection system shall be extended to cover the motor. [214:5.2.9.2]

26.21.2.8.3

Provision shall be made to interlock the fan motors with the fire protection system so that the cooling tower fan motors are stopped in the cell(s) for which the system is actuated. [214:5.2.9.3]

26.21.2.8.4

Where the continued operation of the fans is vital to the process, a manual override switch shall be permitted to be provided to reactivate the fan when it is determined that there is no fire. [214:5.2.9.4]

26.21.2.9 Corrosion Protection.

[214:5.3]

26.21.2.9.1

Piping, fittings, hangers, braces, and attachment hardware including fasteners shall be hot-dipped galvanized steel in accordance with ASTM A153A/153M, *Standard Specification for Zinc Coating (Hot Dip) on Iron and Steel Hardware*, or other materials having a superior corrosion resistance. [214:5.3.1]

26.21.2.9.1.1

Exposed pipe threads and bolts on fittings shall be protected against corrosion. [214:5.3.1.1]

26.21.2.9.1.2

All other components shall be corrosion resistant or protected against corrosion by a coating. [214:5.3.1.2]

26.21.2.9.2*

Wax-type coatings shall not be used on devices without fusible elements. [214:5.3.2]

26.21.2.9.3*

Special care shall be taken in the handling and installation of wax-coated or similar sprinklers to avoid damaging the coating. [214:5.3.3]

26.21.2.9.3.1

Corrosion-resistant coatings shall not be applied to the sprinklers by anyone other than the manufacturer of the sprinklers. [214:5.3.3.1]

26.21.2.9.3.2

In all cases, any damage to the protective coating occurring at the time of installation shall be repaired at once using only the coating of the manufacturer of the sprinkler in an approved manner, so that no part of the sprinkler will be exposed after the installation has been completed. [214:5.3.3.2]

26.22 Standard for the Construction and Fire Protection of Marine Terminals, Piers, and Wharves.**26.22.1** Design Requirements.**26.22.1.1***

Unless the requirements of 26.22.1.2 apply, automatic sprinkler systems shall be designed based upon the design criteria for the protection of Group A plastics. [307:5.4.2.1]

26.22.1.2

With the approval of the authority having jurisdiction, the requirements of 26.22.1.1 shall not apply to buildings used exclusively for the handling or storage of specific cargoes and commodities that are defined as commodity classes less than Group A plastics by this standard. [307:5.4.2.2]

26.22.1.3

Buildings consistent with 26.22.1.2 shall be protected in accordance with the design criteria for the applicable commodity as required by this standard. [307:5.4.2.3]

26.22.1.4

Buildings used for the storage of hazardous materials shall be protected in accordance with this standard and the applicable codes and standards for the type of hazardous material being stored. [307:5.4.2.4]

26.22.2 Installation Requirements.**26.22.2.1 Piers and Wharves with Combustible Substructure.****26.22.2.1.1**

Where there is danger of damage to sprinkler equipment by floating objects, physical barriers shall be provided to exclude such objects. [307:4.3.3.1.2.2]

26.22.2.1.2* Upward Projecting Sprinklers.

Where narrow horizontal channels or spaces are caused by caps, stringers, ties, and other structural members and where the standard upright sprinkler does not project sufficient water upward to extinguish or control fires on the underside of the pier or wharf deck, a sprinkler that projects water upward to wet the overhead shall be used. [307:4.3.3.1.3.1]

(A)

Location, spacing, and deflector position shall be governed by the discharge pattern of the sprinkler and the structure being protected. [307:4.3.3.1.3.1(A)]

(B)

The following design and installation guides shall apply where pendent sprinklers in the upright position or old-style sprinklers are to be utilized:

- (1) The maximum coverage per sprinkler head shall be limited to 80 ft² (7.5 m²).
- (2) Where spacing or arrangement of stringers constitutes typical open-joint construction directly supporting the deck, sprinkler branch lines shall be installed between the bents at right angles to the stringers and shall meet the following requirements:
 - (a) Spacing between branch lines shall not exceed 10 ft (3 m).
 - (b) Sprinklers on branch lines shall be staggered and spaced not to exceed 8 ft (2.5 m) on center.
- (3)* Where crisscross construction is involved, closer spacing of sprinklers shall be permitted as necessary to provide wetting of the entire structure.
- (4) The deflectors of sprinklers on lines under stringers shall be located not less than 4 in. (100 mm) nor more than 10 in. (250 mm) below the bottom plane of the stringer, and not more than 18 in. (450 mm) below the underside of the pier or wharf deck.
- (5)* The sprinkler system shall be hydraulically designed in accordance with the requirements of this standard and shall meet the following requirements:
 - (a) Sprinkler orifice shall be ½ in. (12.7 mm) and shall discharge at a minimum pressure of 12.5 psi (85 kPa).
 - (b) Design area shall be based upon the largest area between firestops plus an additional area embracing at least two branch lines on opposite sides of the firestop.
 - (c) Minimum design area shall be not less than 5000 ft² (465 m²).
- (6) The temperature rating of the sprinkler shall not exceed 165°F (74°C).
- (7) The maximum area to be protected by any one system shall be limited to 25,000 ft² (2325 m²).

[307:4.3.3.1.3.1(B)]

26.22.2.1.2

~~The installation requirements in 26.22.2.1.2.1, 26.22.2.1.2.1(A), and 26.22.2.1.2.1(B) are also required.~~

26.23 Semiconductor Fabrication Facilities.**26.23.1 Design Requirements.****26.23.1.1***

Automatic sprinklers for cleanrooms or clean zones shall be installed in accordance with this standard and shall be hydraulically designed for a density of 0.20 gpm/ft² (8.15 L/min·m²) over a design area of 3000 ft² (278.8 m²). [318:4.1.2.1 11.1.4.2]

26.23.1.2

Automatic sprinkler protection shall be designed and installed in the plenum and interstitial space above cleanrooms in accordance with this standard, for a density of 0.20 gpm/ft² (8.15 L/min·m²) over a design area of 3000 ft² (278.8 m²). [318:4.1.2.5 11.1.4.3]

26.23.1.2.1*

~~Automatic sprinklers shall be permitted to be omitted if the construction and occupancy of these spaces are noncombustible. [318: 4.1.2.5.1]~~

A.26.23.1.2.1

~~Examples of combustible materials that might be found in these spaces are as follows:~~

- ~~Roof, floor, wall construction materials~~
- ~~Unapproved HEPA or ULPA filter modules~~
- ~~Supply air or exhaust ducts~~
- ~~Air handler unit enclosures or air plenum boxes~~
- ~~Exposed electrical cable or pipe insulation~~
- ~~Plastic piping~~
- ~~Flammable or combustible liquid piping~~

~~[318: A.4.1.2.5.1]~~

26.23.1.3*

Sprinklers installed in duct systems shall be hydraulically designed to provide 0.5 gpm (1.9 L/min) over an area derived by multiplying the distance between the sprinklers in a horizontal duct by the width of the duct. [318:4.1.2.6.2 11.2.1.2]

26.23.1.3.1*

Minimum discharge shall be 20 gpm (76 L/min) per sprinkler from the five hydraulically most remote sprinklers. [318:4.1.2.6.2.1 11.2.1.2.1]

26.23.2 Installation Requirements.**26.23.2.1***

Wet pipe automatic sprinkler protection shall be provided throughout facilities containing cleanrooms and clean zones. [318:4.1.1 11.1.4.1]

26.23.2.2*

Approved quick-response sprinklers shall be utilized for sprinkler installations within down-flow airstreams in cleanrooms and clean zones. [318:4.1.2.2 11.1.4.4]

26.23.2.3*

Sprinklers shall be spaced a maximum of 20 ft (6.1 m) apart horizontally and 12 ft (3.7 m) apart vertically. [318:4.1.2.6.2.2 11.2.1.2.2]

26.23.2.4

A separate indicating control valve shall be provided for sprinklers installed in ductwork. [318:4.1.2.6.3 11.2.1.3]

26.23.2.5

The sprinklers shall be accessible for periodic inspection and maintenance. [318:4.1.2.6.6 11.2.1.6]

26.24 Aircraft Hangars.**26.24.1 Design Requirements.**

Sprinkler systems installed in aircraft hangars shall comply with NFPA 409.

26.24.2 Installation Requirements.

Sprinkler systems installed in aircraft hangars shall comply with NFPA 409.

26.25 Airport Terminal Buildings, Fueling Ramp Drainage, and Loading Walkways.**26.25.1 Design Requirements.****26.25.1.1**

Passenger-handling areas shall be classified as Ordinary Hazard Group 1 Occupancy, as defined in this standard, for the purpose of sprinkler system design. [415:4.5.1.3]

26.25.1.2*

Baggage, package, and mail-handling areas shall be classified as Ordinary Hazard Group 2 Occupancy, as defined in this standard, for the purpose of sprinkler system design. [415:4.5.1.4]

A.26.25.1.2

The exposure to the airport terminal building from the airport ramp is significant. The number of building sprinklers operating from the exposure fire ~~can~~ could be greater than the number of building sprinklers operating from an internal ignition source. [415: A.4.5.1.5]

26.25.1.3

Other areas of the airport terminal building shall be classified in accordance with Chapter-5 4 of this standard based on the occupancy of the area. [415:4.5.1.5]

26.25.1.4 Water Supply.

Water supply from public and private sources shall be adequate to supply maximum calculated sprinkler demand plus a minimum of 500 gpm (1893 L/min) for hose streams. The supply shall be available at the rate specified for a period of at least 1 hour. [415:4.5.5]

26.25.1.4.1

Main sizes shall be hydraulically calculated based on the total domestic and fire protection requirements. Mains shall ~~be~~ not be less than 8 in. (203 mm) in diameter except that laterals shall be permitted to be 6 in. (152 mm) in diameter if not over 200 ft (61 m) long. [415:4.5.5.1]

26.25.2 Installation Requirements. (Reserved)**26.26 Aircraft Engine Test Facilities.****26.26.1 Design Requirements.****26.26.1.1***

In engine test cells, the minimum design discharge density shall be 0.50 gpm/ft² (0.34 L/sec/m²) of protected area. [423:7.6.3]

26.26.1.2

In engine test cells, water supplies shall be capable of meeting the largest demand at the design rate plus hose stream demand for a period of 30 minutes. [423:7.6.4]

26.26.1.2.1

Hose stream demand shall be a minimum of 250 gpm (16 L/sec). [423:7.6.4.1]

26.26.1.2.2

The hydraulic calculation and the water supply shall be based on the assumption that all sprinklers in the test cell are operating simultaneously. [423:7.6.4.2]

26.26.2 Installation Requirements. (Reserved)**26.27** Advanced Light Water Reactor Electric Generating Plants.**26.27.1** Design Requirements.**26.27.1.1*** Sprinkler System Water Supply.

The fire water supply shall be calculated on the basis of the largest expected flow rate for a period of 2 hours but shall not be less than 300,000 gal (1,135,500 L), and the following criteria also shall apply:

- (1) The flow rate shall be based on 500 gpm (1892.5 L/min) for manual hose streams plus the largest design demand of any sprinkler or fixed water spray system as determined in accordance with this standard, with NFPA 15, or with NFPA 804.
- (2) The fire water supply shall be capable of delivering the design demand specified in 26.27.1.1(1) with the hydraulically least demanding portion of fire main loop out of service.

[804:9.2.1]

26.27.1.2 Yard Mains.

The underground yard fire main loop shall be installed to furnish anticipated water requirements, and the following criteria also shall be met:

- (1) The type of pipe and water treatment shall be design considerations, with tuberculation as one of the parameters.
- (2) Means for inspecting and flushing the systems shall be provided.

[804:9.4.1]

26.27.1.3 Cable Spreading Room.

The cable spreading room shall have an automatic fixed water-based suppression system, and the following criteria also shall be met:

- (1) The location of sprinklers or spray nozzles shall protect cable tray arrangements to ensure water coverage for areas that could present exposure fire hazards to the cable raceways.
- (2) Automatic sprinkler systems shall be designed for a density of 0.30 gpm/ft² (12.2 L/min·m²) over the most remote 2500 ft² (232.2 m²).

[804:10.4.1.1]

26.27.1.4 Cable Tunnels.

[804:10.4.2]

26.27.1.4.1

Automatic sprinkler systems shall be designed for a density of 0.30 gpm/ft² (12.2 L/min·m²) for the most remote 100 linear ft (30.5 m) of cable tunnel up to the most remote 2500 ft² (232.2 m²). [804:10.4.2.2.2]

26.27.1.4.2

Deluge sprinkler systems or deluge spray systems shall meet the following criteria:

- (1) They shall be zoned to limit the area of protection to that which the drainage system can handle with any two adjacent systems actuated.
- (2) They shall be hydraulically designed with each zone calculated with the largest adjacent zone flowing.

[804:10.4.2.2.4]

26.27.1.5* Beneath Turbine Generator Operating Floor.

All areas beneath the turbine generator operating floor shall be protected by an automatic sprinkler or foam-water sprinkler system meeting the following criteria:

- (1) The sprinkler system beneath the turbine generator shall be designed around obstructions from structural members and piping.
- (2) The sprinkler system shall be designed to a minimum density of 0.30 gpm/ft^2 ($12.2 \text{ L/min}\cdot\text{m}^2$) over a minimum application of 5000 ft^2 (464.5 m^2).

[804:10.8.2.1]

26.27.1.6* Turbine Generator Bearings.

[804:10.8.3]

26.27.1.6.1

Lubricating oil lines above the turbine operating floor shall be protected with an automatic sprinkler system to a minimum density of 0.30 gpm/ft^2 ($12.2 \text{ L/min}\cdot\text{m}^2$) that covers those areas subject to oil accumulation, including the area within the turbine lagging (skirt). [804:10.8.4]

26.27.1.6.2

Where shaft-driven ventilation systems are used, an automatic preaction sprinkler system providing a density of 0.30 gpm/ft^2 ($12.2 \text{ L/min}\cdot\text{m}^2$) over the entire area shall be provided. [804:10.8.7(2)]

26.27.1.7 Standby Emergency Diesel Generators and Combustion Turbines.

The sprinkler and water spray protection systems shall be designed for a 0.25 gpm/ft^2 ($10.19 \text{ L/min}\cdot\text{m}^2$) density over the entire area. [804:10.9.3(2)]

26.27.1.8 Fire Pump Room/House.

If sprinkler and water spray systems are provided for fire pump houses, they shall be designed for a minimum density of 0.25 gpm/ft^2 ($10.19 \text{ L/min}\cdot\text{m}^2$) over the entire fire area. [804:10.22.2]

26.27.1.9 Auxiliary Boilers.

Sprinkler and water spray systems shall be designed for a minimum density of 0.25 gpm/ft^2 ($10.19 \text{ L/min}\cdot\text{m}^2$) over the entire area. [804:10.24.3]

26.27.2 Installation Requirements.**26.27.2.1 Yard Mains, Hydrants, and Building Standpipes.**

[804:9.4]

26.27.2.1.1

Approved visually indicating sectional control valves such as postindicator valves shall be provided to isolate portions of the main for maintenance or repair without simultaneously shutting off the supply to both primary and backup fire suppression systems. [804:9.4.2]

26.27.2.1.2*

Sectional control valves shall allow maintaining independence of the individual loop around each unit, and the following also shall apply:

- (1) For such installations, common water supplies shall also be permitted to be utilized.
- (2) For multiple-reactor sites with widely separated plants [approaching 1 mi (1.6 km) or more], separate yard fire main loops shall be used.

[804:9.4.4]

26.27.2.1.3

Sprinkler systems and manual hose station standpipes shall have connections to the plant underground water main so that a single active failure or a crack in a moderate-energy line can be isolated so as not to impair both the primary and the backup fire suppression systems unless otherwise permitted by the following:

- (1) Alternatively, headers fed from each end shall be permitted inside buildings to supply both sprinkler and standpipe systems, provided steel piping and fittings meeting the requirements of ASME B31.1, *Code for Power Piping*, are used for the headers (up to and including the first valve) supplying the sprinkler systems where such headers are part of the seismically analyzed hose standpipe system.
- (2) Where provided, such headers shall be considered an extension of the yard main system.
- (3) Each sprinkler and standpipe system shall be equipped with an outside screw and yoke (OS&Y) gate valve or other approved shutoff valve.

[804:9.4.7]**26.27.2.2 Cable Tunnels.**

The location of sprinklers or spray nozzles shall protect cable tray arrangements and possible transient combustibles to ensure water coverage for areas that could present exposure fire hazards to the cable raceways. **[804:10.4.2.2.3]**

26.27.2.3 Deluge.

Deluge sprinkler systems or deluge spray systems shall meet the following criteria:

- (1) They shall be zoned to limit the area of protection to that which the drainage system can handle with any two adjacent systems actuated.
- (2) They shall be hydraulically designed with each zone calculated with the largest adjacent zone flowing.

[804:10.4.2.2.4]**26.27.2.4**

Cable tunnels over 50 ft (15.2 m) long shall be provided with hose stations and portable fire extinguishers installed outside the tunnel. **[804:10.4.2.4(3)]**

26.28 Light Water Nuclear Power Plants.**26.28.1 Design Requirements.**

A fire protection water supply of reliability, quantity, and duration shall be provided by one of the two following methods:

- (1) A fire protection water supply of not less than two separate 300,000 gal (1,135,500 L) supplies shall be provided.
- (2) The 2-hour fire flow rate for 2 hours shall be calculated, and the following criteria shall be met:
 - (a) The flow rate shall be based on 500 gpm (1892.5 L/min) for manual hose streams plus the largest design demand of any sprinkler or fixed water spray system(s) in the power block as determined in accordance with NFPA 13 or NFPA 15.
 - (b) The fire water supply shall be capable of delivering this design demand with the hydraulically least demanding portion of fire main loop out of service.

[805:5.5.1]**26.28.2 Installation Requirements.****26.28.2.1**

Sprinkler systems and manual hose station standpipes shall be connected to the plant fire protection water main so that a single active failure or a crack to the water supply piping to these systems can be isolated so as not to impair both the primary and backup fire suppression systems. **[805:5.5.12]**

26.28.2.2

Each sprinkler and standpipe system shall be equipped with an outside screw and yoke (OS&Y) gate valve or other approved shutoff valve. **[805:5.5.17]**

26.29 Hydroelectric Generating Plants. [NFPA 851]

26.29.1 Design Requirements.

26.29.1.1 Hydraulic Control Systems.

Fixed fire protection for this equipment, where provided, should be as follows:

Automatic wet pipe sprinkler systems utilizing a design density of 0.25 gpm/ft^2 (10.2 mm/min) for the entire hazard area.

Automatic foam water sprinkler systems providing a density of 0.16 gpm/ft^2 (6.5 mm/min).

[851: 7.2.4]

26.29.1.2 Cable Concentrations.

Sprinkler or water spray systems should be designed for a density of 0.30 gpm/ft^2 (12.2 mm/min) over 2500 ft^2 (232 m^2). This coverage is for area protection. Individual cable tray tier coverage could be required based on the fire risk evaluation. [851: 7.5.3]

26.29.1.3 Cable Tunnels.

Where protection is required by the fire risk evaluation, cable tunnels should be protected by automatic water spray, automatic wet pipe sprinkler, or foam water spray systems. Automatic sprinkler systems should be designed for a density of 0.30 gpm/ft^2 (12.2 mm/min) over 2500 ft^2 (232 m^2) or the most remote 100 linear ft (30.5 m) of cable tunnel up to 2500 ft^2 (232 m^2). [851: 7.6.1]

26.29.1.4 Emergency Generators.

Emergency generators located within main plant structures should be protected by automatic sprinkler, water spray, foam water sprinkler, compressed air foam, or gaseous type extinguishing systems.

Sprinkler and water spray protection systems should be designed for a 0.25 gpm/ft^2 (10.2 mm/min) density over the fire area. [851: 7.11.2]

26.29.1.5 Air Compressors.

Automatic sprinkler protection designed for a density of 0.25 gpm/ft^2 (10.2 mm/min) over the postulated oil spill or compressed air foam should be considered for air compressors containing a large quantity of oil. [851: 7.12]

26.29.1.6 Hydraulic Systems for Gate and Valve Operators.

Hydraulic control systems should use a listed fire-resistant fluid. Automatic sprinkler protection designed for a density of 0.25 gpm/ft^2 (10.2 mm/min) over the fire area or compressed air foam systems should be considered for hydraulic systems not using a listed fire-resistant fluid. [851: 7.13]

26.29.1.7 Fire Pumps.

Rooms housing diesel-driven fire pumps should be protected by automatic sprinkler, water spray, foam water sprinkler, or compressed air foam systems. If sprinkler and water spray protection systems are provided, they should be designed for a density of 0.25 gpm/ft^2 (10.2 mm/min) over the fire area. For automatic foam water sprinkler systems, a density of 0.16 gpm/ft^2 (6.5 mm/min) should be provided. [851: 7.14]

26.29.2 Installation Requirements.

26.29.2.1 Hydraulic Control Systems.

Fire extinguishing systems, where installed for lube oil systems employing combustible type oil, should include protection for the reservoirs, pumps, and all oil lines, especially where unions exist on piping and beneath any shielded area where flowing oil can collect. Facilities not provided with curbs or drains should extend coverage for a distance of 20 ft (6 m) from the oil lines, when measured from the outermost oil line. [851: 7.2.7]

26.29 Code for the Protection of Cultural Resource Properties — Museums, Libraries, and Places of Worship. [NFPA 909]

26.29.1 Design Requirements.

26.29.1.1*

Standard-response sprinklers shall be permitted for use in light-hazard areas. [909:9.12.13.1 9.12.13.2]

26.29.1.2*

Preaction and dry pipe systems shall be designed to minimize the risk of corrosion in accordance with the requirements of 26.30.2.1 through 22.30.2.5. [909: 9.12.13.5] 9.12.13.3.1 through 9.12.13.3.6.5 of NFPA 909 . [909: 9.12.13.3]

26.29.1.3 System Design for Museums, Libraries, and Their Collections in Compact Storage.**26.29.1.3.1***

The design shall recognize the nature of the potential threat of a fire that originates in a compact mobile storage unit, where fuel loads are invariably large and fire growth is significantly different from that in other kinds of storage. [909:9.12.23.4.1.3 9.12.24.4.1.3]

26.29.1.3.2*

The automatic fire suppression system, the compact storage system, and the storage compartmentalization features shall be designed to limit fire damage in accordance with the facility's fire safety objectives. [909:9.12.23.4.1.4(A) 9.12.24.4.1.4(A)]

26.29.1.3.3

Design calculations shall include the number and size of the storage modules, the separation provided between the modules end-to-end and back-to-back, and the type of material being stored. [909:9.12.23.4.1.4(B) 9.12.24.4.1.4(B)]

26.29.1.3.4

Where the automatic fire suppression is provided by automatic fire sprinkler systems, the systems shall be wet pipe, single interlock preaction, or single non-interlock preaction systems. [909:9.12.23.4.1.4(C) 9.12.24.4.1.4(C)]

26.29.1.3.5

Dry pipe or double-interlock preaction systems shall not be installed in compact storage areas. [909:9.12.23.4.1.4(D) 9.12.24.4.1.4(D)]

26.29.1.3.6

Where compact storage is installed in an existing storage area, the existing automatic fire detection and fire suppression systems shall be modified as required to accommodate the increased fire loading. [909:9.12.23.4.1.4(E) 9.12.24.4.1.4(E)]

26.29.2 Installation Requirements.**26.29.2.1***

Branch lines shall be pitched at least $\frac{1}{2}$ in. per 10 ft (4 mm/m), and mains shall be pitched at least $\frac{1}{4}$ in. per 10 ft (2 mm/m). [909:9.12.13.3.1]

A.26.29.2.1

Although prior to the 2007 edition NFPA 13 permitted the pipe for systems not subject to freezing to be installed without a back pitch, similar to the design of wet pipe systems, this arrangement allows water to accumulate in low points, increasing the rate of corrosion. Proper pitching is an important element in reducing the risk of corrosion. The pitch requirements included in NFPA 13 this standard should be considered the minimum acceptable pitch. Where adequate clearance is provided to permit the system to be installed without causing interferences with structural elements or causing low points, pitches exceeding this minimum requirement such as 4 mm/m ($\frac{1}{2}$ in./10 ft) $\frac{1}{2}$ in./10 ft (4 mm/m) should be considered. [909:A.9.12.12.3.1 A.9.12.13.3.1]

26.29.2.2*

Auxiliary drains shall be provided at all preaction system low points in accordance with NFPA 13 the requirements of this standard for dry pipe systems and whether the preaction systems system piping subject to freezing or not . [909:9.12.13.3.2.1]

A.26.29.2.2

~~Additional auxiliary drainage should be provided, in accordance with NFPA 13. Due to heightened concerns regarding the issues associated with corrosion, additional auxiliary drainage is needed for all preaction systems, regardless of whether or not the protected area is subject to freezing.~~
[909:A.9.12.12.3.2.1 A.9.12.13.3.2.1]

26.29.2.3*

~~Where steel pipe is used in dry pipe and preaction systems, the provisions of this standard it shall be applied assuming assumed that the water supplies and environmental conditions that contribute to unusual corrosive properties, and a plan shall be developed to address piping corrosion.~~
[909:9.12.13.3.3]

A.26.29.2.3

The wording is based on NFPA 13, 5.1.5.2. The special sensitivity of cultural resource properties to water damage that could result from piping corrosion warrants the assumption of water supplies and environmental conditions that contribute to unusual corrosive properties. [909: A.9.12.12.3.3] A plan to address piping corrosion should include one or more of the following:

- (1) Installation of sprinkler piping that is corrosion resistant – Galvanized steel piping is not considered corrosion resistant for the purposes of this recommendation. Galvanized coatings can corrode where water and oxygen are present inside system piping. When galvanized coatings fail, the remaining uncoated steel corrodes at an accelerated rate.
- (2) Installation of a special listed pre-primed preaction system, filled with water under normal conditions.
- (3) Use of a continuous source of dry inert gas for pressure maintenance.
- (4) Testing of the water supply for corrosivity prior to connection to the sprinkler system.
- (5) Equipping any source of compressed air used for pressure maintenance with an air dryer or nitrogen separator
- (6) Implementation of an approved plan for maintaining and monitoring the interior conditions of the pipe at established intervals and locations, including all of the following:
 - (a) Testing water flow devices between the semiannual tests using a means that does not introduce fresh water into the system
 - (b) Drying system piping before returning systems to service after trip tests or other incidents that introduce water into system piping beyond the riser
 - (c) Inspecting for obstructions when any of the following conditions are observed:
 - i. Pinhole leaks
 - ii. Frequent operation of system air compressor(s)
 - iii. Corrosion on the outside of pipe joints, fittings, or sprinklers
 - iv. Pitting, nodules, tubercles, or carbuncles inside piping or valves
 - v. Foreign material in water during drain tests or plugging of inspector's test connection(s)
 - vi. Plugged sprinklers
 - vii. Plugged piping in sprinkler systems dismantled during building alterations²
Frequent false tripping of a dry pipe valve(s) with indications of corrosion inside the valve(s)
 - viii. A 50 percent increase in the time required for water to travel to the inspector's test connection after the valve trips during a full flow trip test of a dry pipe sprinkler system when compared to the original system acceptance test

[909: A.9.12.1.3.3.3]

These options are based on those specified by this standard for applications where water supplies are known to be corrosive. They are recommended in this code for steel dry pipe and preaction systems because the levels of corrosion found in these systems are unacceptable for cultural resource facilities. Although this standard also allows the option of treating all water that enters the system with an approved corrosion inhibitor, experience using this option has not been satisfactory in cultural resource facilities due to potential formation of external crystals on piping and potential reduction in the service life of gaskets in mechanical couplings. This standard includes the additional option of using a special listed pre-primed preaction system, in which the piping is normally filled with water.

[909: A.9.12.13.3.3]

26.30 National Electrical Code.

26.30.1 Design Requirements. (Reserved)

26.30.2 Installation Requirements.**26.30.2.1 Dedicated Electrical Space.**

The space equal to the width and depth of the equipment and extending from the floor to a height of 6 ft (1.8 m) above the equipment or to the structural ceiling, whichever is lower, shall be dedicated to the electrical installation. No piping, ducts, leak protection apparatus, or other equipment foreign to the electrical installation shall be located in this zone.

Exception: Suspended ceilings with removable panels shall be permitted within the 1.8-m (6-ft) zone.

[

70:

110.26(E)(1)(a)]

26.30.2.2

The area above the dedicated space required by 26.30.2.1 shall be permitted to contain foreign systems, provided protection is installed to avoid damage to the electrical equipment from condensation, leaks, or breaks in such foreign systems. [70:110.26(E)(1)(b)]

26.30.2.3

Sprinkler protection shall be permitted for the dedicated space where the piping complies with this section. [70:110.26(E)(1)(c)]

26.31 Fire Protection of Telecommunication Facilities.**26.31.1 Design Requirements. (Reserved)****26.31.2 Installation Requirements.****26.31.2.1**

All piping for dry pipe and preaction sprinkler systems shall be installed with a pitch in accordance with NFPA 13 this standard whether or not the piping is subjected to freezing conditions. [76:8.6.2.2.2]

26.32 Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids.**26.32.1 Design Requirements.****26.32.1.1**

Any portion of an exhaust system utilizing combustible components or having the potential for combustible residue buildup on the inside, where the duct cross-sectional area is greater than or equal to 75 in.² (480 cm²), shall be provided with an automatic extinguishing system within the duct and at the duct intake, hood, enclosure, or canopy, ~~or shall be constructed of material listed for use without sprinkler protection~~. [91:9.1]

26.32.1.2

When a sprinkler system is installed, means shall be provided to prevent water accumulation in the duct or flow of water back to a process subject that could be damaged by water. [91:9.2]

26.32.2 Installation Requirements. (Reserved)**26.33 Hypobaric Facilities.****26.33.1 Design Requirements.****26.33.1.1**

A fire suppression system consisting of independently supplied and operating handline and fixed deluge-type water spray systems shall be installed. [99B:4.5.1.5]

26.33.1.2

Design of the fire suppression system shall be such that failure of components in either the handline or deluge system will not render the other system inoperative. [99B:4.5.1.6]

26.33.1.3

System design shall be such that activation of either the handline or the deluge system shall automatically cause the following:

- (1) Visual and audio alarm indicators shall be activated at the chamber operator's console.
- (2) All ungrounded electrical leads for power and lighting circuits contained inside the chamber shall be disconnected.
- (3) Emergency lighting and communication, where used, shall be activated.

[99B:4.5.1.7]

26.33.1.4

Intrinsically safe circuits, including sound-powered communications, shall be permitted to remain connected when either the handline or deluge system is activated. [99B:4.5.1.8]

26.33.1.5

Control circuitry and other electrical equipment involved in the fire detection and suppression system shall be powered from the critical branch of the emergency electrical system and connected to the uninterruptible power supply (UPS). [99B:4.5.1.11]

26.33.1.6

In chambers that consist of more than one compartment, the deluge system shall operate independently or simultaneously even if the compartments are at different pressures (altitudes). [99B:4.5.2.2]

26.33.1.7

Fixed deluge systems shall not be required in chamber compartments that are used strictly as personnel transfer compartments and for no other purpose. [99B:4.5.2.3]

26.33.1.8

Manual activation and deactivation deluge controls shall be located at the operator's console and in each chamber compartment containing a deluge system. [99B:4.5.2.4]

26.33.1.9

Controls shall be designed to prevent unintended activation. [99B:4.5.2.4.1]

26.33.1.10

Water shall be delivered from the fixed discharge nozzles of the deluge system within 3 seconds of activation of any affiliated deluge control. [99B:4.5.2.5]

26.33.1.11*

Total water demand shall be determined by multiplying the total chamber floor area by 7.5 gpm/ft² (305.6 L/min/m²). [99B:4.5.2.5.1]

26.33.1.12

The minimum operating pressure at the nozzle shall be 30 psi (206 kPa). [99B:4.5.2.5.2]

26.33.1.13

The water supply shall be constantly and fully charged. [99B:4.5.2.6]

26.33.1.14

The water supply pressure shall be constantly monitored and an interlock shall prevent chamber operation if water supply pressure has fallen 10 percent below normal operating charge pressure. [99B:4.5.2.7]

26.33.1.15

There shall be water in the deluge system to maintain the flow specified in 26.33.1.11 simultaneously in each chamber containing the deluge system for 1 minute. [99B:4.5.2.8]

26.33.1.16

The limit on maximum extinguishment duration shall be governed by the chamber capacity (bilge capacity also, if so equipped) and/or its drainage system. [99B:4.5.2.9]

26.33.1.17

The deluge system shall have stored pressure to operate for at least 15 seconds without electrical branch power. [99B:4.5.2.10]

26.33.2 Installation Requirements. (Reserved)**26.34** Coal Mines.**26.34.1** Design Requirements.**26.34.1.1** Underground Mining Operations.**26.34.1.1.1***

Fire sprinkler systems for underground mining operations shall be designed and installed in accordance with NFPA 120.

26.34.1.2 Coal Preparation Plants and Crusher Buildings.**26.34.1.2.1**

When automatic sprinkler systems are to be supplied through the standpipe system, hydraulic calculations shall be used to ensure that the piping and the water supply meet the hose and automatic sprinkler demands simultaneously. [120:6.3.2.3.2]

26.34.1.3 Underground Conveyors.**26.34.1.3.1**

The water supply shall be free of excessive sediment and corrosives. An approved strainer with a flush-out connection and manual shutoff valve shall be provided. [120: 9.4.6.3.1.1]

26.34.1.3.2

The water supply shall provide the required water flow for not less than 60 minutes. [120: 9.4.6.3.1.2]

26.34.1.3.3

Sprinkler systems shall meet the following requirements:

- (1) The sprinklers shall be installed in accordance with this standard as far as practical, and shall have components that have been listed.
- (2) The sprinkler head activation temperature shall not be less than 150°F (65.6°C) or greater than 300°F (148.9°C).
- (3) Sprinklers shall be kept free of excessive rock dust, muck, conveyor string, or any other material that can block the discharge or insulate the fusible link.
- (4) The application rate shall not be less than 10.2 L/min/m² (0.25 gpm/ft²) 0.25 gpm/ft² (10.2 L/min/m²) of the top surface of the top belt. [120: 9.4.6.4] , bottom surface of the top belt, and the top surface of the lower belt.
- (5) With a water flow and pressure than is present under normal mine operating conditions, the residual pressure measured downstream of the opened sprinklers or the 8-head inspector's test connection of 10 psi (70 kPa) or greater for belt drive systems shall be maintained at all times.
- (6) Maximum distance between nozzles on a branch line shall not exceed 8 ft (2.4 m).
- (7) Piping for the deluge, foam, or closed-head sprinkler system shall be metal and listed for sprinkler applications.
- (8)* Sprinkler piping shall be supported by UL-listed pipe hangers or other substantial metal supports such as angle iron, U bolts, or heavy chain.

A.26.34.1.3.3(8)

Pipe hangers should be designed to support five times the weight of the water-filled pipe plus 250 lb (114 kg) at each point of piping support. Hanger rods should be at least $\frac{3}{8}$ in. (9.5 mm) thick for pipe up to 4 in. (102 mm). U hooks should be at least $\frac{5}{16}$ in. (8 mm) thick for pipes up to 2 in. (50.8 mm). Eye rods should be at least $\frac{3}{8}$ in. (9.5 mm) thick for pipe up to 4 in. (102 mm). This information is taken from Chapter 17 of this standard. [120: A.9.4.6.3.2(8)]

- (9) The system shall be interlocked to shut down the conveyor and provide an audible and a visual alarm. [120: 9.4.6.8]
- (10) The components of the system shall be located so as to minimize the possibility of damage by roof fall or by the moving belt and its load.

[120: 9.4.6.3.2]

26.34.1.3.4

The application rate shall not be less than 10.2 L/min/m² (0.25 gpm/ft²) of the top surface of the top belt. [120: 9.4.6.4]

26.34.1.3.5

The water supply shall be free of excessive sediment and corrosives and provide the required flow for not less than 10 minutes. A strainer with a flush-out connection and manual shutoff valve shall be provided. [120: 9.4.6.6]

26.34.1.3.6

The system shall be interlocked to shut down the conveyor and provide an audible and a visual alarm. [120: 9.4.6.8]

26.34.1.3.7

Fire suppression systems shall also comply with 26.35.1.1.1. [120: 9.4.6.10]

26.34.1.3.8

Sprinkler systems shall meet the following requirements:

~~The sprinklers shall be installed in accordance with NFPA 13 as far as practical, and shall have components that have been listed.~~

~~The water supply shall be capable of supplying a constant flow of water with all heads functioning for a period of 10 minutes.~~

~~The sprinkler head activation temperature shall not be less than 65.6°C (150°F) or greater than 148.9°C (300°F).~~

[~~120: 9.4.6.13~~]

26.34.2 Installation Requirements.**26.34.2.1 Underground Conveyors.****26.34.2.1.1**

Deluge water spray systems, foam systems, closed-head sprinkler systems, or dry-chemical systems automatically actuated by rise in temperature shall be installed at main and secondary belt conveyor drives. [~~120:9.4.6.1~~]

26.34.2.1.2

Fire suppression systems shall extend to the drive areas of belt conveyors, including drive motor(s), reducer, head pulley, and belt storage unit (takeup), including any hydraulic power unit; its electrical controls; and the top and bottom of the first ~~15.2 m (50 ft)~~ 50 ft (15.2 m) of belt from the drive on the downwind side. [~~120:9.4.6.2~~]

26.34.2.1.3

~~Piping for the deluge, foam, or closed-head sprinkler system shall be metal and listed for sprinkler applications.~~ [~~120: 9.4.6.3~~]

26.34.2.1.4

~~The discharge shall be directed at both the upper and the bottom surface of the top belt and the upper surface of the bottom belt.~~ [~~120: 9.4.6.5~~]

26.34.2.1.5

~~Maximum distance between nozzles on a branch line shall not exceed 2.4 m (8 ft).~~ [~~120: 9.4.6.7~~]

26.34.2.1.6

~~The components of the system shall be located so as to minimize the possibility of damage by roof fall or by the moving belt and its load.~~ [~~120: 9.4.6.9~~]

26.34.2.1.3

Deluge water spray systems shall meet the requirements of 26.34.2.1.3.1 through 26.34.2.1.3.5.

[~~120:9.4.6.11~~ 9.4.6.3.3]

26.34.2.1.3.1

The system shall be activated by heat detectors or no less effective means . [~~120:9.4.6.11.1~~ 9.4.6.3.3.1]

26.34.2.1.3.2

~~Heat detectors~~ Detectors shall be located at the belt drive, hydraulic takeup unit (unless fire-resistive fluid is used), discharge roller, and the roof above the conveyor. [~~120:9.4.6.11.1.1~~ 9.4.6.3.3.1(A)]

26.34.2.1.3.3

~~Heat detectors~~ Detectors at the roof line should be spaced ~~2.4 m to 3.0 m (8 ft to 10 ft)~~ 8 ft to 10 ft (2.4 m to 3.0 m) apart along the entire length of the protected area of the belt. [~~120:9.4.6.11.1.2~~ 9.4.6.3.3.1(B)]

26.34.2.1.3.4

The water spray nozzles shall be full cone, corrosion resistant, [if less than $\frac{3}{8}$ in. (0.95 cm) inside diameter or K-factor 4.2 or lower], and provided with blow-off dust covers. [~~120:9.4.6.11.2~~ 9.4.6.3.3.2]

26.34.2.1.3.5

A closed sprinkler head shall be used over the electrical controls. [120:9.4.6.11.3 9.4.6.3.3.4]

26.34.2.2 Mine Surface Buildings.**26.34.2.2.1**

In addition, If sprinklers are installed, water flow, valve tamper, and low building temperature alarms shall be provided. [120:8.6.1.2]

26.35 Metal/Nonmetal Mining and Metal Mineral Processing Facilities.**26.35.1 Design Requirements.****26.35.1.1 Water Supplies.****26.35.1.1.1**

When automatic sprinkler systems are supplied through the hand hose line standpipe system, hydraulic calculations shall be used to ensure that the piping and water supply will supply the hose and automatic sprinkler demands simultaneously. [122:6.2.3]

26.35.1.1.2

Where a fire water supply ~~[for a surface mineral processing plant]~~ is required by the risk assessment, capacity and availability shall provide the water demand for fire-fighting purposes, including hose and sprinkler systems, for a minimum duration of 2 hours. [122:13.7.2]

26.35.1.2*

Where provided, automatic sprinkler systems installed for the protection of flammable liquid or diesel fuel storage areas shall be of the foam-water type. [122:11.3.1]

26.35.1.3 New Solvent Extraction (SX) Facilities.**26.35.1.3.1**

Fixed fire suppression shall be provided for the following SX facility areas and equipment:

- (1) Buildings housing SX processes
- (2) Interior of all mixer-settler vessels/cells
- (3) Crud tanks that include treatment filters and centrifuges
- (4) Coalescers
- (5) Along launders and weirs outside of mixer-settler vessels
- (6) Inside pipe trenches carrying solvents
- (7) Inside organic solvent and diluent tanks
- (8) Inside dikes enclosing organic solvent storage tanks
- (9) Over organic solvent pumps
- (10) Over elevated pipe racks carrying organic solvents in plastic pipes
- (11) Other areas handling, processing, or exposed to flammable or combustible liquids

[122:13.19.1]

26.35.1.3.2*

Fire suppression for applications in 26.35.1.3.1 shall be water, foam, dry chemical, or water mist. [122:13.19.1.1]

26.35.1.3.3*

Design of fire suppression systems in 26.35.1.3.1 shall be based on criteria set forth in NFPA 11, NFPA 15, NFPA 16, and NFPA 17. [122:13.19.1.2]

26.35.1.3.4*

Actuation of fire suppression systems in 26.35.1.3.1 shall be automatic. [122:13.19.1.3]

26.35.1.3.5

As exposure protection, automatic water-only deluge (open-head) sprinkler systems shall be provided between mixer-settler trains if spaced closer than ~~15.24 m (50 ft)~~ 50 ft (15.24 m) from each other. [122:13.19.2]

26.35.1.3.6

As exposure protection, automatic water-only deluge sprinkler systems shall be provided around the exterior perimeter of organic solvent tanks if spaced closer than ~~15.24 m (50 ft)~~ 50 ft (15.24 m) from each other. [122:13.19.3]

26.35.1.3.7

As exposure protection, automatic fire suppression shall be provided over other critical equipment (i.e., transformers) or outside along important building walls [i.e., motor control center (MCC) rooms] that are within ~~15.24 m (50 ft)~~ 50 ft (15.24 m) of a solvent fire area. [122:13.19.4]

26.35.1.3.8

Hydraulic design of automatic fire suppression systems in 26.35.1.3.1 shall include the simultaneous operation of all fire protection systems associated with a single (multi-cell) train. [122:13.19.5]

26.35.1.3.9

The total flow rate of foam application and water associated with the discharge of automatic fire extinguishing systems, fixed monitors, and hydrants shall determine the total volume of fire water required. [122:13.19.6]

26.35.2 Installation Requirements. (Reserved)**26.36** Hazardous Materials Code.**26.36.1** Design Requirements.

Sprinkler system discharge criteria for the protection of hazardous materials shall comply with NFPA 400.

26.36.1.1 Requirements for Occupancies Storing Quantities of Hazardous Materials Exceeding the Maximum Allowable Quantities per Control Area for High Hazard Contents.

The design of the sprinkler system shall be not less than ordinary hazard Group 2 in accordance with NFPA-13, this standard except as follows:

- (1) Where different requirements are specified in Chapters 11 through 21 of NFPA 400
- (2) Where the materials or storage arrangement requires a higher level of sprinkler system protection in accordance with nationally recognized standards
- (3) Where approved alternative automatic fire extinguishing systems are permitted

[400:6.2.1.1.1]

26.36.1.2 ~~General Requirements for Storage of Ammonium Nitrate Solids and Liquids.~~

~~Sprinkler systems shall be of the approved type and designed and installed in accordance with NFPA-13, and the following:~~

~~Ammonium nitrate in noncombustible or combustible containers (paper bags or noncombustible containers with removable combustible liners) shall be designated as a Class I commodity.~~

~~Where contained in plastic containers, ammonium nitrate shall be designated as a Class II commodity.~~

~~Where contained in fiber packs or noncombustible containers in combustible packaging, ammonium nitrate shall be designated as a Class III commodity.~~

[400: 41.2.6.1.3]

26.36.1.2 General Requirements for Storage of Organic Peroxide Formulations.

26.36.1.2.1

Where required by other provisions of this code, automatic sprinklers and water spray systems shall be designed and installed according to the requirements of NFPA 13 this standard and NFPA 15 and shall provide the following discharge densities:

- (1) Class I — 0.50 gpm/ft² (20.4 L/min/m²)
- (2) Class II — 0.40 gpm/ft² (16.3 L/min/m²)
- (3) Class III — 0.30 gpm/ft² (12.2 L/min/m²)
- (4) Class IV — 0.25 gpm/ft² (10.2 L/min/m²)

[400:14.2.6.1 14.2.5.1]

26.36.1.2.2

The system shall be designed as follows:

- (1) It shall provide the required density over a 3000 ft² (280 m²) area for areas protected by a wet pipe sprinkler system or 3900 ft² (360 m²) for areas protected by a dry pipe single-interlock preaction sprinkler system.
- (2) Buildings using a dry pipe sprinkler system shall be provided with a required density over the hydraulically most remote 3900 ft² (360 m²) design area, and, if used, sprinklers shall be within 6 ft (1.8 m) of the top of any stored organic peroxide formulation.
- (3) The entire area of any building of less than 3000 ft² (280 m²) shall be used as the area of application.

[400:14.2.6.2 14.2.5.2]

26.36.1.2.3

Where required for detached storage buildings containing Class I organic peroxide formulations in quantities exceeding 2000 lb (907 kg), automatic sprinkler protection shall be open-head deluge-type, designed and installed in accordance with NFPA 13 this standard. [400:14.2.6.3 14.2.5.3]

26.36.1.3 Indoor Storage of Oxidizer Solids and Liquids.**26.36.1.3.1**

Sprinkler protection for Class 2 oxidizers shall be designed in accordance with Table 26.36.1.3.1.

[400:15.3.2.3.4.1]

Table 26.36.1.3.1 Ceiling Sprinkler Protection for Class 2 Oxidizers in Palletized or Bulk and Rack Storage Areas

Type of Storage	Ceiling Sprinklers						In-Rack Sprinklers
	Storage Height		Density		Area of Application		
	ft	m	gpm/ft ²	L/min/m ²	ft ²	m ²	
Palletized or bulk	8	2.4	0.20	8	3750	348	—
Palletized or bulk	12	3.7	0.35	14	3750	348	—
Rack	12	3.7	0.20	8	3750	348	One line above each level of storage, except the top level
Rack	16	4.9	0.30	12	2000	186	One line above each level of storage, except the top level

[400: Table 15.3.2.3.2.10(B)]

26.36.1.3.2

Ceiling sprinklers shall be high-temperature sprinklers. [400:15.3.2.3.4.2]

26.36.1.3.3 Storage Protection for Class 2 Oxidizers with In-Rack Sprinklers.**(A)**

In-rack sprinklers shall be quick-response sprinklers with an ordinary-temperature rating and have a K-factor of not less than $K = 8.0$. [400:15.3.2.3.4.3(A)]

(B)

In-rack sprinklers shall be designed to provide 25 psi (172 kPa) for the six most hydraulically remote sprinklers on each level. [400:15.3.2.3.4.3(B)]

(C)

The in-rack sprinklers shall be 8 ft to 10 ft (2.4 m to 3.0 m) spacings in the longitudinal flue space at the intersection of the transverse flue spaces. [400:15.3.2.3.4.3(C)]

26.36.1.3.4 Sprinkler Criteria for Class 3 Oxidizers.**26.36.1.3.4.1 Class 3 Oxidizers Less than 2300 lb (1043 2700 lb (1225 kg)).****(A)**

Sprinkler design criteria for buildings that require sprinkler protection and contain total quantities of Class 3 oxidizers less than 2300 lb (1043 2700 lb (1225 kg)) shall be in accordance with the requirements of 26.36.1.3.4.1(B). [400:15.3.2.4.13.1(A)]

(B)

Facilities that require sprinkler protection and contain total quantities of Class 3 oxidizers greater than 200 lb (91 kg), but less than 2300 lb (1043 2700 lb (1225 kg)), shall follow the sprinkler design criteria in Table 26.36.1.3.4.1(B). [400:15.3.2.4.13.1(B)]

Table 26.36.1.3.4.1(B) Sprinkler Protection of Class 3 Oxidizers Stored in Total Quantities Greater than 200 lb (91 kg) but Less than 2300 lb (1043 2700 lb (1225 kg))

<u>Storage Parameters</u>	<u>Shelf</u>	<u>Bulk or Pile</u>	<u>Bulk or Pile</u>	<u>Rack</u>
Maximum storage height	6 ft (1.8 m)	5 ft (1.5 m)	10 ft (3 m)	10 ft (3 m)
Maximum ceiling height	25 ft (7.6 m)	25 ft (7.6 m)	25 ft (7.6 m)	NA
Aisles — pile separation	4 ft (1.2 m) min. clear aisles	4 ft (1.2 m) min. clear aisles	8 ft (2.4 m) min. clear aisles	8 ft (2.4 m) min. clear aisles
Ceiling design criteria	0.45 gpm/ft ² /2000 ft ²	0.35 gpm/ft ² /or 5000 ft ² or 0.6 gpm/2000 ft ²	0.65 gpm/ft ² /5000 ft ²	0.35 gpm/ft ² /or 5000 ft ² or 0.6 gpm/ft ² /2000 ft ²
In-rack sprinklers	NP	NP	NA	See 15.3.2.4.12.2, 26.36.1.3.4.2
Hose stream demand	500 gpm	500 gpm	500 gpm	500 gpm
Duration	120 minutes	120 minutes	120 minutes	120 minutes

For SI units, 1 gal = 3.79 L. NA: Not applicable. NP: Not permitted.

[400: Table 15.3.2.4.12.1(B) 15.3.2.4.13.1(B)]

26.36.1.3.4.2 Storage Protection for Class 3 Oxidizers In-Rack Sprinkler Criteria.

(A)

Where required by Table 26.36.1.3.4.1(B), in-rack sprinkler protection shall be as follows:

- (1) In-rack sprinklers shall be installed above every level of oxidizer storage.
- (2) In-rack sprinklers shall be spaced at maximum 4 ft (1.2 m) intervals to provide one sprinkler in each flue space.
- (3) In-rack sprinklers shall be quick-response sprinklers with an ordinary-temperature rating and have a K-factor of not less than $K = 8.0$.
- (4) In-rack sprinklers shall be designed to provide 25 psi (172 kPa) for the six most hydraulically remote sprinklers on each level.

[400:15.3.2.4.13.3(A)]

26.36.1.3.4.3 Class 3 Oxidizers Greater than or Equal to ~~2300 lb (1043 kg)~~ 2700 lb (1225 kg).

The sprinkler protection required by 26.36.1.3.4.3 shall be in accordance with Table 26.36.1.3.4.3.

[400:15.3.2.4.13.4(B)]

Table 26.36.1.3.4.3 Sprinkler Protection of Class 3 Oxidizers Stored in Total Quantities of Greater than or Equal to ~~2300 lb (1043 kg)~~ 2700 lb (1225 kg)

<u>Storage Parameters</u>	<u>Bulk or Pile</u>	<u>Rack</u>
Maximum storage height	5 ft (1.5 m)	10 ft (3 m)
Maximum ceiling height	25 ft (7.6 m)	NP
Aisles — pile separation	8 ft (2.4 m) min. clear aisles	8 ft (2.4 m) min. clear aisles
Ceiling design criteria	0.35 gpm/ft ² /5000 ft ² (1.32 L/min/m ² /464.5 m ²)	Predominant for other commodities but not less than ordinary hazard Group II
In-rack sprinklers	NP	See ~~15.3.2.4.12.4~~ <u>26.36.1.3.4.4(B)</u>
Hose stream demand	500 gpm (1893 L/min)	500 gpm (1893 L/min)
Duration	120 minutes	120 minutes

NP: Not permitted.

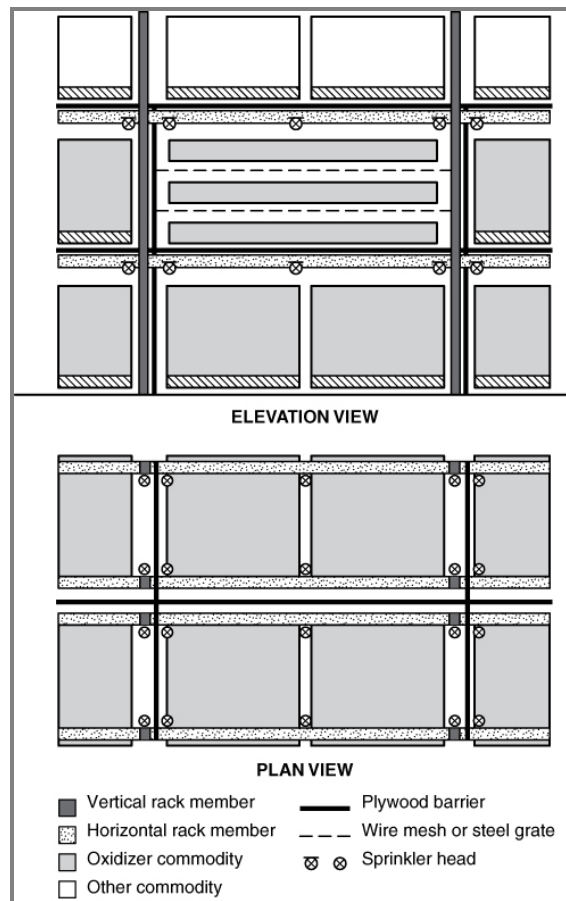
[400: Table ~~15.3.2.4.12.3(B)~~ 15.3.2.4.13.4(B)]

26.36.1.3.4.4 Special In-Rack Sprinkler Protection for Class 3 Oxidizers.

(A)

Where required by Table 26.36.1.3.4.3, special in-rack sprinkler protection, which is required by 26.36.1.3.4.4(C), shall be as shown in Figure 26.36.1.3.4.4(A). [400:15.3.2.4.13.5(A)]

Figure 26.36.1.3.4.4(A) Arrangement of Barriers and In-Rack Sprinklers for Special Fire Protection Provisions. [400: Figure 15.3.2.4.13.5(A)]

**(B)**

In-rack automatic sprinklers shall be provided under each horizontal barrier and arranged in accordance with 26.36.1.3.4.4(C) through 26.36.1.3.4.4(J). [400:15.3.2.4.13.5(K) 15.3.2.4.13.5(L)]

(C)

For double-row racks, two lines of in-rack sprinklers shall be provided between the face of the rack and the longitudinal vertical barrier located in the center of the rack. [400:15.3.2.4.13.5(L) 15.3.2.4.13.5(M)]

(D)

For single-row racks, two lines of in-rack sprinklers shall be provided between each rack face. [400:15.3.2.4.13.5(M) 15.3.2.4.13.5(N)]

(E)

Three in-rack sprinklers shall be provided on each in-rack sprinkler line as follows:

- (1) Two sprinklers on each line shall be spaced approximately 1½ in. (38.1 mm) from each transverse vertical barrier.
- (2) One in-rack sprinkler on each in-rack sprinkler line shall be located approximately equidistant between the transverse vertical barriers.

[400:15.3.2.4.13.5(N) 15.3.2.4.13.5(O)]

(F)

In-rack sprinklers shall be of the upright or pendent type, with the fusible element located no more than 6 in. (152.4 mm) from the horizontal barrier. [400:15.3.2.4.13.5(O) 15.3.2.4.13.5(P)]

(G)

The stock shall be maintained at least 6 in. (152.4 mm) below the sprinkler deflector.

[**400:** 15.3.2.4.13.5(Q)]

(H)

In-rack sprinklers shall be K = 8.0, quick-response, ordinary-temperature-rated sprinklers.

[**400:**15.3.2.4.13.5(Q) 15.3.2.4.13.5(R)]

(I)

The in-rack sprinkler system shall be designed to supply 6 sprinklers on each line, with a total of 12 sprinklers operating at gauge pressure of 25 psi (172 kPa). [**400:**15.3.2.4.13.5(R) 15.3.2.4.13.5(S)]

(J)

The design of the in-rack sprinkler system shall be independent of, and shall not be required to be balanced with, ceiling sprinkler systems. [**400:**15.3.2.4.13.5(S) 15.3.2.4.13.5(T)]

26.36.1.3.4.5 Sprinkler Criteria for Class 4 Oxidizers.**(A)**

Sprinkler protection for Class 4 oxidizers shall be installed on a deluge sprinkler system to provide water density of 0.35 gpm/ft² (14.4 L/min/m²) over the entire storage area. [**400:**15.3.2.5.4.6(A)]

(B)

Sprinkler protection shall be installed in accordance with NFPA-13 [this standard](#) . [**400:**15.3.2.5.4.6(B)]

26.36.2 Installation Requirements. (Reserved)**Supplemental Information**

<u>File Name</u>	<u>Description</u>	<u>Approved</u>
13-2016_Chapter_26.docx	Chapter 26--for staff use.	

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: National Fire Protection Assoc

Street Address:

City:

State:

Zip:

Submittal Date: Tue Aug 08 11:27:49 EDT 2017

Committee Statement

Committee Statement: Updated extracted text.

Response Message:

25.12.3.3.1

Where in-rack sprinklers have been installed to protect rack storage of the following commodities and storage arrangements, the minimum allowable design pressure at the hydraulically most remote in-rack sprinkler shall be 30 gpm (115 L/min).

Class I through Class IV and Group A plastic commodities stored in racks with solid shelves.

Class I through Class IV and Group A plastic commodities stored in racks over 25 ft (7.6 m) in height protected by CMDA sprinklers at ceiling level.

25.12.3.4 In-Rack Design Based on 60 gpm (230 L/min).

Where in-rack sprinklers have been installed to protect rack storage protected by ESFR sprinklers at ceiling level, the minimum allowable design pressure at the hydraulically most remote in-rack sprinkler shall be 60 gpm (230 L/min).

Supplemental Information

<u>File Name</u>	<u>Description</u>	<u>Approved</u>
TG_25_Draft_Chapter_25_Clean_Second_Draft_18-Jul-2017_.docx	Complete revision of Chapter 25. For staff use.	
Copy_of_Draft_Tables_for_Chapter_25_for_NFPA_Staff.xlsx	This is a copy of all the Tables that are in Chapter 25 for use by NFPA staff.	

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submission Date: Tue Jul 18 10:25:38 EDT 2017

Committee Statement

Committee Statement: See new Word Doc for Chapter 25 addressing all in-rack requirements.

Response Message:

[Public Comment No. 5-NFPA 13-2017 \[Global Input\]](#)

[Public Comment No. 148-NFPA 13-2017 \[New Section after 25.8.2\]](#)

[Public Comment No. 4-NFPA 13-2017 \[Global Input\]](#)

[Public Comment No. 307-NFPA 13-2017 \[Section No. 25.5.2.13\]](#)

[Public Comment No. 139-NFPA 13-2017 \[New Section after 25.5.1.1\]](#)

[Public Comment No. 292-NFPA 13-2017 \[Section No. 25.5.1.1.2\]](#)

[Public Comment No. 218-NFPA 13-2017 \[Section No. 25.1.2.1\]](#)



Second Revision No. 399-NFPA 13-2017 [Section No. A.20.3]



A.20.3

Commodity classification is governed by the types and amounts of materials (e.g., metal, paper, wood, plastics) that are a part of a product and its primary packaging. Consideration of all characteristics of the individual storage units, not just the product, is critical to identify the appropriate commodity classification. Refer to Table A.20.3 for general guidance for classifying commodities. For situations where it is difficult to determine the appropriate classification, testing should be considered to appropriately characterize the commodity.

Table A.20.3 General Guide to Identifying the Commodity Class for Solid Combustibles

<u>Characteristics of Unit Load</u>			<u>Commodity Class</u>
<u>Material Used to Construct Product</u>	<u>Packaging Material</u>	<u>Pallet Material</u>	
Noncombustible Product			
Entirely noncombustible	None or single-layer corrugated cartons	None, metal, or wood	Class I
Entirely noncombustible	None or single-layer corrugated cartons	Plastic	Class I, II, or III; see 5-6-2 20.3.2
Entirely noncombustible	Multiple-layered corrugated cartons, wooden crates, or wood boxes	None, metal, or wood	Class II
Entirely noncombustible	Multiple-layered corrugated cartons, wooden crates, or wood boxes	Plastic	Class II, III, or IV; see 5-6-2 20.3.2
Entirely noncombustible	Corrugated cartons, wooden crates, or wood boxes, with internal plastic packaging	None, metal, or wood	See Figure 5-6-3.3.3-1 20.4.3.3(a)
Entirely noncombustible	Corrugated cartons, wooden crates, or wooden boxes, with internal plastic packaging	Plastic	See 5-6-2 20.3.2 and Figure 5-6-3.3.3-1 20.4.3.3(a)
Wood, Paper, Natural Fibers, or Group C Plastics			
Entirely wood, paper, natural fibers, or Group C plastics, or a mix of these with noncombustible materials	None, corrugated cartons, wooden crates, or wood boxes	None, metal, or wood	Class III
Entirely wood, paper, natural fibers, or Group C plastics, or a mix of these with noncombustible materials	Corrugated cartons, wooden crates, or wood boxes, with internal plastic packaging	None, metal, or wood	See Figure 5-6-3.3.3-1 20.4.3.3(a)
Entirely wood, paper, natural fibers, or Group C plastics, or a mix of these with noncombustible materials	None, corrugated cartons, wooden crates, or wood boxes	Plastic	Class III or IV or cartoned nonexpanded Group A plastic; see 5-6-2 20.3.2
Entirely wood, paper, natural fibers, or Group C plastics, or a mix of these with noncombustible materials	Corrugated cartons, wooden crates, or wood boxes, with internal plastic packaging	Plastic	See 5-6-2 20.3.2 and Figure 5-6-3.3.3-1 20.4.3.3(a)

<u>Characteristics of Unit Load</u>			<u>Commodity Class</u>
<u>Material Used to Construct Product</u>	<u>Packaging Material</u>	<u>Pallet Material</u>	
Group B Plastics			
Entirely Group B plastics, or a mix of these with noncombustible, wood, paper, natural fibers, or Group C plastics materials	None, corrugated cartons, wooden crates, or wood boxes	None, metal, or wood	Class IV
Entirely Group B plastics, or a mix of these with noncombustible, wood, paper, natural fibers, or Group C plastics materials	Corrugated cartons, wooden crates, or wood boxes	Plastic	Class IV or cartoned nonexpanded Group A plastic; see 5-6-2 20.3.2
Entirely Group B plastics, or a mix of these with noncombustible, wood, paper, natural fibers, or Group C plastics materials	None	Plastic	Class IV or cartoned nonexpanded Group A plastic; see 5-6-2 20.3.2
Entirely Group B plastics, or a mix of these with noncombustible, wood, paper, natural fibers, or Group C plastics materials	Corrugated cartons, wooden crates, or wood boxes, with plastic internal packaging	None, metal, or wood	See Figure 5-6-3.3.3-1 20.4.3.3(a)
Entirely Group B plastics, or a mix of these with noncombustible, wood, paper, natural fibers, or Group C plastics materials	Corrugated cartons, wooden crates, or wood boxes, with plastic internal packaging	Plastic	See 5-6-2 20.3.2 and Figure 5-6-3.3.3-1 20.4.3.3(a)
Group A Plastics			
Free-flowing Group A plastic materials	Corrugated cartons, wooden crates, wood boxes, or bagged	None, metal, wood	Class IV
Free-flowing Group A plastic materials	Corrugated cartons, wooden crates, wood boxes, or bagged	Plastic	Class IV or cartoned nonexpanded Group A plastic; see 5-6-2 20.3.2
Entirely nonexpanded Group A plastic	Corrugated cartons, wooden crates, or wood boxes	None, metal, wood, or plastic	Cartoned nonexpanded Group A plastic
Entirely nonexpanded Group A plastic	None	None, metal, wood, or plastic	Exposed nonexpanded Group A plastic
Entirely nonexpanded Group A plastic	Corrugated cartons, wooden crates, or wood boxes, with internal plastic packaging	None, metal, wood, or plastic	See Figure 5-6-3.3.3-1 20.4.3.3(a)
Entirely expanded Group A plastic	Corrugated cartons, wooden crates, or wood boxes, with or without internal plastic packaging	None, metal, wood, or plastic	Cartoned expanded Group A plastic
Entirely expanded Group A plastic	None	None, metal, wood, or plastic	Exposed expanded Group A plastic
Mix of Group A plastics, noncombustible, wood, paper, natural fibers, Group B or C	Corrugated cartons, wooden crates, or wood boxes, with or without	None, metal, or wood	See Figure 5-6-3.3.3-1 20.4.3.3(a)

<u>Characteristics of Unit Load</u>			<u>Commodity Class</u>
<u>Material Used to Construct Product</u>	<u>Packaging Material</u>	<u>Pallet Material</u>	
plastics materials	internal plastic packaging		
Mix of Group A plastics, noncombustible, wood, paper, natural fibers, Group B or C plastics materials	Corrugated cartons, wooden crates, or wood boxes	Plastic	See ~~5.6.2~~ <u>20.3.2</u> and Figure ~~5.6.3.3.1~~ <u>20.4.3.3(a)</u>
Mix of Group A plastics, noncombustible, wood, paper, natural fibers, Group B or C plastics materials	None	None, metal, or wood	See Figure ~~5.6.3.3.2~~ <u>20.4.3.3(b)</u>
Mix of Group A plastics, noncombustible, wood, paper, natural fibers, Group B or C plastics materials	None	Plastic	See ~~5.6.2~~ <u>20.3.2</u> and Figure ~~5.6.3.3.2~~ <u>20.4.3.3(b)</u>
Note: This table provides guidance for the general characteristics to be considered in classifying a commodity. The additional commodity classification information included in this standard as well as any relevant test data that is available should be considered in identifying the appropriate classification.			

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Fri Jul 14 14:56:24 EDT 2017

Committee Statement

Committee Statement: Editorial revision.

Response Message:



Second Revision No. 400-NFPA 13-2017 [Section No. A.20.4]

[Detail SR-1038](#)

[Global SR-531](#)

A.20.4

~~See Table A.20.4.~~

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

Table A.20.4(a) provides examples of commodities not addressed by the classifications in Section 20.4. The commodities listed in Table A.20.4(a) are outside the scope of NFPA 13 protection.

Table A.20.4(a) includes lithium ion batteries. Lithium ion batteries have been a research project within the NFPA Research Foundation. As a result, the following reports have been published:

- (1) *Lithium Ion Batteries Hazard and Use Assessment*, published July 2011 and available at the NFPA Research Foundation web site.
- (2) *Flammability Characterization of Lithium-ion Batteries in Bulk Storage*, published March 2013 and available at www.fmglobal.com/researchreports.
- (3) *Lithium Ion Batteries Hazard and Use Assessment Phase IIB, Flammability Characterization of Lithium-ion Batteries for Storage Protection*, published April 2013 and available at the NFPA Research Foundation web site.
- (4) *Lithium Ion Batteries Hazard and Use Assessment — Phase III*, published November 2016 and available at the NFPA Research Foundation web site.

Table A.20.4(b) is an alphabetized list of commodities with corresponding classifications.

Table A.20.4.1, Table A.20.4.2, Table A.20.4.3, Table A.20.4.4, and Table A.20.4.5.1 provide examples of commodities within a specific class.

Table A.20.4(a) Examples of Commodities Not Addressed by Classifications in Section 20.4

Ammunition Components

- Bulk primers and powder

Batteries

- Lithium and other similar exotic metals

- Lithium-ion and other rechargeable batteries that contain combustible electrolyte

Boat Storage

- Stored on racks

Boxes, Crates

- Empty, wood slatted*

Carpet Rolls

Combustible Metals — unless specifically identified otherwise

Compressed or Liquefied Flammable Gases (i.e., filled propane cylinders) — unless specifically identified otherwise

Explosives

- Blasting primers and similar items

Fertilizers (nitrates)

Fireworks

- Consumer and display

Flammable and Combustible Liquids — unless specifically identified otherwise

- Liquids that contain greater than 20 percent alcohol

Hanging Garments, Bulk Storage

Lighters (butane)

- Loose in large containers (Level 3 aerosol)

Storage Container

- Large container storage of household goods

*Should be treated as idle pallets.

Table A.20.4(b) Alphabetical Listing of Commodity Classes

<u>Product Heading</u>	<u>Product</u>	<u>NFPA 13</u>
Batteries	Dry cells (excludes lithium, lithium-ion, and other similar exotic metals or combustible electrolyte); without blister packing (if blister packed refer to commodity classification definitions)	Class I
	Vehicle; any size (e.g., automobile or truck); empty plastic casing	Group A Nonexpanded
	Vehicle; large (e.g., truck or larger); dry or wet (excludes lithium-ion and other cells containing combustible electrolyte) cells	Group A Nonexpanded
	Vehicle; small (e.g., automobile); wet (excludes lithium-ion and other cells containing combustible electrolyte) cells	Class I
Empty Containers	Noncombustible	Class I
	PET, bottles or jars	Class IV
	Rigid plastic (not including PET), up to 32 oz. (1 L)	Group A Nonexpanded
	Rigid plastic (not including PET), greater than 32 oz. (1 L)	Group A Expanded
	Wood; solid sided (e.g., crates, boxes)	Class II
Film Rolls, Including Photographic	Film (polypropylene, ~~polyester~~ polyester, polyethylene); rolled on any reel type	Group A Nonexpanded
	Film; 35 mm metal film cartridges in polyethylene cans; cartoned	Class III
	Film; motion picture or bulk rolls in polycarbonate, polyethylene or in metal cans; polyethylene bagged; cartoned	Class II
	Film; rolls in polycarbonate plastic cassettes; cartoned	Class IV
	Photographic paper; sheets; bagged in polyethylene; cartoned	Class III
Flammable/Combustible Liquids	Aerosol; Level 1	Class III
	Lighters; butane; blister-packed; cartoned	Group A Nonexpanded
	Liquids; up to 20 percent alcohol (e.g. alcoholic beverages, flavoring extracts); greater than 5 gallon (20 L) plastic containers with wall thickness greater than 1/4 in. (6 mm)	Group A Nonexpanded
	Liquids; up to 20 percent alcohol (e.g., alcoholic beverages, flavoring extracts); metal, glass or ceramic containers	Class I
	Liquids; up to 20 percent alcohol (e.g., alcoholic beverages, flavoring extracts); plastic containers greater than 5 gallons (20 L) and wall thickness up to 1/4 in. (6 mm)	Class II

<u>Product Heading</u>	<u>Product</u>	<u>NFPA 13</u>
Food Products — Frozen	Liquids; up to 20 percent alcohol (e.g., alcoholic beverages, flavoring extracts); up to 5 gallons (20 L) plastic bottles or jars	Class I
	Liquids; up to 20 percent alcohol (e.g., alcoholic beverages, flavoring extracts); wood containers	Class II
	Frozen foods; nonwaxed or nonplastic packaging	Class I
	Frozen foods; plastic trays	Class III
Food Products — Non-Frozen	Frozen foods; waxed or plastic-coated paper packaging	Class II
	Butter (stick or whipped spread) or margarine (up to 50 percent oil)	Class III
	Dry foods (such as baked goods, candy, cereals, cheese, chocolate, cocoa, coffee, grains, granular sugar, nuts, etc.); bagged or cartoned	Class III
	Foods (e.g., coffee, fish products, fruit, meat products, nuts, poultry, etc.); metal cans	Class I
	Fruits and vegetables (noncombustible semi-liquids); crushed; plastic containers up to 5 gallons (20 L)	Class I
	Fruits and vegetables; fresh; wood spacers, non-plastic trays or containers	Class I
	Margarine; over 50 and up to 80 percent oil	Group A Nonexpanded
	Meat; fresh; no plastic packaging; <u>uncartoned exposed</u>	Class I
	Meat; fresh; no plastic packaging; cartoned	Class II
	Meat; fresh; plastic trays	Class III
	Milk; any container; stored in solid plastic crates	Group A Nonexpanded
	Milk; paper containers, or plastic bottles or jars up to 5 gallons (20 L) plastic bottles or jars	Class I
	Salt; bagged	Class I
	Salt; cartoned	Class II
	Snack foods (e.g., potato chips); plasticized aluminum bags; cartoned	Group A Nonexpanded
	Syrup; wooden container	Class II
Furniture and Bedding	Furniture and bedding; with foam cushioning	Group A Expanded
	Furniture; metal (e.g., file cabinets or desks with plastic trim); cartoned	Class I
	Furniture; wood (e.g., doors, windows, cabinets, etc.); no plastic coverings or foam cushioning	Class III
	Furniture; wood; plastic coverings nonexpanded plastic trim	Class IV
	Box spring; standard (minimal plastic materials)	Class III
	Box spring; wrapped in plastic cover	Class IV
	Mattress; foam (in finished form)	Group A Expanded
Housing Materials/Appliances	Appliances; major (e.g., stoves, refrigerators); no appreciable plastic interior or exterior trim; cartoned	Class II

<u>Product Heading</u>	<u>Product</u>	<u>NFPA 13</u>
Miscellaneous	Appliances; major (e.g., stoves, refrigerators); no appreciable plastic interior or exterior trim; ~~uncartoned~~ ~~exposed~~	Class I
	Appliances; no appreciable plastic exterior trim (interior of unit can have appreciable plastic)	Class III
	Carpet tiles; cartoned	Group A Nonexpanded
	Fiberglass insulation; paper-backed rolls; bagged or unbagged	Class IV
	Floor coverings; vinyl, stacked tiles	Class IV
	Floor coverings; vinyl; rolled	Group A Nonexpanded
	Gypsum board	Class I
	Housing materials (such as sinks, countertops, etc.); noncombustible, cartoned or crated	Class II
	Paint; oil-based; friction-top metal containers; cartoned	Class IV
	Paint; water-based (latex); friction-top metal containers; cartoned	Class I
	Roofing shingles; asphalt-coated fiberglass	Class III
	Roofing shingles; asphalt-impregnated felt	Class IV
	Ammunition; small arms and shotgun; cartoned	Class IV
	Charcoal; mineral spirit impregnated; bagged	Group A Expanded
	Charcoal; standard (non-mineral spirit impregnated); bagged	Class III
	Leather hides; baled	Class II
	Leather; finished products (e.g., shoes, jackets, gloves, bags, luggage, belts)	Class III
	Motors; electric	Class I
	Shock absorbers; metal dust cover	Class II
	Shock absorbers; plastic dust cover	Class III
	Skis; composite materials (plastic, fiberglass, foam, etc.)	Class IV
	Tobacco products; cartoned	Class III
	Toys; stuffed; foam or synthetic	Group A Expanded
	Transformer; dry or empty (i.e., void of oil)-filled	Class I
Noncombustible Liquids	Liquids or semi-liquids; PET containers greater than 5 gallon (20 L) having a nominal wall thickness greater than 0.25 in (6 mm)	Class IV
	Liquids or semi-liquids; PET containers up to 5 gallon (20 L) or greater than 5 gallon (20 L) having a nominal wall thickness up to 0.25 in (6 mm)	Class I
	Liquids or semi-liquids (e.g., crushed fruits and vegetables); plastic containers up to 5 gallon (18.9 L) capacity	Class I
	Liquids or semi-liquids; plastic (except PET) containers greater than 5 gallon (20 L) capacity having a nominal wall thickness greater than 0.25 in. (6 mm)	Group A Nonexpanded

<u>Product Heading</u>	<u>Product</u>	<u>NFPA 13</u>
Paper Products	Liquids or semi-liquids; plastic (except PET) containers greater than 5 gallon (20 L) capacity having a nominal wall thickness up to 0.25 in. (6 mm)	Class II
	Liquids; cardboard drink boxes, plastic-coated, wax-coated, and/or aluminum-lined; ~~uncartoned~~ exposed or on corrugated carton trays with plastic sheeting.	Class I
	Liquids; cardboard drink boxes, plastic-coated, wax-coated, and/or aluminum-lined; stored in plastic containers	Group A Nonexpanded
	Liquids; glass bottles or jars; cartoned	Class I
	Liquids; pharmaceuticals (nonflammable); glass bottles or jars; cartoned	Class II
	Liquids; plastic bottles or jars; stored in open or solid plastic crates	Group A Nonexpanded
	Book signatures (paper part of book without hard cover)	Class II
	Cartons (i.e., cardboard flats); corrugated; partially assembled	Class IV
	Cartons (i.e., cardboard flats); corrugated; unassembled in neat piles	Class III
	Cartons; wax-coated, single-walled corrugated	Group A Nonexpanded
	Cellulosic paper products; nonwax-coated (e.g., books, cardboard games, cartoned tissue products, magazines, newspapers, paper cups, paper plates, paper towels, plastic-coated paper food containers, stationery)	Class III
	Cellulosic paper products; wax-coated (e.g., paper plates, cups); loosely packed; cartoned	Group A Nonexpanded
	Cellulosic paper products; wax-coated (e.g., paper plates, cups.); nested; cartoned	Class IV
	Matches; paper-type; cartoned	Class IV
	Matches; wooden; cartoned	Group A Nonexpanded
Plastic/Rubber	Rolled; lightweight; in storage racks	Class IV
	Rolled; medium or heavyweight; in storage racks or on-side	Class III
	Tissue products; plastic-wrapped; cartoned	Class III
	Tissue products; plastic-wrapped; ~~uncartoned~~ exposed	Group A Nonexpanded
	ABS (Acrylonitrile-butadiene-styrene copolymer)	Group A Nonexpanded
	Acetal (polyformaldehyde)	Group A Nonexpanded
	Acrylic (polymethyl methacrylate)	Group A Nonexpanded
	Automobile bumpers and dashboards	Group A Expanded
	Butyl rubber	Group A Nonexpanded
	Cellulose Acetate	Class IV
	Cellulose Acetate Butyrate	Group A Nonexpanded
	Chloroprene rubber	Class IV

<u>Product Heading</u>	<u>Product</u>	<u>NFPA 13</u>
	Containers; nonexpanded plastic gridded or solid; collapsed or nested with no air spaces	Group A Nonexpanded
	ECTFE (ethylene-chlorotrifluoro-ethylene copolymer)	Class IV
	EPDM (ethylene-propylene rubber)	Group A Nonexpanded
	ETFE (ethylene-tetrafluoroethylene copolymer)	Class IV
	Ethyl Cellulose	Group A Nonexpanded
	FEP (fluorinated ethylene-propylene copolymer)	Class IV
	FRP (fiberglass-reinforced polyester)	Group A Nonexpanded
	Melamine (melamine formaldehyde)	Class III
	Nitrile Rubber (acrylonitrile-butadiene rubber)	Group A Nonexpanded
	Nylon (nylon 6, nylon 6/6)	Group A Nonexpanded
	PCTFE (polychlorotrifluoroethylene)	Class III
	PET (Polyethylene Terephthalate — thermoplastic polyester)	Group A Nonexpanded
	Phenolic	Class III
	Plastics; stored in fully closed and solid (no openings), metal containers	Class I
	Polybutadiene	Group A Nonexpanded
	Polycarbonate	Group A Nonexpanded
	Polyester elastomer	Group A Nonexpanded
	Polyethylene	Group A Nonexpanded
	Polypropylene	Group A Nonexpanded
	Polystyrene; foam products (plates, cups, etc.)	Group A Expanded
	Polystyrene; rigid products	Group A Nonexpanded
	Polyurethane	Group A Expanded
	PTFE (polytetrafluoroethylene)	Class III
	PVC (polyvinyl chloride) products, up to 20% <u>percent</u> plasticizer	Class III
	PVC (polyvinyl chloride) products, greater than 20% <u>percent</u> plasticizer	Group A Nonexpanded
	PVC resins; bagged	Class III
	PVDC (polyvinylidene chloride)	Class III
	PVDF (polyvinylidene fluoride)	Class III
	PVF (polyvinyl fluoride)	Group A Nonexpanded
	Rubber; natural in blocks; cartoned	Group A Nonexpanded
	Rubber; natural; expanded	Group A Expanded
	Rubber; natural; nonexpanded	Group A Nonexpanded
	Rubber; synthetic (santoprene)	Group A Nonexpanded
	SAN (styrene acrylonitrile)	Group A Nonexpanded
	SBR (styrene-butadiene rubber)	Group A Nonexpanded
	Silicone rubber	Class IV
	Urea (urea formaldehyde)	Class III

<u>Product Heading</u>	<u>Product</u>	<u>NFPA 13</u>
Plastic Containers	Bottles or jars (except PET) greater than 1 gallon (4 L) containing noncombustible solids	Group A Nonexpanded
	Bottles or jars (except PET) up to 1 gallon (4 L) containing noncombustible solids	Group A, cartoned (treat as cartoned even if ~~uncartoned~~ <u>exposed</u>) Nonexpanded
Powders/Pills	Pharmaceutical pills; glass bottles or jars; cartoned	Class II
	Pharmaceuticals pills; plastic bottles or jars; cartoned	Class IV
	Polyvinyl Alcohol (PVA) resins; bagged	Class IV
	Powders; combustible (ordinary such as sugar or flour); free-flowing; bagged	Class II
	Powders; noncombustible free-flowing powdered or granular materials (cement, calcium chloride, clay, iron oxide, sodium chloride, sodium silicate, etc.)	Class I
	Powders; noncombustible; glass bottles or jars; cartoned	Class I
	Powders; noncombustible; PET bottles or jars	Class II
	Powders; noncombustible; plastic (other than PET) bottles or jars; ~~uncartoned~~ <u>exposed</u>	Group A Nonexpanded
	Powders; noncombustible; plastic bottles or jars greater than 1 gallon (4 L) capacity	Group A Nonexpanded
	Powders; noncombustible; plastic bottles or jars up to 1 gallon (4 L) capacity; cartoned	Class IV
Textile Materials/Products	Cloth; natural fibers; baled	Class III
	Cloth; synthetic cloth	Group A Nonexpanded
	Clothing; natural fibers (e.g., wool, cotton) and viscose	Class III
	Cotton; cartoned	Class III
	Diapers; cotton or linen	Class III
	Diapers; plastic or nonwoven fabric; cartoned	Class IV
	Diapers; plastic or nonwoven fabric; plastic-wrapped; ~~uncartoned~~ <u>exposed</u>	Group A Nonexpanded
	Fabric; rayon and nylon	Group A Nonexpanded
	Fabric; synthetic (except rayon and nylon); greater than 50/50 blend	Group A Nonexpanded
	Fabric; synthetic (except rayon and nylon); up to 50/50 blend	Group A Nonexpanded
	Fabric; vinyl-coated (e.g., tablecloth); cartoned	Group A Nonexpanded
	Fibers; rayon and nylon; baled	Class IV
	Fibers; synthetic (except rayon and nylon); baled	Group A Nonexpanded
	Thread or yarn; rayon and nylon; wood or paper spools	Class IV
	Thread or yarn; rayon or nylon; plastic spools	Group A Nonexpanded
	Thread or yarn; synthetic (except rayon and nylon); greater than 50/50 blend; paper or wood spools	Group A Nonexpanded Plastic

<u>Product Heading</u>	<u>Product</u>	<u>NFPA 13</u>
	Thread or yarn; synthetic (except rayon and nylon); greater than 50/50 blend; plastic spools	Group A Nonexpanded
	Thread or yarn; synthetic (except rayon and nylon); up to 50/50 blend; plastic spools	Group A Nonexpanded
	Thread or yarn; synthetic (except rayon and nylon); up to 50/50 blend; wood or paper spools	Group A Nonexpanded Plastic
Wax Products	Candles	Group A Expanded
	Paraffin or petroleum wax; blocks	Group A Expanded
Wire/Cable/Spools	Spools; plastic; empty	Group A Nonexpanded
	Spools; wood; empty	Class III
	Wire or cable; PVC insulated; metal or wood spools	Class II
	Wire or cable; PVC insulated; plastic spools	Class IV
	Wire; bare; metal spools; ~~uncartoned~~ <u>exposed</u>	Class I
	Wire; bare; metal spools; cartoned	Class II
	Wire; bare; plastic spools; cartoned	Class IV
	Wire; bare; plastic spools; ~~uncartoned~~ <u>exposed</u>	Group A Nonexpanded
	Wire; bare; wood or cardboard spools	Class II
Wood Products	Wood patterns	Class IV
	Wood products (e.g., fiberboard, lumber, particle board, plywood, pressboard with smooth ends and edges); bundled solid blocks	Class II
	Wood products (e.g., fiberboard, lumber, particle board, plywood, pressboard with smooth ends and edges); unbundled or non-solid blocks	Class III
	Wood products (e.g., toothpicks, clothespins and hangers)	Class III

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Fri Jul 14 15:37:38 EDT 2017

Committee Statement

Committee Statement: Editorial revision.

Response Message:

**Second Revision No. 1050-NFPA 13-2017 [Section No. A.20.5.3]****A.20.5.3**

Many factors affect the protection of rack storage. Section ~~20.5.7~~ 20.5.3 defined the variables that limit or change the available protection criteria found in Chapters 21 through ~~24~~ 25 . Paragraphs ~~20.5.7.1~~ through ~~20.5.7.2~~ 20.5.3.1 through 20.5.3.3 identify the general terms of rack storage that identify which type of rack and shelving criteria is to be used in Chapters 21 through ~~24~~ 25 .

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: National Fire Protection Assoc

Street Address:

City:

State:

Zip:

Submittal Date: Mon Oct 16 14:19:57 EDT 2017

Committee Statement

Committee Statement: Reference updates.

Response Message:



Second Revision No. 1038-NFPA 13-2017 [Detail]

A.25.4.9

[Move text and table to the beginning of existing A.20.4] Specification of the type, amount, and arrangement of combustibles for any commodity classification is essentially an attempt to define the potential fire severity, based on its burning characteristics, so the fire can be successfully controlled by the prescribed sprinkler protection for the commodity class. In actual storage situations, however, many storage arrays do not fit precisely into one of the fundamental classifications; therefore, the user needs to make judgments after comparing each classification to the existing storage conditions. Storage arrays consist of thousands of products, which makes it impossible to specify all the acceptable variations for any class. As an alternative, a variety of common products are classified in this annex based on judgment, loss experience, and fire test results.

Table A.25.4.9 A.20.4(a) provides examples of commodities not addressed by the classifications in Section 20.5. The commodities listed in Table A.25.4.9 A.20.4(a) are outside the scope of NFPA 13 protection.

Table A.20.3 A.20.4(a) includes lithium ion batteries. Lithium ion batteries have been a research project within the NFPA Research Foundation. As a result, the following reports have been published:

- (1) *Lithium Ion Batteries Hazard and Use Assessment*, published July 2011 and available at the NFPA Research Foundation web site.
- (2) *Flammability Characterization of Lithium-ion Batteries in Bulk Storage*, published March 2013 and available at www.fmglobal.com/researchreports.
- (3) *Lithium Ion Batteries Hazard and Use Assessment Phase IIB, Flammability Characterization of Lithium-ion Batteries for Storage Protection*, published April 2013 and available at the NFPA Research Foundation web site.
- (4) *~~Sprinkler Protection Criteria for Lithium Ion Batteries Stored in Cartons~~ Hazard and Use Assessment — Phase III*, published July November 2016 and available at the NFPA Research Foundation web site.

Table A.20.5 A.20.4(b) is an alphabetized list of commodities with corresponding classifications.

Table A.20.4.1, Table A.20.4.2, Table A.20.4.3, Table A.20.4.4, and Table A.20.4.5.1 provide examples of commodities within a specific class.

Table A.25.4.9 A.20.4(a) Examples of Commodities Not Addressed by Classifications in Section 5.6 20.4

Ammunition Components
- Bulk primers and powder
Batteries
- Lithium and other similar exotic metals
- Lithium-ion and other rechargeable batteries that contain combustible electrolyte
Boat Storage
- Stored on racks
Boxes, Crates
- Empty, wood slatted*
Carpet Rolls
Combustible Metals — unless specifically identified otherwise

Compressed or Liquefied Flammable Gases (i.e., filled propane cylinders) — unless specifically identified otherwise

Explosives

- Blasting primers and similar items

Fertilizers (nitrates)

Fireworks

- Consumer and display

Flammable and Combustible Liquids — unless specifically identified otherwise

- Liquids that contain greater than 20% alcohol

Hanging Garments, Bulk Storage

Lighters (butane)

- Loose in large containers (Level 3 aerosol)

Storage Container

- Large container storage of household goods

*Should be treated as idle pallets.

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: [Not Specified]

Street Address:

City:

State:

Zip:

Submittal Date: Wed Sep 27 11:52:16 EDT 2017

Committee Statement

Committee Statement: This annex was located in the wrong section relocate to A.20.4.

Response Message:



Second Revision No. 1035-NFPA 13-2017 [Chapter C]

Annex C Explanation of Test Data and Procedures for Rack Storage

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

C.1

Annex C provides an explanation of the test data and procedures that led to the development of sprinkler system discharge criteria for rack storage applications. Numbers in brackets refer to paragraphs in the text.

C.2 [5.6] [20.3]

A review of full-scale fire tests run on the standard commodity (double tri-wall carton with metal liner), of Hallmark products and 3M products (e.g., abrasives, pressure-sensitive tapes of plastic fiber, and paper), and of the considerable number of commodity tests conducted provides a guide for commodity classifications. Such guidance is not related to any other method of classification of materials; therefore, sound engineering judgment and analysis of the commodity and the packaging should be used when selecting a commodity classification.

C.3 [8.13.3.4] [25.3.5.1]

Tests 71, 73, 81, 83, 91, 92, 95, and 100 in the 20 ft (6.1 m) high array involving a single level of in-rack sprinklers were conducted without heat or water shields. Results were satisfactory.

Test 115 was conducted with two levels of sprinklers in racks with shields. Test 116, identical to Test 115 but without water shields, produced a lack of control. Visual observation of lower level in-rack sprinklers that did not operate although they were in the fire area indicated a need for water shields.

Tests 115 and 116 were conducted to investigate the necessity for water shields where multiple levels of in-rack sprinklers are installed. Where water shields were not installed in Test 116, the fire jumped the aisle, and approximately 76 boxes were damaged. In Test 115 with water shields, the fire did not jump the aisle, and only 32 boxes were damaged. Water shields are, therefore, suggested wherever multiple levels of in-rack sprinklers are installed, except for installations with horizontal barriers or shelves that serve as water shields.

C.4 [8.17.1.7] [25.1.3.3]

The time of operation of the first sprinkler varied from 52 seconds to 3 minutes and 55 seconds, with most tests under 3 minutes, except in Test 64 (Class III), where the first sprinkler operated in 7 minutes and 44 seconds. Fire detection more sensitive than waterflow is, therefore, considered necessary only in exceptional cases.

C.5 [8.17.5.4] [16.15.1 and 20.11.1]

In most tests conducted, it was necessary to use small hose for mop-up operations. Small hose was not used in the high-expansion foam test.

Test 97 was conducted to evaluate the effect of dry pipe sprinkler operation. Test results were approximately the same as the base test with a wet pipe system. A study of NFPA records, however, indicates an increase in area of operation of 30 percent to be in order for dry pipe systems as compared with wet pipe systems.

C.6 [12.1.1] [20.6.5]

Tests were conducted as a part of this program with eave line windows or louvers open to simulate smoke and heat venting. These tests opened 87.5 percent and 91 percent more sprinklers than did comparative tests without windows or louvers open. Venting tests that have been conducted in other programs were without the benefit of sprinkler protection and, as such, are not considered in this report, which covers only buildings protected by sprinklers. The design curves are based upon the absence of roof vents or draft curtains in the building. During mop-up operations, ventilating systems, where installed, should be capable of manual exhaust operations.

C.7 [12.12.1.3] [20.14.1.3]

No tests were conducted with idle pallets in racks using standard spray sprinklers. However, tests were conducted using ESFR and large drop sprinklers. Such storage conceivably would introduce fire severity in excess of that contemplated by protection criteria for an individual commodity classification.

C.8 ~~[12.8.6]~~ [20.12.2.6]

In all valid tests with double-row racks, sprinkler water supplies were shut off at approximately 60 minutes. In only one test did the last sprinkler operate in excess of 30 minutes after ignition; the last sprinkler operated in excess of 25 minutes in three tests, with the majority of tests involving the last sprinkler operating within 20 minutes.

C.9 ~~[16.1.1 and 17.1.1]~~ [25.2.1.1]

The discharge criteria of Section 42.3 20.10 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 × 250 ft (61 m × 76 m) [50,000 ft² (4650 m²) in area], of fire-resistive construction, and contains a volume of approximately 2.25 million ft³ (63,713 m³), the equivalent of a 100,000 ft² (9300 m²) building that is 22.5 ft (6.9 m) high. The test building has two primary heights beneath a single large ceiling. The east section is 30 ft (9.1 m) high, and the west section is 60 ft (18 m) high.

The test series for storage height of 20 ft (6.1 m) was conducted in the 30 ft (9.1 m) section with clearances from the top of storage to the ceiling nominally 10 ft (3.0 m).

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

The entire test series was fully instrumented with thermocouples attached to rack members, simulated building columns, bar joists, and the ceiling.

Racks were constructed of steel vertical and horizontal members designed for 4000 lb (1815 kg) loads. Vertical members were 8 ft (2.4 m) on center for conventional racks and 4 ft (1.2 m) on center for simulated automated racks. Racks were 3½ ft (1 m) wide with 6 in. (150 mm) longitudinal flue space for an overall width of 7½ ft (2.3 m). Simulated automated racks and slave pallets were used in the main central rack in the 4 ft (1.2 m) aisle tests. Conventional racks and conventional pallets were used in the main central rack in the 8 ft (2.4 m) aisle tests. The majority of the tests were conducted with 100 ft² (9.3 m²) sprinkler spacing.

The test configuration for storage heights of 15 ft (4.6 m), 20 ft (6.1 m), and 25 ft (7.6 m) covered an 1800 ft² (167.2 m²) floor area, including aisles between racks. Tests that were used in producing this standard limited fire damage to this area. The maximum water damage area anticipated in the standard is 6000 ft² (555 m²), the upper limit of the design curves.

The test data show that, as density is increased, both the extent of fire damage and sprinkler operation are reduced. The data also indicate that, with sprinklers installed in the racks, a reduction is gained in the area of fire damage and sprinkler operations (e.g., water damage).

Table C.9 illustrates these points. The information shown in the table is taken from the test series for storage height of 20 ft (6.1 m) using the standard commodity.

The fact that there is a reduction in both fire damage and area of water application as sprinkler densities are increased or where sprinklers are installed in racks should be considered carefully by those responsible for applying this standard to the rack storage situation.

In the test for storage height of 25 ft (7.6 m), a density of 0.55 gpm/ft² (22.4 mm/min) produced 42 percent, or 756 ft² (70 m²), fire damage in the test array and a sprinkler-wetted area of 1400 ft² (130 m²). Lesser densities would not be expected to achieve the same limited degree of control. Therefore, if the goal of smaller areas of fire damage is to be achieved, sprinklers in racks should be considered.

The test series for storage height over 25 ft (7.6 m) was conducted in the 60 ft (18 m) section of the test building with nominal clearances from the top of storage to the ceiling of either 30 ft (9.1 m) or 10 ft (3.0 m).

Doors at the lower and intermediate levels and ventilation louvers at the top of walls were kept closed during the fire tests, which minimized the effect of exterior wind conditions.

The purpose of the tests for storage height over 25 ft (7.6 m) was to accomplish the following:

- (1) Determine the arrangement of in-rack sprinklers that can be repeated as pile height increases and that provide control of the fire
- (2) Determine other protective arrangements, such as high-expansion foam, that provide control of the fire

Control was considered to have been accomplished if the fire was unlikely to spread from the rack of origin to adjacent racks or spread beyond the length of the 25 ft (7.6 m) test rack. To aid in this judgment, control was considered to have been achieved if the fire failed to exhibit the following characteristics:

- (1) Jump the 4 ft (1.2 m) aisles to adjoining racks
- (2) Reach the end face of the end stacks (north or south ends) of the main rack

Control is defined as holding the fire in check through the extinguishing system until the commodities initially involved are consumed or until the fire is extinguished by the extinguishing system or manual aid.

The standard commodity as selected in the 20 ft (6.1 m) test series was used in the majority of tests for storage over 25 ft (7.6 m). Hallmark products and 3M products described in the 20 ft (6.1 m) test series report also were used as representative of Class III or Class IV commodities, or both, in several tests. The results of privately sponsored tests on Hallmark products and plastic encapsulated standard commodities also were made available to the committee.

A 25 ft (7.6 m) long test array was used for the majority of the tests for storage over 25 ft (7.6 m). The decision to use such an array was made because it was believed that a fire in racks over 25 ft (7.6 m) high that extended the full length of a 50 ft (15 m) long rack could not be considered controlled, particularly as storage heights increased.

One of the purposes of the tests was to determine arrangements of in-rack sprinklers that can be repeated as pile height increases and that provide control of the fire. The tests for storage height of 30 ft (9.1 m) explored the effect of such arrays. Many of these tests, however, produced appreciable fire spread in storage in tiers above the top level of protection within the racks. (In some cases, a total burnout of the top tiers of both the main rack and the target rack occurred.) In the case of the 30 ft (9.1 m) Hallmark Test 134 on the 60 ft (18 m) site, the material in the top tiers of storage burned vigorously, and the fire jumped the aisle above the fourth tier. The fire then burned downward into the south end of the fourth tier. In the test on the floor, a nominal 30 ft (9.1 m) clearance occurred between the top of storage and the ceiling sprinklers, whereas on the platform this clearance was reduced to nominal 10 ft (3.0 m). In most cases, the in-rack sprinklers were effective in controlling fire below the top level of protection within the racks. It has been assumed by the Test Planning Committee that, in an actual case with a clearance of 10 ft (3.0 m) or less above storage, ceiling sprinklers would be expected to control damage above the top level of protection within the racks. Tests have been planned to investigate lesser clearances.

Tests 114 and 128 explore the effect of changing the ignition point from the in-rack standard ignition point to a face ignition location. It should be noted, however, that both of these tests were conducted with 30 ft (9.1 m) clearance from the ceiling sprinklers to the top of storage and, as such, ceiling sprinklers had little effect on the fire in the top two tiers of storage. Firespread in the three lower tiers is essentially the same. A similar change in the firespread where the ignition point is changed was noted in Tests 126 and 127. Once again, 30 ft (9.1 m) clearance occurred between the top of storage and the ceiling sprinklers, and, as such, the ceiling sprinklers had little effect on the face fire. Comparisons of Tests 129, 130, and 131 in the test series for storage height of 50 ft (15 m) indicate little effect of point of ignition in the particular configuration tested.

Test 125, when compared with Test 133, indicates no significant difference in result between approved low-profile sprinklers and standard sprinklers in the racks.

Table C.9 Summary of Relationship Between Sprinkler Discharge Density and the Extent of Fire Damage and Sprinkler Operation

<u>Density [gpm/ft² (Lpm/m²)]</u>	<u>Fire Damage in Test Array</u>		<u>Sprinkler Operation [165°F (74°C)] Area</u>
	<u>%</u>	<u>ft²(m²)</u>	<u>[ft² (m²)]</u>
0.30 (12.2) (ceiling only)	22	395 (37)	4500–4800 (418–446)
0.375 (15.2) (ceiling only)	17	306 (24)	1800 (167)
0.45 (18.3) (ceiling only)	9	162 (15)	700 (65)
0.20 (8.1) (ceiling only)	28–36	504–648 (46–60)	13,100–14,000 (1217–1300)
0.20 (8.1) (sprinklers at ceiling and in racks)	8	144 (13)	4100 (380)
0.30 (12.2) (sprinklers at ceiling and in racks)	7	126 (12)	700 (65)

For SI units, 1 ft = 0.3048 m; °C = $\frac{5}{9}(\text{°F} - 32)$; 1 gpm/ft² = 40.746 mm/min.

C.10 [16.1.4 and 17.1.4] [20.15]

Temperatures in the test column were maintained below 1000°F (538°C) with densities, of roof ceiling sprinklers only, of 0.375 gpm/ft² (15.3 mm/min) with 8 ft (2.4 m) aisles and 0.45 gpm/ft² (18.3 mm/min) with 4 ft (1.2 m) aisles using the standard commodity.

C.11 ~~[16.1.6.1 and 17.1.5.1]~~ [25.6.3.1]

Test 98 with solid shelves 24 ft (7.3 m) long and 7½ ft (2.3 m) deep at each level produced total destruction of the commodity in the main rack and jumped the aisle. Density was 0.3 gpm/ft² (12.2 mm/min) from the ceiling sprinklers only. Test 108 with shelves 24 ft (7.3 m) long and 3½ ft (1.0 m) deep and with a 6 in. (150 mm) longitudinal flue space and one level of sprinklers in the rack resulted in damage to most of the commodity in the main rack but did not jump the aisle. Density from ceiling sprinklers was 0.375 gpm/ft² (15.3 mm/min), and rack sprinklers discharged at 15 psi (1.0 bar).

These tests did not yield sufficient information to develop a comprehensive protection standard for solid shelf racks. Items such as increased ceiling density, use of bulkheads, other configurations of sprinklers in racks, and limitation of shelf length and depth should be considered.

Where such rack installations exist or are contemplated, the damage potential should be considered, and sound engineering judgment should be used in designing the protection system.

Test 98, with solid shelving obstructing both the longitudinal and transverse flue space, produced unsatisfactory results and indicates a need for sprinklers at each level in such a rack structure.

Test 147 was conducted with ceiling sprinklers only. Density was 0.45 gpm/ft² (18.3 mm/min) with a sprinkler spacing of 100 ft² (9.3 m²). A total of 47 sprinklers opened, and 83 percent of the commodity was consumed. The fire jumped both aisles and spread to both ends of the main and target racks. The test was considered unsuccessful.

Test 148 was conducted with ceiling sprinklers and in-rack sprinklers. In-rack sprinklers were provided at each level (top of first, second, and third tiers) and were located in the longitudinal flue. They were directly above each other and 24 ft (7.3 m) on center or 22 ft (6.7 m) on each side of the ignition flue. Ceiling sprinkler discharge density was 0.375 gpm/ft² (15.3 mm/min). In-rack sprinkler discharge pressure was 30 psi (2.1 bar). A total of 46 ceiling sprinklers and three in-rack sprinklers opened, and 34 percent of the commodity was consumed. The fire consumed most of the material between the in-rack sprinklers and jumped both aisles.

C.12 ~~[16.1.7 and 17.1.6]~~ [20.3.3]

Fire tests with open-top containers in the upper tier of storage and a portion of the third tier of storage produced an increase in sprinkler operation from 36 to 41 sprinklers and a more pronounced aisle jump and increase in firespread in the main array. The smooth underside of the containers closely approximates fire behavior of slave pallets.

C.13 ~~[16.1.10 and 17.1.9]~~ [20.5.8.4.1.1]

Test 80 was conducted to determine the effect of closing back-to-back longitudinal 6 in. (150 mm) flue spaces 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 kept open.

Tests 145 and 146 were conducted to investigate the influence of longitudinal and transverse flue dimensions in double-row racks without solid shelves. Results were compared with Tests 65 and 66. Flue dimensions in Tests 65, 66, 145, and 146 were 6 in. (150 mm), 6 in. (150 mm), 3 in. (75 mm), and 12 in. (300 mm), respectively. All other conditions were the same.

In Tests 65 and 66, 45, and 48, sprinklers operated compared with 59 and 58 for Tests 145 and 146, respectively. Fire damage in Tests 145 and 146 was somewhat less than in Tests 65 and 66; 2100 ft³ (59 m³) and 1800 ft³ (51 m³) in Tests 145 and 146, respectively, versus 2300 ft³ (65 m³) and 2300 ft³ (65 m³) in Tests 65 and 66, respectively, of combustible material were consumed.

Test results indicate narrow flue spaces of about 3 in. (75 mm) allow reasonable passage of sprinkler water down through the racks.

Tests 96 and 107, on multiple-row racks, used 6 in. (150 mm) transverse flue spaces. The water demand recommended in the standard is limited to those cases with nominal 6 in. (150 mm) transverse flues in vertical alignment.

C.14 [\[16.2.1.3.1\]](#) [\[21.4.1.1 and 25.2.3.2.3.1\]](#)

Tests 65 and 66, compared with Test 69, and Test 93, compared with Test 94, indicated a reduction in areas of application of 44.5 percent and 45.5 percent, respectively, with high temperature-rated sprinklers as compared with ordinary temperature-rated sprinklers. Other extensive Factory Mutual tests produced an average reduction of 40 percent. Design curves are based on this area reduction. In constructing the design curves, the high-temperature curves above 3600 ft² (335 m²) of application, therefore, represent 40 percent reductions in area of application of the ordinary temperature curves in the 6000 ft² to 10,000 ft² (555 m² to 930 m²) range.

Test 84 indicated the number of intermediate temperature-rated sprinklers operating is essentially the same as ordinary temperature-rated sprinklers.

C.15 [\[16.2.1.3.2.1\]](#) [\[21.4.1.2.1\]](#)

Tests were not conducted with aisles wider than 8 ft (2.4 m) or narrower than 4 ft (1.2 m). It is, therefore, not possible to determine whether lower ceiling densities should be used for aisle widths greater than 8 ft (2.4 m) or if higher densities should be used for aisle widths less than 4 ft (1.2 m).

C.16 [\[16.2.1.4.2.3\]](#) [\[25.4.2.1\]](#)

In one 20 ft (6.1 m) high test, sprinklers were buried in the flue space 1 ft (300 mm) above the bottom of the pallet load, and results were satisfactory. Coverage of aisles by in-rack sprinklers is, therefore, not necessary, and distribution across the tops of pallet loads at any level is not necessary for the occupancy classes tested.

C.17 [\[16.2.1.4.2.6\]](#) [\[25.5.1.6.1\]](#)

In all tests with in-rack sprinklers, obstructions measuring 3 in. × 3 ft (75 mm × 900 mm) were introduced on each side of the sprinkler approximately 3 in. (75 mm) from the sprinkler to simulate rack structure member obstruction. This obstruction had no effect on sprinkler performance in the 20 ft (6.1 m) high tests.

Tests 103, 104, 105, and 109 in the 30 ft (9.1 m) high test with in-rack sprinklers obstructed by rack uprights produced unsatisfactory results. Tests 113, 114, 115, 117, 118, and 120 in the 30 ft (9.1 m) high test series with in-rack sprinklers located a minimum of 2 ft (600 mm) from rack uprights produced improved results.

C.18 [\[16.2.1.4.3\]](#) [\[25.8.2.6\]](#)

In all except one case, using the standard commodity with one line of sprinklers installed in racks, only two sprinklers opened. In the one exception, two sprinklers opened in the main rack, and two sprinklers opened in the target rack.

C.19 [\[16.2.1.4.4, 16.3.2.7.10, 17.2.2.6.8\]](#) [\[25.12.3\]](#)

Operating pressures were 15 psi (1.0 bar) on all tests of sprinklers in racks with storage 20 ft (6.1 m) high and 30 psi (2.1 bar) for storage 30 ft (9.1 m) and 50 ft (15 m) high.

Tests 112 and 124 were conducted to compare the effect of increasing sprinkler discharge pressure at in-rack sprinklers from 30 psi to 75 psi (2.1 bar to 5.2 bar). With the higher discharge pressure, the fire did not jump the aisle, and damage below the top level of protection within the racks was somewhat better controlled by the higher discharge pressure of the in-rack sprinklers. A pressure of 15 psi (1 bar) was maintained on in-rack sprinklers in the first 30 ft (9.1 m) high tests (Tests 103 and 104). Pressure on in-rack sprinklers in subsequent tests was 30 psi (2.1 bar), except in Test 124, where it was 75 psi (5.2 bar).

C.20 [\[16.2.4.1.1, 17.2.4.1.1\]](#) [\[21.8.1.1 and 23.13.1\]](#)

A full-scale test program was conducted with various double-row rack storage arrangements of a cartoned Group A nonexpanded plastic commodity at the Factory Mutual Research Corporation (FMRC) test facility. The series of nine tests included several variations, one of which involved the use of the following four distinct shelving arrangements: slatted wood, solid wood, wire mesh, and no shelving. The results of the testing program, specifically Tests 1, 2, 3, and 5, clearly demonstrate the acceptable performance of sprinkler systems protecting storage configurations that involve the use of slatted shelving as described in [16.2.4.1.1](#) [21.8.1.1](#) and [17.2.4.1.1](#) [23.13.1](#). As a result of the test program, Factory Mutual has amended FM Loss Prevention Data Sheet 8-9 to allow slatted shelving to be protected in the same manner as an open rack arrangement.

Complete details of the test program are documented in the FMRC technical report FMRC J. I. 0X1R0.RR, "Large-Scale Fire Tests of Rack Storage Group A Plastics in Retail Operation Scenarios Protected by Extra Large Orifice (ELO) Sprinklers."

C.21 [17.4.2.1] [21.5.1]

In the RSP rack storage test series as well as the stored plastics program palletized test series, compartmented 16 oz (1.1 bar) polystyrene jars were found to produce significantly higher protection requirements than the same commodity in a nested configuration. Polystyrene glasses and expanded polystyrene plates were comparable to the nested jars.

Different storage configurations within cartons or different products of the same basic plastic might, therefore, require reduced protection requirements.

In Test RSP-7, with nominal 15 ft (4.6 m) high storage with compartmented jars, a 0.6 gpm/ft² (24.4 mm/min) density, 8 ft (2.4 m) aisles, and a 10 ft (3.0 m) clearance to ceiling, 29 sprinklers opened. In Tests RSP-4 with polystyrene glasses, RSP-5 with expanded polystyrene plates, and RSP-16 with nested polystyrene jars all stored at nominal 15 ft (4.6 m) height, 10 ft (3.1 m) clearance to ceiling, 8 ft (2.4 m) aisles, and 0.6 gpm/ft² (24.4 mm/min) density, only four sprinklers opened.

However, Test RSP-11, with expanded polystyrene plates and 6 ft (1.8 m) aisles, demonstrated an increase in the number of operating sprinklers to 29. Test RSP-10 with expanded polystyrene plates, nominally 15 ft (4.6 m) high with a 10 ft (3.1 m) clearance and 8 ft (2.4 m) aisles, but protected only by 0.45 gpm/ft² (18.3 mm/min) density, opened 46 sprinklers and burned 100 percent of the plastic commodity.

At a nominal 20 ft (6.1 m) storage height with 8 ft (2.4 m) aisles, a 3 ft (900 mm) clearance to ceiling, and a 0.6 gpm/ft² (24.4 mm/min) density opened four sprinklers with polystyrene glasses in Test RSP-2 and 11 sprinklers with expanded polystyrene plates in Test RSP-6. In Test RSP-8, however, with the clearance to ceiling increased to 10 ft (3.1 m) and other variables held constant, 51 sprinklers opened, and 100 percent of the plastic commodity burned.

Test RSP-3, with polystyrene glasses at a nominal height of 25 ft (7.6 m) with a 3 ft (900 mm) clearance to ceiling, 8 ft (2.4 m) aisles, and 0.6 gpm/ft² (24.4 mm/min) ceiling sprinkler density in combination with one level of in-rack sprinklers, resulted in four ceiling sprinklers and two in-rack sprinklers operating. Test RSP-9, with the same configuration but with polystyrene plates, opened 12 ceiling sprinklers and three in-rack sprinklers.

No tests were conducted with compartmented polystyrene jars at storage heights in excess of a nominal 15 ft (4.6 m) as a part of this program.

C.22 ~~[17.2.1.2]~~ [21.5]

The protection of Group A plastics by extra large orifice (ELO) sprinklers designed to provide 0.6 gpm/ft²/2000 ft² (24.4 mm/min/186 m²) or 0.45 gpm/ft²/2000 ft² (18.3 mm/min/186 m²) without the installation of in-rack sprinklers was developed from full-scale testing conducted with various double-row rack storage arrangements of a cartoned Group A nonexpanded plastic commodity at the Factory Mutual Research Corporation (FMRC) test facility. The results of this test program are documented in the FMRC technical report, FMRC J.I. 0X1R0.RR, "Large-Scale Fire Tests of Rack Stored Group A Plastics in Retail Operation Scenarios Protected by Extra Large Orifice (ELO) Sprinklers." The test program was initiated to address the fire protection issues presented by warehouse-type retail stores with regard to the display and storage of Group A plastic commodities including, but not limited to, acrylonitrile-butadiene-styrene copolymer (ABS) piping, polyvinyl chloride (PVC) hose and hose racks, tool boxes, polypropylene trash and storage containers, and patio furniture. Tests 1 and 2 of this series included protection of the Group A plastic commodity stored to 20 ft (6.1 m) under a 27 ft (8.2 m) ceiling by a design density of 0.6 gpm/ft² (24.4 mm/min) utilizing ELO sprinklers. The results of the testing program clearly demonstrate the acceptable performance of sprinkler systems that protect storage configurations involving Group A plastics up to 20 ft (6.1 m) in height under a 27 ft (8.2 m) ceiling where using ELO sprinklers to deliver a design density of 0.6 gpm/ft² (24.4 mm/min) and Group A plastics up to 14 ft (4.2 m) in height under a 22 ft (6.7 m) ceiling where using ELO sprinklers to deliver a design density of 0.45 gpm/ft² (18.3 mm/min). The tabulation of the pertinent tests shown in Table C.22 demonstrates acceptable performance.

Table C.22 Summary of Test Results for Plastic Commodities Using $\frac{5}{8}$ in. (15.9 mm) Orifice Sprinklers

<u>Test Parameters</u>	<u>Date of Test</u>						
	<u>8/20/93</u>	<u>8/25/93</u>	<u>9/2/93</u>	<u>10/7/93</u>	<u>2/17/94</u>	<u>2/25/94</u>	<u>4/27/94</u>
Type of shelving	Slatted wood	Slatted wood	Slatted wood	Slatted wood	Slatted wood	Slatted wood	Wire mesh
Other conditions/ inclusions	—	—	—	—	Draft curtains	Draft curtains	—
Storage height (ft-in.)	19-11	19-11	15-4	15-4	19-11	19-11	13-11
Number of tiers	6 ^a	6 ^a	5 ^b	5 ^b	6 ^a	6 ^b	3
Clearance to ceiling/sprinklers (ft-in.)	6-10/6-3	6-10/6-3	11-5/10-10	11-5/10-10	6-10/6-3	6-10/6-3	8-4/7-9
Longitudinal/ transverse flues (in.)	6/6 to 7½	6/6 to 7½	6/6 to 7	6/6 to 7½	6/6 to 7½	6/6 to 7½	6/3 ^c
Aisle width (ft)	7½	7½	7½	7½	7½	7½	7½
Ignition centered below (number of sprinklers)	2	2	1	1	2	2	1
Sprinkler orifice size (in.)	0.64	0.64	0.64	0.64	0.64	0.64	0.64
Sprinkler temperature rating (°F)	165	286	286	165	165	286	286
Sprinkler RTI (ft-sec) ^{1/2}	300	300	300	300	300	300	300
Sprinkler spacing (ft× ft)	8 × 10	8 × 10	8 × 10	8 × 10	8 × 10	8 × 10	10 × 10
Sprinkler identification	ELO-231	ELO-231	ELO-231	ELO-231	ELO-231	ELO-231	ELO-231
Constant water pressure (psi)	19	19	19	19	19	19	15.5
Minimum density (gpm/ft ²)	0.6	0.6	0.6	0.6	0.6	0.6	0.45
Test Results							
First sprinkler operation (min:sec)	2:03	2:25	1:12	0:44	1:25	0:52	0:49
Last sprinkler operation (min:sec)	2:12	15:19	6:34	7:34	15:54	14:08	10:58
Total sprinklers opened	4	9	7	13	35	18	12

<u>Test Parameters</u>	<u>Date of Test</u>						
	<u>8/20/93</u>	<u>8/25/93</u>	<u>9/2/93</u>	<u>10/7/93</u>	<u>2/17/94</u>	<u>2/25/94</u>	<u>4/27/94</u>
Total sprinkler discharge (gpm)	205	450	363	613	1651	945	600
Average discharge per sprinkler (gpm)	51	50	52	47	47	52	50
Peak/maximum 1-min average gas temperature (°F)	1107/566	1412/868	965/308	662/184	1575/883	1162/767	1464/895
Peak/maximum 1-min average steel temperature (°F)	185/172	197/196	233/232	146/145	226/225	255/254	502/500
Peak/maximum 1-min average plume velocity (ft/sec)	27/15	25/18	18/15 ^d	14/10 ^d	26/23	20/18 ^d	33/20
Peak/maximum 1-min heat flux (Btu/ft ² /sec)	0.6/0.5	2.0/1.9	2.8/2.5	1.1/0.8	1.0/0.9	4.8/3.0	1.6/1.4
Aisle jump, east/west target ignition (min:sec)	None	8:24/None	5:35/10:10	None	None	^e 8:18	^e /None
Equivalent number of pallet loads consumed	3	9	6	5	12	13	12
Test duration (min)	30	30	30	30	30	30	30
Results acceptable	Yes	Yes	Yes	Yes	No ^f	No ^g	Yes

For SI units, 1 ft = 0.305 m; 1 in. = 25.4 mm; °F = (1.8 × °C) + 32; °C = (°F - 32)/1.8; 1 psi = 0.069 bar; 1 gpm = 3.8 L/min; 1 ft/sec = 0.31 m/sec; 1 gpm/ft² = 40.746 mm/min.

^a Main (ignition) racks divided into five or six tiers; bottom tiers each approximately 2 ft (600 mm) high and upper tiers each about 5 ft (1.5 m) high; wood shelving below commodity at second through fifth tiers.

^b Main (ignition) racks divided into five or six tiers; bottom tiers each approximately 2 ft (600 mm) high and upper tiers each about 5 ft (1.5 m) high; wood shelving below commodity at second through fifth tiers; wire mesh shelving below commodity at sixth tier or below fifth (top) tier commodity.

^c Transverse flues spaced 8 ft (2.4 m) apart [versus 3½ ft (1.1 m) apart in all other tests].

^d Instrumentation located 5 ft (1.5 m) north of ignition.

^e Minor surface damage to cartons.

^f High water demand.

^g Excessive firespread; marginally high water demand.

C.23 [16.3.1.1] [25.9.2.1, 25.9.2.2, 25.9.2.3]

The recommended use of ordinary temperature-rated sprinklers at ceiling for storage higher than 25 ft (7.6 m) was determined by the results of fire test data. A test with high temperature-rated sprinklers and 0.45 gpm/ft² (18.3 mm/min) density resulted in fire damage in the two top tiers just within acceptable limits, with three ceiling sprinklers operating. A test with 0.45 gpm/ft² (18.3 mm/min) density and ordinary temperature-rated sprinklers produced a dramatic reduction in fire damage with four ceiling sprinklers operating.

The four ordinary temperature-rated ceiling sprinklers operated before the first of the three high temperature-rated ceiling sprinklers. In both tests, two in-rack sprinklers at two levels operated at approximately the same time. The high temperature-rated sprinklers were at all times fighting a larger fire with less water than the ordinary temperature-rated ceiling sprinklers.

Tests 115 and 119 compare ceiling sprinkler density of 0.3 gpm/ft² (12.2 mm/min) with 0.45 gpm/ft² (18.3 mm/min). Damage patterns coupled with the number of boxes damaged in the main rack suggest that the increase in density produces improved control, particularly in the area above the top tier of in-rack sprinklers.

Tests 119 and 122 compare ceiling sprinkler temperature ratings of 286°F (141°C) and 165°F (74°C). A review of the number of boxes damaged and the firespread patterns indicates that the use of ordinary temperature-rated ceiling sprinklers on a rack configuration that incorporates in-rack sprinklers dramatically reduces the amount of firespread. Considering that in-rack sprinklers in the tests for storage over 25 ft (7.6 m) operated prior to ceiling sprinklers, it would seem that the installation of in-rack sprinklers converts an otherwise rapidly developing fire, from the standpoint of ceiling sprinklers, to a slower developing fire with a lower rate of heat release.

In the 20 ft (6.1 m) high test series, ceiling sprinklers operated before in-rack sprinklers. In the 30 ft (9.1 m) high series, ceiling sprinklers operated after in-rack sprinklers. The 50 ft (15 m) high test did not operate ceiling sprinklers. Ceiling sprinklers would, however, be needed if fire occurred in upper levels.

The results of these tests indicate the effect of in-rack sprinklers on storage higher than 25 ft (7.6 m). From the ceiling sprinkler operation standpoint, a fire with an expected high heat release rate was converted to a fire with a much lower heat release rate.

Since the fires developed slowly and opened sprinklers at two levels in the racks, only a few ceiling sprinklers were needed to establish control. Thus, the sprinkler operating area does not vary with height for storage over 25 ft (7.6 m) or for changes in sprinkler temperature rating and density.

All tests with sprinklers in racks were conducted using nominal ½ in. (15 mm) orifice size sprinklers of ordinary temperature.

C.24 [21.12]

[20.6] A series of fire tests were conducted by Spacesaver Corporation that indicated control was achieved with light hazard sprinkler spacing and design. The tests used quick-response, ordinary-temperature sprinklers on 15 ft × 15 ft (4.6 m × 4.6 m) spacing with an 8 ft (2.4 m) high compact storage unit located in the middle of the sprinkler array. Results indicated a classic definition of control, the fire was held in check within the compact storage module and the fire did not jump the aisle or ignite any of the target arrays.

C.25 [\[21.11.6\]](#)

[20.5] In July and August of 2007, a series of three large-scale fire tests were conducted at Southwest Research Institute to investigate the effectiveness of a specific ceiling and in-rack sprinkler protection scheme dedicated for the protection of paper files in 12 in. (300 mm) wide, and 16 in. (400 mm) and 10 in. (250 mm) high corrugated cardboard boxes (containers) maintained in multiple-row racks to a nominal height of 37 ft (11 m).

The storage rack for the main array in all three tests consisted of two 50 in. (1.3 m) deep racks placed back-to-back and separated by a 2 in. (50 mm) gap. The storage rack for the target array in all three tests consisted of a single 50 in. (1.3 m) deep rack separated on both sides of the main array by a 30 in. (750 mm) wide aisle. Rack uprights were a nominal 3 in. (75 mm) wide. Rack bays were 120 in. (3.0 m) wide, 38 in. (950 mm) high, and equipped with perforated metal decking having a minimum of 50 percent openings. Each storage bay was provided with 9 containers between uprights that was 3 containers deep and 3 containers high for a total of 81 containers per rack bay. Nominal 6 in. (150 mm) wide transverse flue spaces were provided at each rack upright. Both the main array and the target array were 4 bays long for an overall length of 41 ft 3 in. (12.6 m).

Open-grated (expanded) catwalks were provided in both storage aisles at the top of the third [9 ft 8 in. (2.9 m)], sixth [19 ft 2 in. (5.8 m)], and ninth [28 ft 8 in. (8.7 m)] tier levels.

The ceiling sprinkler system consisted of K-8.0 (115), 165°F (74°C) nominally rated, standard-response pendent automatic sprinklers installed on 10 ft × 10 ft (3.0 m × 3.0 m) spacing arranged to provide a constant 0.30 gpm/ft² (12.2 mm/min) density. A nominal 3 ft (900 mm) clearance was provided between the top of storage and the ceiling sprinklers.

The in-rack sprinkler system consisted of K-8.0 (115), 165°F (74°C) nominally rated, quick-response upright automatic sprinklers that were equipped with water shields and arranged to provide a constant 30 gpm (115 L/min) flow from each operating in-rack sprinkler. In-rack sprinklers were provided within the transverse flue spaces of the main array, 2 ft (600 mm) horizontally from the face of the rack, at the top of the third and ninth tier levels on one side of the main array and at the top of the sixth tier level on the other side of the main array. A minimum 6 in. (150 mm) vertical clearance was provided between the in-rack sprinkler and the top of storage within the storage rack.

The same type of sprinklers installed within the storage racks were also installed under each catwalk and designed to provide a constant 30 gpm (115 L/min) flow from each operating sprinkler. These sprinklers were centered within the aisles and installed 10 ft 3 in. (3.1 m) on line. They were arranged to be aligned with the adjacent transverse flue space when the flue space was not equipped with an in-rack sprinkler; they were positioned halfway between transverse flue spaces when the adjacent flue spaces were equipped with in-rack sprinklers.

In Test No. 1, ignition was at grade level, at the face of the rack and centered between rack uprights. The in-rack sprinklers within the transverse flue spaces nearest to the ignition location were at the top of the sixth tier level; the sprinkler under the catwalk at the top of the sixth tier level was located a horizontal distance of 15 in. (375 mm) away from the ignition location. The sprinkler under the catwalk at the top of the sixth tier level was the first sprinkler to operate at a time 2 minutes and 49 seconds after ignition. A total of 3 in-rack sprinklers and 1 catwalk sprinkler operated during this test; no ceiling-level sprinklers operated. The results of the test were considered acceptable.

In Test No. 2, ignition was at grade level at a rack upright, 2 ft (600 mm) horizontally from the rack face. The in-rack sprinkler within the transverse flue space of fire origin was at the top of the sixth tier level. The in-rack sprinkler directly over the ignition location was the first sprinkler to operate at a time 2 minutes and 9 seconds after ignition. A total of 2 in-rack sprinklers operated during this test; no ceiling-level sprinklers operated. The results of the test were considered acceptable.

In Test No. 3, ignition was at grade level, centered between rack uprights within the 2 in. (50 mm) gap. To allow vertical fire growth directly above the point of ignition, the gap was maintained open throughout the height of the storage rack. A total of 4 in-rack sprinklers and 1 sprinkler under a catwalk operated during the test; no ceiling-level sprinklers operated. The first in-rack sprinkler to operate was located at the top of the sixth tier level at a time 3 minutes and 1 second after ignition. The second in-rack sprinkler to operate was also at the top of the sixth tier level. The last 2 in-rack sprinklers to operate were both located at the top of the third tier level. The fifth and final sprinkler to operate was a sprinkler located under a catwalk at the top of the third tier level. The results of the test were considered acceptable.

All three tests were considered successful and confirmed that the ceiling and in-rack sprinkler protection scheme outlined in this standard for the protection of cartoned records storage maintained in multiple-row racks with catwalk access is acceptable.

C.26 [16.1.10.3, 16.1.11.1.2, 17.1.9.3, 17.1.10.1.2] [20.5.8.4.2.2]

During full-scale fire tests, flue space width and alignment are typically set with care for test consistency and repeatability. Some full-scale fire tests and fire experience have shown sprinkler protection designed and installed in accordance with this standard are able to tolerate random variations in flue width and vertical flue alignment. For example, see Test 7 in the National Quick Response Sprinkler Research Project: Large-Scale Fire Evaluation of Early Suppression Quick Fast -Response (ESFR) Automatic Sprinklers (report available from the NFPA Research Foundation web site). For Test 7, transverse flue variations were substantial such that some flues at various tiers were completely closed (i.e., pallet loads placed immediately adjacent to each other), and the vertical alignment of one transverse flue was completely disrupted. The result was the operation of eight K14 (K200) ESFR sprinklers as well as minor aisle jump to both target racks. Reported damage was 2½ pallet loads in the main rack array and ¼ pallet load in the large racks. Findings such as Test 7 support the toleration of flue variations in the real world. However, ideally pallet loads should be positioned in racks with care to reduce the challenge faced by sprinklers should a fire occur.

Submitter Information Verification**Submitter Full Name:** AUT-SSD**Organization:** National Fire Protection Assoc**Street Address:****City:****State:****Zip:****Submittal Date:** Tue Aug 22 13:51:24 EDT 2017**Committee Statement****Committee Statement:** Editorial.**Response Message:**



Second Revision No. 1024-NFPA 13-2017 [Chapter D]

Annex D Sprinkler System Information from the 2012 2018 Edition of the *Life Safety Code*

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

D.1 Introduction.

This annex is provided as an aid to the user of NFPA 13 by identifying those portions of the 2012 edition of NFPA 101 that pertain to sprinkler system design and installation. It is not intended that this annex provide complete information regarding all aspects of fire protection addressed by NFPA 101. It is important to note that this information was copied from NFPA 101 but did not use NFPA's extract policy and is not intended to be a part of the requirements of NFPA 13.

D.1.1

The following sections cover situations where NFPA 101 provides different guidance on the design or installation of a fire sprinkler system from NFPA 13. In some cases, this different guidance is based on descriptions of unique situations handled by NFPA 101. In other cases, this different guidance stems from the different objective for NFPA 101, life safety of the occupant, rather than the property protection afforded by NFPA 13.

D.1.1.1 Features of Fire Protection.

D.1.1.1.1 Atriums.

Glass walls and inoperable windows shall be permitted in lieu of the fire barriers where all the following are met:

- (1) Automatic sprinklers are spaced along both sides of the glass wall and the inoperable windows at intervals not to exceed 6 ft (1830 mm).
- (2) The automatic sprinklers specified in 8.6.7(1)(c)(i) of NFPA 101 are located at a distance from the glass wall not to exceed 12 in. (305 mm) and arranged so that the entire surface of the glass is wet upon operation of the sprinklers.
- (3) The glass wall is of tempered, wired, or laminated glass held in place by a gasket system that allows the glass framing system to deflect without breaking (loading) the glass before the sprinklers operate.
- (4) The automatic sprinklers required by 8.6.7(1)(c)(i) of NFPA 101 are not required on the atrium side of the glass wall and the inoperable window where there is no walkway or other floor area on the atrium side above the main floor level. [**101:8.6.7(1)(c)**]

D.1.1.2 Special Structures and High-Rise Buildings.

D.1.1.2.1

High-rise buildings shall be protected throughout by an approved, supervised automatic sprinkler system in accordance with NFPA 101, Section 9.7. A sprinkler control valve and a waterflow device shall be provided for each floor. [**101:11.8.3.1**]

D.1.1.3 Lodging or Rooming Houses.

D.1.1.3.1

In buildings sprinklered in accordance with NFPA 13, closets that contain equipment such as washers, dryers, furnaces, or water heaters shall be sprinklered regardless of size. [**101:26.3.6.3.5** 26.3.6.2.5]

D.1.1.3.2

In existing lodging or rooming houses, sprinkler installations shall not be required in closets not exceeding 24 ft² (2.2 m²) and in bathrooms not exceeding 55 ft² (5.1 m²). [**101:26.3.6.3.6** 26.3.6.2.6]

D.1.1.4 New Hotels and Dormitories.

D.1.1.4.1

The provisions for draft stops and closely spaced sprinklers in NFPA 13 shall not be required for openings complying with NFPA 101, 8.6.9.1, where the opening is within the guest room or guest suite. [101:28.3.5.4]

D.1.1.4.2

Listed quick-response or listed residential sprinklers shall be used throughout guest rooms and guest room suites. [101:28.3.5.6]

D.1.1.5 Existing Hotels and Dormitories.**D.1.1.5.1**

In guest rooms and in guest room suites, sprinkler installations shall not be required in closets not exceeding 24 ft² (2.2 m²) and in bathrooms not exceeding 55 ft² (5.1 m²). [101:29.3.5.5]

D.1.1.6 New Apartment Buildings.**D.1.1.6.1**

In buildings sprinklered in accordance with NFPA 13, :

- (1) ~~closets~~ Closets less than 12 ft² (1.1 m²) ~~in area~~ in individual dwelling units shall not be required to be sprinklered.
- (2) Closets that contain equipment such as washers, dryers, furnaces, or water heaters shall be sprinklered regardless of size.

[101:30.3.5.3]

D.1.1.6.2

Listed quick-response or listed residential sprinklers shall be used throughout all dwelling units. [101:30.3.5.5 30.3.5.6]

D.1.1.6.3

The draft stop and closely spaced sprinkler requirements of NFPA 13 shall not be required for convenience openings complying with NFPA 101, 8.6.9.1, where the convenience opening is within the dwelling unit. [101:30.3.5.4 30.3.5.5]

D.1.1.7 Existing Apartment Buildings.**D.1.1.7.1**

In individual dwelling units, sprinkler installation shall not be required in closets not exceeding 24 ft² (2.2 m²) and in bathrooms not exceeding 55 ft² (5.1 m²). Closets that contain equipment such as washers, dryers, furnaces, or water heaters shall be sprinklered regardless of size. [101:31.3.5.3]

D.1.1.7.2

In buildings sprinklered in accordance with NFPA 13, bathrooms not greater than 55 ft² (5.1 m²) in individual dwelling units shall not be required to be sprinklered. [101 : 31.3.5.4]

D.1.1.7.3

The draft stop and closely spaced sprinkler requirements of NFPA 13 shall not be required for convenience openings complying with NFPA 101, 8.6.9.1, where the convenience opening is within the dwelling unit. [101:31.3.5.4 31.3.5.5]

D.1.1.8 Existing Residential Board and Care Occupancies.**D.1.1.8.1**

Standard-response sprinklers shall be permitted for use in hazardous areas in accordance with NFPA 101, 33.2.3.2. [101:33.2.2.2.4]

D.1.1.8.2

Where an automatic sprinkler system is installed, for either total or partial building coverage, all of the following requirements shall be met:

- (1) The system shall be in accordance with NFPA 101, Section 9.7, and shall initiate the fire alarm system in accordance with 33.2.3.4.1, as modified by 33.2.3.5.3.1 through 33.2.3.5.3.6 of NFPA 101.
- (2) The adequacy of the water supply shall be documented to the authority having jurisdiction.

[101:33.2.3.5.3]

D.1.1.8.2.1

In prompt evacuation capability facilities, all of the following shall apply:

- (1) An automatic sprinkler system in accordance with NFPA 13D shall be permitted.
- (2) Automatic sprinklers shall not be required in closets not exceeding 24 ft² (2.2 m²) and in bathrooms not exceeding 55 ft² (5.1 m²), provided that such spaces are finished with lath and plaster or materials providing a 15-minute thermal barrier.

[101:33.2.3.5.3.1]

D.1.1.8.2.2

In slow and impractical evacuation capability facilities, all of the following shall apply:

- (1) An automatic sprinkler system in accordance with NFPA 13D with a 30-minute water supply, shall be permitted.
- (2) All habitable areas and closets shall be sprinklered.
- (3) Automatic sprinklers shall not be required in bathrooms not exceeding 55 ft² (5.1 m²), provided that such spaces ~~ster~~ are finished with lath and plaster or materials providing a 15-minute thermal barrier.

[101:33.2.3.5.3.2]

D.1.1.8.2.3

In prompt and slow evacuation capability facilities, where an automatic sprinkler system is in accordance with NFPA 13, sprinklers shall not be required in closets not exceeding 24 ft² (2.2 m²) and in bathrooms not exceeding 55 ft² (5.1 m²), provided that such spaces are finished with lath and plaster or materials providing a 15-minute thermal barrier. [101:33.2.3.5.3.3]

D.1.1.8.2.4

In prompt and slow evacuation capability facilities in buildings four or fewer stories above grade plane, systems in accordance with NFPA 13R shall be permitted. [101:33.2.3.5.3.4]

D.1.1.8.2.5

In impractical evacuation capability facilities in buildings four or fewer stories above grade plane, systems in accordance with NFPA 13R shall be permitted. All habitable areas and closets shall be sprinklered.

Automatic sprinklers shall not be required in bathrooms not exceeding 55 ft² (5.1 m²), provided that such spaces are finished with lath and plaster or materials providing a 15-minute thermal barrier.

[101:33.2.3.5.3.5]

D.1.1.8.2.6

Initiation of the fire alarm system shall not be required for existing installations in accordance with NFPA 101, 33.2.3.5.6. [101:33.2.3.5.3.6]

D.1.1.8.2.7

All impractical evacuation capability facilities shall be protected throughout by an approved, supervised automatic sprinkler system in accordance with NFPA 101, 33.2.3.5.3. [101:33.2.3.5.3.7]

D.1.1.9 New Mercantile Occupancies.

D.1.1.9.1 Protection of Vertical Openings.

Any vertical opening shall be protected in accordance with NFPA 101, Section 8.6, except under the following conditions:

- (1) In Class A or Class B mercantile occupancies protected throughout by an approved, supervised automatic sprinkler system in accordance with NFPA 101, 9.7.1.1(1), unprotected vertical openings shall be permitted at one of the following locations:
 - (a) Between any two floors
 - (b) Among the street floor, the first adjacent floor below, and adjacent floor (or mezzanine) above
- (2) In Class C mercantile occupancies, unprotected openings shall be permitted between the street floor and the mezzanine.
- (3) The draft stop and closely spaced sprinkler requirements of NFPA 13 shall not be required for unenclosed vertical openings permitted in NFPA 101, 36.3.1(1) and (2).

[101:36.3.1]

D.1.1.9.2

Rooms housing building service equipment, janitor closets, and service elevators shall be permitted to open directly onto exit passageways, provided that all of the following criteria are met:

- (1) The required fire resistance rating between such rooms or areas and the exit passageway shall be maintained in accordance with NFPA 101, 7.1.3.2.
- (2) Such rooms or areas shall be protected by an approved, supervised automatic sprinkler system in accordance with NFPA 101, 9.7.1.1(1), but the exceptions in NFPA 13 allowing the omission of sprinklers from such rooms shall not be permitted.

[101:36.4.4.6.2 36.4.4.9.2]

D.1.1.10 Existing Mercantile Occupancies.**D.1.1.10.1** Protection of Vertical Openings.

Any vertical opening shall be protected in accordance with NFPA 101, Section 8.6, except under any of the following conditions:

- (1) In Class A or Class B mercantile occupancies protected throughout by an approved, supervised automatic sprinkler system in accordance with NFPA 101, 9.7.1.1(1), unprotected vertical openings shall be permitted at one of the following locations:
 - (a) Between any two floors
 - (b) Among the street floor, the first adjacent floor below, and the adjacent floor (or mezzanine) above
- (2) In Class C mercantile occupancies, unprotected openings shall be permitted between the street floor and the mezzanine.
- (3) The draft stop and closely spaced sprinkler requirements of NFPA 13 shall not be required for unenclosed vertical openings permitted in NFPA 101, ~~37.3.1(1)~~ 36.3.1(1) and (2).

[101:37.3.1]

D.1.1.10.2

Rooms housing building service equipment, janitor closets, and service elevators shall be permitted to open directly onto exit passageways, provided that all of the following criteria are met:

- (1) The required fire resistance rating between such rooms or areas and the exit passageway shall be maintained in accordance with NFPA 101, 7.1.3.2.
- (2) Such rooms or areas shall be protected by an approved automatic sprinkler system in accordance with NFPA 101, 9.7.1.1(1) but the exceptions in NFPA 13 allowing the omission of sprinklers from such rooms shall not be permitted.

[101:37.4.4.6.2 37.4.4.9.2]

D.1.1.11 Industrial Occupancies.

D.1.1.11.1 Special Provisions — High-Rise Buildings.

The provisions of NFPA 101, 11.8.5.2.4(2) 11.8.5.3.4(2) for jockey pumps and NFPA 101, 11.8.5.2.4(3) 11.8.5.3.4(3) for air compressors serving dry-pipe and preaction systems shall not apply to special-purpose industrial occupancies. [101:40.4.1 40.4.2.2]

D.2 Life Safety Code.**D.2.1 Features of Fire Protection.****D.2.1.1 Design Requirements. (Reserved)****D.2.1.2 Installation Requirements.****D.2.1.2.1 Atriums.**

Glass walls and inoperable windows shall be permitted in lieu of the fire barriers where all the following are met:

- (1) Automatic sprinklers are spaced along both sides of the glass wall and the inoperable windows at intervals not to exceed 6 ft (1830 mm).
- (2) The automatic sprinklers specified in NFPA 101, 8.6.7(1)(c)(i) are located at a distance from the glass wall not to exceed 12 in. (305 mm) and arranged so that the entire surface of the glass is wet upon operation of the sprinklers.
- (3) The glass wall is of tempered, wired, or laminated glass held in place by a gasket system that allows the glass framing system to deflect without breaking (loading) the glass before the sprinklers operate.
- (4) The automatic sprinklers required by NFPA 101, 8.6.7(1)(c)(i) are not required on the atrium side of the glass wall and the inoperable window where there is no walkway or other floor area on the atrium side above the main floor level. [101:8.6.7(1)(c)]

D.2.2 Special Structures and High-Rise Buildings.**D.2.2.1 Design Criteria.****D.2.2.1.1**

High-rise buildings shall be protected throughout by an approved, supervised automatic sprinkler system in accordance with NFPA 101, Section 9.7. A sprinkler control valve and a waterflow device shall be provided for each floor. [101:11.8.3.1]

D.2.3 New Assembly Occupancies.**D.2.3.1 Design Criteria.****D.2.3.1.1 Protection of Vertical Openings.**

Any vertical opening shall be enclosed or protected in accordance with Section 8.6 of NFPA 101, unless otherwise permitted by one of the following:

- (1) Stairs or ramps shall be permitted to be unenclosed between balconies or mezzanines and main assembly areas located below, provided that the balcony or mezzanine is open to the main assembly area.
- (2) Exit access stairs from lighting and access catwalks, galleries, and gridirons shall not be required to be enclosed.
- (3) Assembly occupancies protected by an approved, supervised automatic sprinkler system in accordance with Section 9.7 of NFPA 101 shall be permitted to have unprotected vertical openings between any two adjacent floors, provided that such openings are separated from unprotected vertical openings serving other floors by a barrier complying with 8.6.5 of NFPA 101.
- (4) Assembly occupancies protected by an approved, supervised automatic sprinkler system in accordance with Section 9.7 of NFPA 101 shall be permitted to have convenience stair openings in accordance with 8.6.9.2 of NFPA 101.

[101:12.3.1]

D.2.3.2 Installation Requirements. (Reserved)**D.2.4 Existing Assembly Occupancies.****D.2.4.1 Design Criteria.**

D.2.4.1.1 Protection of Vertical Openings.

Any vertical opening shall be enclosed or protected in accordance with NFPA 101, Section 8.6, unless otherwise permitted by one of the following:

- (1) Stairs or ramps shall be permitted to be unenclosed between balconies or mezzanines and main assembly areas located below, provided that the balcony or mezzanine is open to the main assembly area.
- (2) Exit access stairs from lighting and access catwalks, galleries, and gridirons shall not be required to be enclosed.
- (3) Assembly occupancies protected by an approved, supervised automatic sprinkler system in accordance with NFPA 101, Section 9.7, shall be permitted to have unprotected vertical openings between any two adjacent floors, provided that such openings are separated from unprotected vertical openings serving other floors by a barrier complying with NFPA 101, 8.6.5.
- (4) Assembly occupancies protected by an approved, supervised automatic sprinkler system in accordance with NFPA 101, Section 9.7, shall be permitted to have convenience stair openings in accordance with NFPA 101, 8.6.9.2.

[101:13.3.1]

D.2.4.2 Installation Requirements. (Reserved)

D.2.5 New Educational Occupancies. (Reserved)

D.2.6 Existing Educational Occupancies. (Reserved)

D.2.7 New Day-Care Occupancies. (Reserved)

D.2.8 Existing Day-Care Occupancies. (Reserved)

D.2.9 New Health Care Occupancies. (Reserved)

D.2.10 Existing Health Care Occupancies. (Reserved)

D.2.11 New Ambulatory Health Care Occupancies. (Reserved)

D.2.12 Existing Ambulatory Health Care Occupancies. (Reserved)

D.2.13 New Detention and Correctional Occupancies. (Reserved)

D.2.14 Existing Detention and Correctional Occupancies. (Reserved)

D.2.15 One- and Two-Family Dwellings. (Reserved)

D.2.16 Lodging or Rooming Houses.

D.2.16.1 Design Requirements. (Reserved)

D.2.16.2 Installation Requirements.

D.2.16.2.1

In buildings sprinklered in accordance with NFPA 13 closets that contain equipment such as washers, dryers, furnaces, or water heaters shall be sprinklered, regardless of size. [~~101:26.3.6.3.5~~ 26.3.6.2.5]

D.2.16.2.2

In existing lodging or rooming houses, sprinkler installations shall not be required in closets not exceeding 24 ft² (2.2 m²) and in bathrooms not exceeding 55 ft² (5.1 m²). [~~101:26.3.6.3.6~~ 26.3.6.2.6]

D.2.17 New Hotels and Dormitories.

D.2.17.1 Design Requirements. (Reserved)

D.2.17.2 Installation Requirements.

D.2.17.2.1

The provisions for draft stops and closely spaced sprinklers in NFPA 13 shall not be required for openings complying with NFPA 101, 8.6.9.1, where the opening is within the guest room or guest suite.

[~~101:28.3.5.4~~]

D.2.17.2.2

Listed quick-response or listed residential sprinklers shall be used throughout guest rooms and guest room suites. [101:28.3.5.6]

D.2.18 Existing Hotels and Dormitories.**D.2.18.1 Design Requirements. (Reserved)****D.2.18.2 Installation Requirements.****D.2.18.2.1**

In guest rooms and in guest room suites, sprinkler installations shall not be required in closets not exceeding 24 ft² (2.2 m²) and in bathrooms not exceeding 55 ft² (5.1 m²). [101:29.3.5.5]

D.2.19 New Apartment Buildings.**D.2.19.1 Design Requirements. (Reserved)****D.2.19.2 Installation Requirements.****D.2.19.2.1**

In buildings sprinklered in accordance with NFPA 13:

- (1) ~~closets~~ Closets less than 12 ft² (1.1 m²) ~~in area~~ in individual dwelling units shall not be required to be sprinklered.
- (2) Closets that contain equipment such as washers, dryers, furnaces, or water heaters shall be sprinklered regardless of size.

[101:30.3.5.3]

D.2.19.2.2

Listed quick-response or listed residential sprinklers shall be used throughout all dwelling units.

~~[101:30.3.5.5]~~ 30.3.5.6]

D.2.19.2.3

The draft stop and closely spaced sprinkler requirements of NFPA 13 shall not be required for convenience openings complying with NFPA 101, 8.6.9.1, where the convenience opening is within the dwelling unit. ~~[101:30.3.5.4]~~ 30.3.5.5]

D.2.20 Existing Apartment Buildings.**D.2.20.1 Design Requirements. (Reserved)****D.2.20.2 Installation Requirements.****D.2.20.2.1**

In individual dwelling units, sprinkler installation shall not be required in closets not exceeding 24 ft² (2.2 m²) and in bathrooms not exceeding 55 ft² (5.1 m²). Closets that contain equipment such as washers, dryers, furnaces, or water heaters shall be sprinklered, regardless of size. [101:31.3.5.3]

D.2.20.2.2

The draft stop and closely spaced sprinkler requirements of NFPA 13 shall not be required for convenience openings complying with NFPA 101, 8.6.9.1, where the convenience opening is within the dwelling unit. ~~[101:31.3.5.4]~~ 31.3.5.5]

D.2.21 New Residential Board and Care Occupancies. (Reserved)**D.2.22 Existing Residential Board and Care Occupancies.****D.2.22.1 Design Requirements. (Reserved)****D.2.22.2 Installation Requirements.****D.2.22.2.1**

Standard-response sprinklers shall be permitted for use in hazardous areas in accordance with NFPA 101, 33.2.3.2. [101:33.2.2.2.4]

D.2.22.2.2

In prompt and slow evacuation facilities, where an automatic sprinkler system is in accordance with NFPA 13 sprinklers shall not be required in closets not exceeding 24 ft² (2.2 m²) and in bathrooms not exceeding 55 ft² (5.1 m²), provided that such spaces are finished with lath and plaster or materials providing a 15-minute thermal barrier. [101:33.2.3.5.3.3]

D.2.23 New Mercantile Occupancies.**D.2.23.1 Design Requirements. (Reserved)****D.2.23.2 Installation Requirements.****D.2.23.2.1 Protection of Vertical Openings.**

Any vertical opening shall be protected in accordance with NFPA 101, Section 8.6, except under any of the following conditions:

- (1) In Class A or Class B mercantile occupancies protected throughout by an approved, supervised automatic sprinkler system in accordance with NFPA 101, 9.7.1.1(1), unprotected vertical openings shall be permitted at one of the following locations:
 - (a) Between any two floors
 - (b) Among the street floor, the first adjacent floor below, and adjacent floor (or mezzanine) above
- (2) In Class C mercantile occupancies, unprotected openings shall be permitted between the street floor and the mezzanine.
- (3) The draft stop and closely spaced sprinkler requirements of NFPA 13 shall not be required for unenclosed vertical openings permitted in NFPA 101, 36.3.1(1) and (2).

[101:36.3.1]

D.2.23.2.2

Rooms housing building service equipment, janitor closets, and service elevators shall be permitted to open directly onto exit passageways, provided that all of the following criteria are met:

- (1) The required fire resistance rating between such rooms or areas and the exit passageway shall be maintained in accordance with NFPA 101, 7.1.3.2.
- (2) Such rooms or areas shall be protected by an approved, supervised automatic sprinkler system in accordance with NFPA 101, 9.7.1.1(1) but the exceptions in NFPA 13 allowing the omission of sprinklers from such rooms shall not be permitted.

[101:36.4.4.6.2 36.4.4.9.2]

D.2.24 Existing Mercantile Occupancies.**D.2.24.1 Design Requirements. (Reserved)****D.2.24.2 Installation Requirements.****D.2.24.2.1 Protection of Vertical Openings.**

Any vertical opening shall be protected in accordance with NFPA 101, Section 8.6, except under any of the following conditions:

- (1) In Class A or Class B mercantile occupancies protected throughout by an approved, supervised automatic sprinkler system in accordance with NFPA 101, 9.7.1.1(1), unprotected vertical openings shall be permitted at one of the following locations:
 - (a) Between any two floors
 - (b) Among the street floor, the first adjacent floor below, and the adjacent floor (or mezzanine) above
- (2) In Class C mercantile occupancies, unprotected openings shall be permitted between the street floor and the mezzanine.
- (3) The draft stop and closely spaced sprinkler requirements of NFPA 13 shall not be required for unenclosed vertical openings permitted in NFPA 101, ~~37.3.1(1)~~ 36.3.1(1) and (2). [101:37.3.1]

D.2.24.2.2

Rooms housing building service equipment, janitor closets, and service elevators shall be permitted to open directly onto exit passageways, provided that all of the following criteria are met:

- (1) The required fire resistance rating between such rooms or areas and the exit passageway shall be maintained in accordance with NFPA 101, 7.1.3.2.
- (2) Such rooms or areas shall be protected by an approved, supervised automatic sprinkler system in accordance with NFPA 101, 9.7.1.1(1), but the exceptions in NFPA 13 allowing the omission of sprinklers from such rooms shall not be permitted.

[~~101:37.4.4.6.2~~ 37.4.4.9.2]

D.2.25 New Business Occupancies.**D.2.25.1** Design Requirements. (Reserved)**D.2.25.2** Installation Requirements. (Reserved)**D.2.26** Existing Business Occupancies.**D.2.26.1** Design Requirements. (Reserved)**D.2.26.2** Installation Requirements. (Reserved)**D.2.27** Industrial Occupancies. (Reserved)**D.2.27.1** Design Criteria.**D.2.27.1.1** Special Provisions — High-Rise Buildings.

The provisions of NFPA 101, ~~11.8.5.2.4(2)~~ 11.8.5.3.4(2) , for jockey pumps and NFPA 101, ~~11.8.5.2.4(3)~~ 11.8.5.3.4(3) , for air compressors serving dry-pipe and pre-action systems shall not apply to special-purpose industrial occupancies. [~~101:40.4.1~~ 40.2.2]

D.2.28 Storage Occupancies. (Reserved)**Supplemental Information**

<u>File Name</u>	<u>Description</u> <u>Approved</u>
Annex_D_Sprinkler_System_Information_from_the.docx	For staff use.

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: National Fire Protection Assoc

Street Address:

City:

State:

Zip:

Submittal Date: Wed Aug 16 10:39:15 EDT 2017

Committee Statement

Committee Statement: Updates extract information from the 2015 edition of the life Safety Code.

Response Message:

**Second Revision No. 1023-NFPA 13-2017 [Section No. F.3]****F.3 References for Extracts in Informational Sections.**

NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*, 2016 edition.

NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*, 2019 edition.

NFPA 33, *Standard for Spray Application Using Flammable or Combustible Materials*, 2018 edition.

NFPA 36, *Standard for Solvent Extraction Plants*, 2017 edition.

NFPA 37, *Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines*, 2018 edition.

NFPA 40, *Standard for the Storage and Handling of Cellulose Nitrate Film*, 2019 edition.

NFPA 75, *Standard for the Fire Protection of Information Technology Equipment*, 2017 edition.

NFPA 82, *Standard on Incinerators and Waste and Linen Handling Systems and Equipment*, 2014 edition.

NFPA 86, *Standard for Ovens and Furnaces*, 2019 edition.

NFPA 99, *Health Care Facilities Code*, 2018 edition.

NFPA 99B, *Standard for Hypobaric Facilities*, 2018 edition.

NFPA 101[®], *Life Safety Code*[®], 2018 edition.

NFPA 120, *Standard for Fire Prevention and Control in Coal Mines*, 2015 edition.

NFPA 122, *Standard for Fire Prevention and Control in Metal/Nonmetal Mining and Metal Mineral Processing Facilities*, 2015 edition.

NFPA 140, *Standard on Motion Picture and Television Production Studio Soundstages, Approved Production Facilities, and Production Locations*, 2018 edition.

NFPA 214, *Standard on Water-Cooling Towers*, 2016 edition.

NFPA 307, *Standard for the Construction and Fire Protection of Marine Terminals, Piers, and Wharves*, 2016 edition.

NFPA 318, *Standard for the Protection of Semiconductor Fabrication Facilities*, 2018 edition.

NFPA 415, *Standard on Airport Terminal Buildings, Fueling Ramp Drainage, and Loading Walkways*, 2016 edition.

NFPA 423, *Standard for Construction and Protection of Aircraft Engine Test Facilities*, 2016 edition.

NFPA 804, *Standard for Fire Protection for Advanced Light Water Reactor Electric Generating Plants*, 2015 edition.

NFPA 909, *Code for the Protection of Cultural Resource Properties — Museums, Libraries, and Places of Worship*, 2017 edition.

Submitter Information Verification

Submitter Full Name: AUT-SSD

Organization: National Fire Protection Assoc

Street Address:

City:

State:

Zip:

Submittal Date: Sat Aug 12 17:50:10 EDT 2017

Committee Statement

Committee Statement: NFPA 120 is not referenced in the annex and therefore has been deleted per MOS.

Response Message: