**ROLLED NONWOVEN FABRIC STORAGE**

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## 1.0 SCOPE

This data sheet provides fire protection guidelines for indoor storage of various types of rolled nonwoven fabrics stored solid-piled or palletized; on end or on side and on-rack; or on end or on side.

### 1.1 Changes

January 2015. Completely revised the document to be technically consistent with other data sheets. Removed references to obsolete data sheets and terminology.

Major changes include the following:

1. Incorporated Sections 2.2.1, 2.2.2, and 2.2.3. Section 2.2.1 provides appropriate references to other standards, while Sections 2.2.2 and 2.2.3 provide general guidance for ceiling and in-rack sprinkler protection, respectively.

2. Replaced the terms “control mode density area (CMDA) sprinkler,” “control mode specific application (CMSA) sprinkler,” and “suppression mode sprinkler” with the term “storage sprinkler.” The term “large-drop” sprinkler has been replaced with K11.2 (K160) upright sprinkler where applicable. This terminology is consistent with other FM Global storage data sheets.

## 2.0 LOSS PREVENTION RECOMMENDATIONS

### 2.1 Construction and Location

#### 2.1.1 Building Construction

2.1.1.1 Construct storage facilities in accordance with the relevant FM property loss prevention data sheets, including the 1-series data sheets.

2.1.1.2 Adhere to the recommendations in the applicable occupancy - specific data sheet to ensure the construction features of the facility are compatible with the Storage sprinkler being used.

2.1.1.3 Properly anchor the rack storage structures to prevent them from falling over and, in turn, causing nearby racks to fall over (i.e., creating a “domino” effect).

2.1.1.4 Take into consideration the effects of rack loads, the additional load created by the collection or absorption of fire protection water by the stored commodity, the weight of in-rack sprinkler piping filled with water, the effect of natural hazards, and any other loads the structure may be exposed to. Natural hazards include: wind, snow, rain, hail, and seismic conditions (see Data Sheet 1-2, *Earthquakes*).

#### 2.1.2 Steel Protection

2.1.2.1 When sprinkler systems are installed in accordance with this data sheet, fire protection of roof steel is unnecessary.

2.1.2.2 Provide protection for steel building columns located wholly or partially within storage arrays. A sidewall sprinkler at a 15 ft (4.6 m) elevation, pointed toward one side of the steel column, discharging 30 gpm (115 L/min is adequate.

#### 2.1.3 False Ceilings

2.1.3.1 If necessary to achieve appropriate clearance over the top of the storage, install a false ceiling over the storage with sprinklers installed below the ceiling. Provide sprinkler protection at roof level if the roof or ceiling is combustible. Ensure false ceilings are of substantial construction, capable of withstanding temperatures above 1000°F (538°C) for up to 10 minutes and uplift velocity pressures of at least 3 lb/ft$^2$ (0.14 kPa). Materials suitable for such a purpose include ⅜ in. (9.5 cm) plywood, ⅜ in. (9.5 cm) gypsum board, corrugated or sheet steel, or mineral tile. Sheets of these materials can be mechanically fastened to the underside of existing framework or supported on framework from above or below. If the false ceiling is hung from existing roof framework, verify that the roof framework can support the ceiling and additional automatic sprinkler piping.

2.1.3.2 If the false ceiling is partial, extend it at least 10 ft (3 m) beyond any storage and add a row of sprinklers 2 to 3 ft (0.6 to 1 m) inside the edge (storage side of edge) of the false ceiling.

### 2.1.4 Ventilation

FM recommended protection assumes roof vents and draft curtains are not provided. Fire tests have not shown automatic vents to be cost effective; they may even increase sprinkler water demand. Therefore, permanent heat and smoke vents, if any, should be arranged for manual operation. Smoke removal during mop-up operations can usually be achieved through eaveline windows, doors, monitors, nonautomatic exhaust systems (gravity or mechanical) or manually operated heat and smoke vents. Fire service personnel can cut holes in steel or wood roofs and can also use their smoke exhausters.

### 2.1.5 Water Damage Protection

2.1.5.1 Provide skids, pallets, trenches, floor drains or other suitable means to minimize water damage.

### 2.1.6 Allowable Loads

2.1.6.1 Design upper floors used for rolled nonwoven fabric storage to hold possible additional weight from rolled nonwoven fabric water absorption that will vary between types of fabrics. Higher absorption may be anticipated with longer sprinkler discharge durations and inadequate drainage or skidding. However, neither total absorption nor the confinement of a large depth of water are likely.

## 2.2 Protection

### 2.2.1 General

2.2.1.1 Base protection for locations having mixed storage or several different storage arrangements on the greater storage hazard.

2.2.1.2 When determining the fire protection options for a storage facility, consider all the protection options the water supply can support. This approach will help maximize operational flexibility when considering potential future commodity changes and/or storage arrangements.

2.2.1.3 See Section 2.2.3 for ceiling-level sprinklers, Section 2.2.4 for in-rack sprinkler guidance, Section 2.2.5 for design guidelines related to highloft nonwovens, and Sections 2.2.6 and 2.2.7 for design guidelines related to nonwoven fabrics.

2.2.1.4 Regardless of the sprinkler system protection option chosen, it is imperative to coordinate a facility's construction, occupancy, and protection details in the planning stages so they are all compatible. It is critical that no objects between the top of storage and the ceiling-level sprinklers interfere with the sprinkler's proper discharge pattern. See Data Sheet 2-0, *Installation Guidelines for Automatic Sprinklers,* for guidelines related to obstructions of Storage sprinklers.

2.2.1.5 In addition to the recommendations in this data sheet, follow the sprinkler installation guidelines for Storage sprinklers in Data Sheet 2-0, *Installation Guidelines for Automatic Sprinklers.*

2.2.1.6 For facilities located in earthquake-prone regions, refer to Data Sheet 2-8, *Earthquake Protection for Water-Based Fire Protection Systems.*

2.2.1.7 See Data Sheet 3-0, *Hydraulics of Fire Protection Systems,* to determine how to calculate the sprinkler system designs offered in this data sheet.

### 2.2.2 Sprinkler System Types

2.2.2.1 Ceiling-level sprinkler systems designed for at least 15 sprinklers or 1500 $ft^2$ (140 $m^2$) can be wet-pipe or pre-action. In-rack sprinkler systems can be wet-pipe or pre-action. Pre-action sprinkler systems must be single-interlocked and arranged as outlined in Data Sheet 2-0, *Installation Guidelines for Automatic Sprinklers*, to be the equivalent of a wet-pipe system for design purposes. Note, however, that grid-type piping configurations are only recommended for wet-pipe sprinkler systems. Only wet-pipe sprinkler system types are recommended for protecting nonwoven with sprinkler designs less than 15 sprinklers or 1,500 $ft^2$.

2.2.2.2 Do not use dry-pipe sprinkler systems for the protection of rolled nonwoven fabric storage.

2.2.2.3 See Data Sheet 2-0, *Installation Guidelines for Automatic Sprinklers,* for additional guidelines related to the installation of all sprinkler system types.

2.2.2.4 See Data Sheet 5-48, *Automatic Fire Detection,* for guidelines related to the installation of detection devices for single-interlocked pre-action type sprinkler systems.

### 2.2.3 Ceiling-Level Storage Sprinklers

2.2.3.1 Use only FM Approved sprinklers for storage occupancy hazards listed in the *Approval Guide,* an online resource of FM Approvals. These are listed under the heading of Storage Sprinklers (Ceiling-Level).

2.2.3.2 Currently, FM Approved ceiling-level Storage sprinklers have K-factor values ranging from 11.2 (160) to 25.2 (360). The units for K-factor values given throughout this section are gpm/psi$^{0.5}$ (Lpm/bar$^{0.5}$).

2.2.3.3 The minimum operating pressure for any ceiling-level Storage sprinkler is 7 psi (0.5 bar).

2.2.3.4 Extend the hydraulic design for storage occupancies at least 15 ft (4.5 m) beyond all edges of the storage, or to a wall, whenever there is mixed-use occupancy. Whenever two adjacent storage occupancies are protected differently, extend the design for the higher hazard 15 ft (4.5 m) into the lower-hazard area.

2.2.3.5 Do not interpolate the values in Tables 1-4 for intermediate storage heights.

### 2.2.4 In-Rack Sprinklers (IRAS)

2.2.4.1 Protection options for rack storage arrangements are based on ceiling-only sprinkler systems, or a combination of ceiling-level and in-rack sprinkler systems. When in-rack sprinklers are needed, they can be used in combination with any of the ceiling sprinklers listed in Table 2 or 3.

2.2.4.2 When in-rack sprinklers are needed as a supplement to ceiling-level sprinklers, as outlined in Tables 3 and 4, use FM Approved in-rack sprinklers listed in the *Approval Guide,* an online resource of FM Approvals, under the heading of Storage Sprinklers (In-Racks).

2.2.4.3 Use nominally rated 160°F (70°C), FM Approved in-rack sprinklers for all in-rack sprinkler installations.

2.2.4.4 Use in-rack sprinklers listed as quick-response when installing K14.0 (K200) or smaller sprinklers. In-rack sprinklers with larger K-factor values can be either quick-response or standard-response.

2.2.4.5 Ensure the storage height above the top level of in-rack sprinklers is no more than 10 ft (3.0 m).

2.2.4.6 Balance the ceiling-level sprinkler system water demand with the in-rack sprinkler system water demand at the point where the two systems are connected.

2.2.4.7 Apply the following guidelines for positioning IRAS:

2.2.4.7.1 Locate all in-rack sprinklers within the rack storage array. In-rack sprinklers may be located outside the rack storage structure of a single-row rack that is located within 12 in. (300 mm) horizontally of a wall. Ensure the in-rack sprinklers are no more than 6 in. (150 mm) horizontally away from the rack structure as well as no more than 3 in. (75 mm) offset from the transverse flue space intersection they are intended to protect; be sure to position the in-rack sprinklers so they are not directly behind rack uprights.

2.2.4.7.2 At each tier level where in-rack sprinklers are needed, position the in-rack sprinkler deflector at or just below the bottom of the rack's horizontal support member when it is under full load conditions.

2.2.4.7.3 Arrange sprinkler piping and in-rack sprinklers to avoid mechanical damage, but ensure proper distribution from the in-rack sprinkler can be achieved. Prior to installing in-rack sprinklers, check the proposed in-rack sprinkler locations to ensure both adequate protection against mechanical damage and proper sprinkler discharge are provided.

2.2.4.7.4 When installed in combination with a horizontal barrier, in-rack sprinklers do not have to be positioned relative to the proximity of the transverse flue spaces unless there is less than 6 in. (150 mm) clearance between the top of storage and deflector of the in-rack sprinkler.

### 2.2.5 Highloft Nonwoven Fabric

2.2.5.1 In addition to the guidance provided in 2.2.3, use 280°F (140°C) nominally rated sprinklers at ceiling level.

2.2.5.2 Store fiberfill, highloft, and batting in a one-hour-rated cutoff area with ceiling protection capable of providing 0.60 gpm/ft$^2$ (24 mm/min) over the entire area. Alternatively, store fiberfill, highloft, and batting using one of the following options:

- In a low-value sprinklered or unsprinklered detached building.
- In 500 $ft^2$ (46 $m^2$) piles separated by 20 ft (6.1 m) in all directions. Limit storage height to 10 ft (3 m) with a maximum ceiling height of 30 ft (9.1 m) and ceiling protection capable of 0.60 gpm/$ft^2$ (24 mm/min) over 3000 $ft^2$ (280 $m^2$).
- In 500 $ft^2$ (46 $m^2$) piles separated by 20 ft (6.1 m) in all directions. Limit storage height to 5 ft (1.5 m) with a maximum ceiling height of 30 ft (9.1 m) and ceiling protection capable of 0.30 gpm/$ft^2$ (12 mm/min) over 2000 $ft^2$ (185 $m^2$).

### 2.2.6 Nonwoven Fabric Stored on Floor

2.2.6.1 In addition to the guidance provided in 2.2.3, use Table 1 to determine the sprinkler design for various storage heights. Note that standard-response, high-temperature sprinklers are recommended. On-floor/on-end arrangements have continuous flue spaces that have the potential to produce very strong fire plumes that can overpower quick-response sprinklers.

2.2.6.2 Water demand for rolled nonwoven fabrics wrapped in plastic is the same as for rolls not wrapped in plastic.

*Table 1. Ceiling-Level Protection Guidelines for On-Floor Storage of Rolled Nonwoven Fabric*

| *Storage Configuration: Floor, On-End, Closed or Standard Array.*<br>*Maximum Ceiling Height: 30 ft (9.1 m).* | | | | |
|---|---|---|---|---|
| Maximum Storage Height ft (m) | Pendent or Upright Sprinklers, Standard Response, 280°F (140°C)<br>No. of AS @ psi (bar) | | | |
| | **K11.2 (K160)** | **K14.0 (K200)** | **K16.8 (K240)** | **K25.2 (K360)** |
| 5 (1.5) | 20 @ 7 (0.5) | 20 @ 7 (0.5) | 20 @ 7 (0.5) | 20 @ 7 (0.5) |
| 10 (3.0) | 15 @ 75 (5.2) | 15 @ 48 (3.3) | 15 @ 33 (2.3) | 15 @ 15 (1.0) |
| 16 (4.9) | 20 @ 75 (5.2) | 20 @ 48 (3.3) | 20 @ 33 (2.3) | 20 @ 15 (1.0) |
| 20 (6.1) | 25 @ 75 (5.2) | 25 @ 48 (3.3) | 25 @ 33 (2.3) | 25 @ 15 (1.0) |
| Hose stream: 250 gpm (950 L/min)<br>Water supply duration: 2 hours | | | | |
| Rolls of nonwoven fabric either 1) enclosed, including both ends, in corrugated cardboard carton, or 2) wrapped, including both ends, with at least four layers of 40 lb/1000 $ft^2$ (19.6 kg/100 $m^2$) of heavy kraft paper, may be protected as unexpanded plastic per Data Sheet 8-9, *Storage of Class 1, 2, 3, 4 and Plastic Commodities*. | | | | |

### 2.2.7 Nonwoven Fabric Stored In Racks or Palletized

2.2.7.1 In addition to the guidance in Section 2.2.3 and Section 2.2.4, use Tables 2, 3, and 4 to determine the sprinkler design for various storage arrangements and storage heights.

2.2.7.2 Water demand for rolled nonwoven fabrics wrapped in plastic is the same for rolls not wrapped in plastic.

2.2.7.3 Apply Table 2 when using quick response Storage sprinklers that have a nominal temperature rating of 160°F (70°C). Use K14.0 (K200) and larger sprinklers, pendent, standard-coverage.

2.2.7.3.1 Apply Table 2 to rolled nonwovens made with polypropylene, rayon, and polyethylene. Do not use these guidelines for fiberfill, highloft and batting, or nonwovens such as dry-laid pulp.

*Table 2. Ceiling-Level Protection Guidelines for In-Rack or Palletized Storage of Rolled Nonwoven Fabric, Using Quick Response Storage Sprinklers*

| *Storage Configuration: In-Rack (On-Side or One-End) or Palletized.<br>Banding: Banded or Unbanded.<br>Maximum Ceiling Height: 40 ft (12.2 m).* | | | | |
|---|---|---|---|---|
| Maximum Storage Height ft (m) | Wet-pipe, Pendent Sprinklers, Quick Response, 160°F (70°C) No. of AS @ psi (bar) | | | |
| | **K14.0 (K200)** | **K16.8 (K240)** | **K22.4 (320)** | **K25.2 (K360)** |
| 35 (10.7) | 12 @ 75(5.2) | 12 @ 52 (3.6) | 12 @ 45 (3.1) | 12 @ 40 (2.8) |
| Hose Stream: 250 gpm (950 L/min)<br>Water Supply Duration: 1 hour | | | | |

2.2.7.4 Storage on Axial Rods

2.2.7.4.1 Limit storage height to 10 ft (3 m) or less. Store rolls as close together as possible in at least one direction to reduce flue space and minimize reradiation.

2.2.7.5 Apply Tables 3 and 4 when using standard response Storage sprinklers having a nominal temperature rating of 286°F (140°C). Use K 11.2 (K160) and larger, standard-coverage sprinklers.

*Table 3. Protection Guidelines for Double-Row Rack Storage of Rolled Nonwoven Fabric Using Standard Response Storage Sprinklers*

| *Approx. Height of Storage On End or On Side, ft (m)* | *Minimum Ceiling Density, gpm/ft² (mm/min)* | *Recommended In-Rack Sprinkler Protection* |
|---|---|---|
| 10 (3.0) | 0.3 (12) | 1. Install three lines of sprinklers over top of storage (flue & face), staggered.<br>2. Design for eight sprinklers, four sprinklers on each of the two most hydraulically remote sprinkler lines.<br>3. See Figure 1. |
| | | OR:<br>1. Install two lines of sprinklers over top of storage (face), staggered.<br>2. Design for eight sprinklers, four sprinklers on each of the two most hydraulically remote sprinkler lines.<br>3. Provide barrier within 5 ft (1.5 m) of top of storage.<br>4. See Figure 1a. |
| | 0.15 (6) | 1. Install three lines of sprinklers over top of storage (flue & face) staggered.<br>2. Design for eight sprinklers, four sprinklers on each of the two most hydraulically remote sprinkler lines.<br>3. Provide barrier within 5 ft (1.5 m) of top of storage.<br>4. See Figure 1b. |
| 11 to 15 (3.4 to 4.6) | 0.45 (18) | 1. Install one level of in-rack sprinklers, including flue and face sprinklers (three lines) staggered, at approximately ½ to ⅔ height of storage.<br>2. Design for eight sprinklers, four sprinklers on each of the two most hydraulically remote in-rack sprinkler lines.<br>3. See Figure 2. |
| | | OR:<br>1. Install a barrier at approximately the 10 ft (3 m) level.<br>2. Install one level (2 lines) of in-rack sprinklers (face) beneath the barrier, staggered.<br>3. Design for eight sprinklers, four sprinklers on each of the two most hydraulically remote in-rack sprinkler lines.<br>4. See Figure 2a. |
| | 0.15 (6) | 1. Install a barrier at approximately the 10 ft (3 m) level and also at approximately the 15 ft (4.6 m) level.<br>2. Install two lines of in-rack sprinklers (face), staggered, beneath the lower barrier; and three lines of in-rack sprinklers (face and flue), staggered beneath the top barrier.<br>3. Design for eight sprinklers, four sprinklers on each of the most hydraulically remote in-rack sprinkler lines.<br>4. See Figure 2b. |

*Table 3. Protection Guidelines for Double-Row Rack Storage of Rolled Nonwoven Fabric (continued)*

| *Approx. Height of Storage On End or On Side, ft (m)* | *Minimum Ceiling Density, gpm/ft$^2$ (mm/min)* | *Recommended In-Rack Sprinkler Protection* |
|---|---|---|
| 16 to 20 (4.9 to 6.1) | 0.60 (24) | 1. Install one level of in-rack sprinklers, including flue and face sprinklers (3 lines) staggered, at approximately mid-height of storage.<br>2. Design for eight sprinklers, four sprinklers on each of the two most hydraulically remote sprinkler lines.<br>3. See Figure 3. |
| | | OR:<br>1. Install a barrier at approximately the 10 ft (3 m) level.<br>2. Install two lines of in-rack sprinklers (face) beneath the barrier, staggered.<br>3. Design for eight sprinklers, four sprinklers on each of the two most hydraulically remote in-rack sprinkler lines.<br>4. See Figure 3a. |
| | 0.15 (6) | 1. Install a barrier at approximately the 10 ft (3 m) level and also at approximately the 20 ft (6.1 m) level.<br>2. Install two lines of in-rack sprinklers (face), staggered, beneath the lower barrier; and three lines of in-rack sprinklers (face and flue), staggered, beneath the top barrier.<br>3. Design for eight sprinklers, four sprinklers on each of the two most hydraulically remote sprinkler lines.<br>4. See Figure 3b. |
| | | OR:<br>1. Install a barrier at approximately the 20 ft (6.1 m) level with three lines of in-rack sprinklers (face and flue), staggered, beneath the barrier.<br>2. Install three lines of in-rack sprinklers (face and flue), staggered, at approximately the 10 ft (3 m) level.<br>3. Design for eight sprinklers, four sprinklers on each of the two most hydraulically remote in-rack sprinkler lines.<br>4. See Figure 3c. |

*Table 3. Protection Guidelines for Double-Row Rack Storage of Rolled Nonwoven Fabric (continued)*

| *Approx. Height of Storage On End or On Side, ft (m)* | *Minimum Ceiling Density, gpm/ft$^2$ (mm/min)* | *Recommended In-Rack Sprinkler Protection* |
|---|---|---|
| Over 20 (6.1) | 0.60 (24) | 1. Install three lines of in-rack sprinklers at each approximately 10 ft (3 m) level (face and flue), except for the top-most 10 ft (3 m) of storage, staggered.<br>2. Design for 14 sprinklers, seven sprinklers on each of the two most hydraulically remote in-rack sprinkler lines.<br>3. See Figure 4 Arrangement A or B. |
| | 0.45 (18) | 1. Install three lines of in-rack sprinklers at each approximately 10 ft (3 m) level (face & flue) except for the top most 5 ft (1.5 m) of storage, staggered.<br>2. Design for 14 sprinklers, seven sprinklers on each of the two most hydraulically remote in-rack sprinkler lines.<br>3. See Figure 5, Arrangement A or B. |
| | 0.15 (6) | 1. Install three lines of in-rack sprinklers at each approximately 10 ft (3 m) level (face and flue), staggered.<br>2. Install a barrier over and within 5 ft (1.5 m) of the top-most level of storage.<br>3. Install three lines of in-rack sprinklers beneath the barrier (face and flue), staggered.<br>4. Design for 14 sprinklers, seven sprinklers on each of the two most hydraulically remote in-rack sprinkler lines.<br>5. See Figure 6, Arrangement A or B |
| | | OR:<br>1. Install a barrier at each approximately 10 ft (3 m) level.<br>2. Install two lines of in-rack sprinklers (face) staggered beneath each barrier, except for the top-most barrier.<br>3. Install three lines of in-rack sprinklers (face and flue) staggered, beneath the top-most barrier.<br>4. Design for 14 sprinklers, seven sprinklers on each of the two most hydraulically remote in-rack sprinkler lines.<br>5. See Figure 7. |

*ADDITIONAL GENERAL RECOMMENDATIONS—Tables 3 and 4*

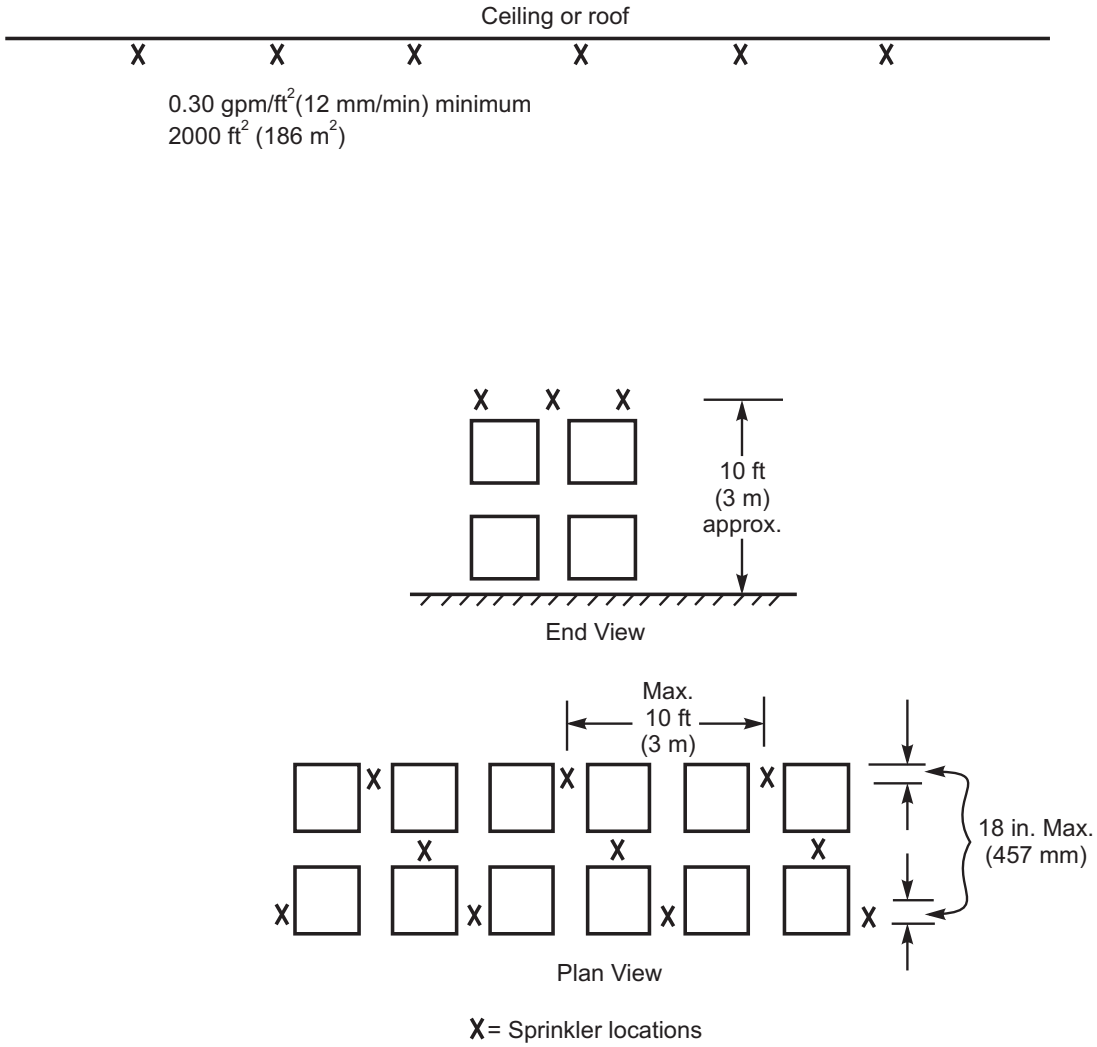
1. Ceiling area of demand: 2000 ft$^2$ (186 m$^2$) for all storage heights.
2. In-rack sprinkler discharge: 30 gpm (115 L/min) from most remote sprinkler.
3. In-rack sprinkler spacing, maximum 10 ft (3 m).
4. Clearance: up to 25 ft (7.6 m) clearance: top of storage to ceiling sprinklers—is acceptable in buildings 30 ft (9.1 m) high or less. For buildings higher than 30 ft (9.1 m) clearance should not exceed 10 ft (3 m) except if three lines of sprinklers are installed beneath a barrier over the top of storage.
5. Hose stream demand 250 gpm (950 L/min).
6. Water supply duration: 2 hours.
7. Single row racks: two sprinkler lines (face) staggered.
8. Rolls, either (1) enclosed, including both ends, in a cardboard carton or (2) wrapped, including both ends, with at least four layers of 40 lb/1000 ft$^2$ (19.6 kg/100 m$^2$) or heavier kraft paper may be protected as unexpanded plastic per Data Sheet 8-9, *Storage of Class 1, 2, 3, 4 and Plastic Commodities*.
9. When clearance between top of storage and sprinklers is maintained at 4 ½ ft (1.4 m) or less, the design area may be reduced 15%, but not to less than 2000 ft$^2$ (186 m$^2$).

*Table 4. Protection Guidelines for Multiple-Row Rack Storage of Rolled Nonwoven Fabric*

| *Approx. Height of Storage On End or On Side, ft (m)* | *Minimum Ceiling Density, gpm/ft$^2$ (mm/min)* | *Recommended In-Rack Sprinkler Protection* |
|---|---|---|
| Up to 20 (6.1) | 0.60 (24) | 1. Install in-rack sprinklers at approximately the 10 ft (3 m) level (face and flue), staggered.<br>2. Design for eight sprinklers, four sprinklers on each of the two most hydraulically remote in-rack sprinkler lines.<br>3. See Figure 8. |
| Over 20 (6.1) | 0.60 (24) | 1. Install in-rack sprinklers at each approximately 10 ft (3 m) level (face and flue), except for the top-most 10 ft (3 m) of storage, staggered.<br>2. Design for 14 sprinklers, seven sprinklers on each of the two most hydraulically remote in-rack sprinkler lines.<br>3. See Figure 8. |
| | 0.45 (18) | 1. Install in-rack sprinklers at each approximately 10 ft (3 m) level (face and flue), except for the top-most 5 ft (1.5 m) of storage, staggered.<br>2. Design for 14 sprinklers, seven sprinklers on each of the two most hydraulically remote in-rack sprinkler lines.<br>3. See Figure 9. |
| | 0.15 (6) | 1. Install a barrier at each approximately 10 ft (3 m) level.<br>2. Install face sprinklers on maximum 10 ft (3 m) spacing, staggered.<br>3. Install flue sprinklers on maximum 10 ft (3 m) spacing, staggered, except for top-most level of in-rack sprinklers.<br>4. Design for 14 sprinklers, seven sprinklers on each of the two most hydraulically remote in-rack sprinkler lines.<br>5. See Figure 10. |

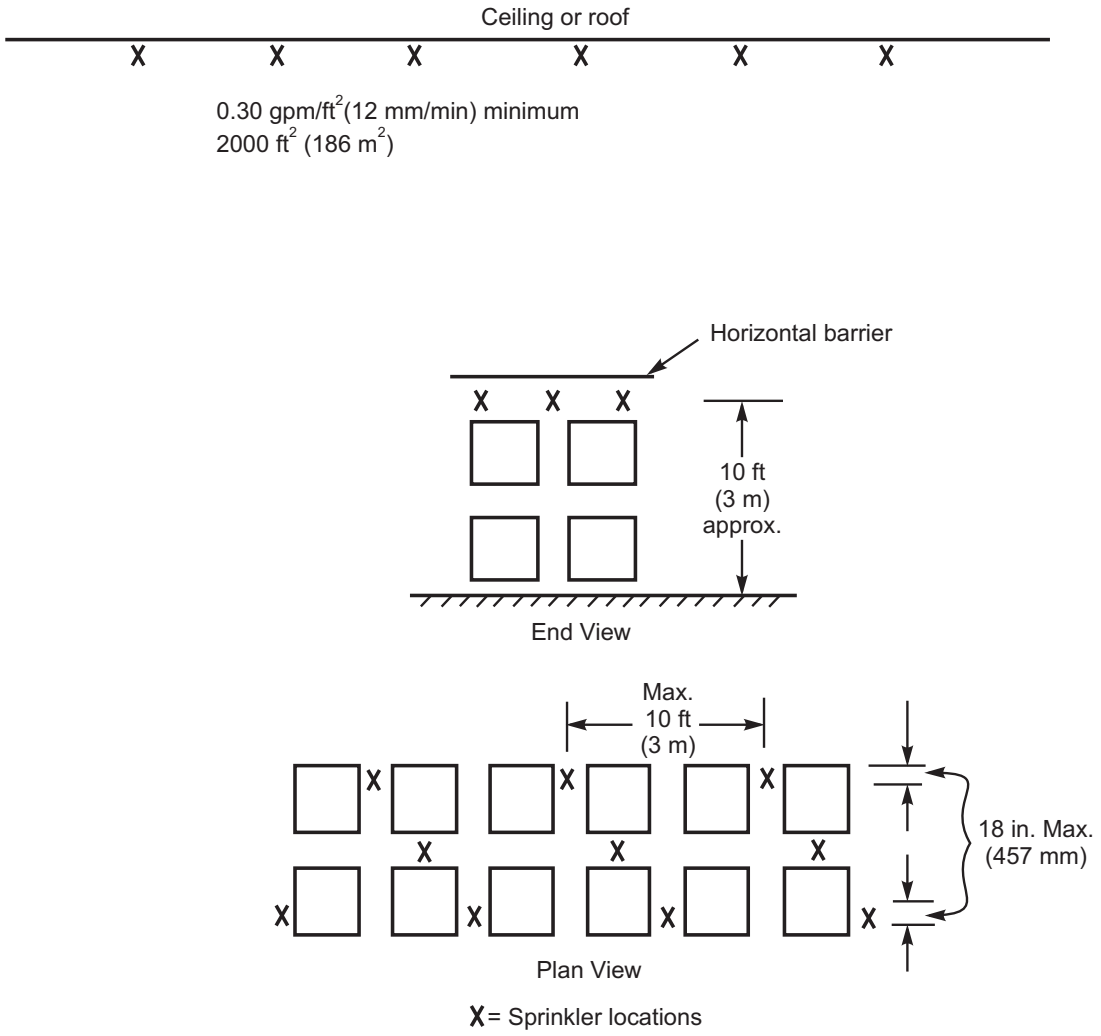
*ADDITIONAL GENERAL RECOMMENDATIONS—Tables 3 and 4*

1. Ceiling area of demand: 2000 ft$^2$ (186 m$^2$) for all storage heights.
2. In-rack sprinkler discharge: 30 gpm (115 L/min) from most remote sprinkler.
3. In-rack sprinkler spacing, maximum 10 ft (3 m).
4. Clearance: up to 25 ft (7.6 m) clearance— top of storage to ceiling sprinklers—is acceptable in buildings 30 ft (9.1 m) high or less. For buildings higher than 30 ft (9.1 m) clearance should not exceed 10 ft (3 m) except if three lines of sprinklers are installed beneath a barrier over the top of storage.
5. Hose stream demand 250 gpm (950 L/min).
6. Water supply duration: 2 hours.
7. Single row racks: two sprinkler lines (face) staggered.
8. Rolls, either (1) enclosed, including both ends, in a cardboard carton or (2) wrapped, including both ends, with at least four layers of 40 lb/1000 ft$^2$ (19.6 kg/100 m$^2$) or heavier kraft paper may be protected as unexpanded plastic per Data Sheet 8-9, *Storage of Class 1, 2, 3, 4 and Plastic Commodities*.
9. When clearance between top of storage and sprinklers is maintained at 4 ½ ft (1.4 m) or less, the design area may be reduced 15%, but not to less than 2000 ft$^2$ (186 m$^2$).



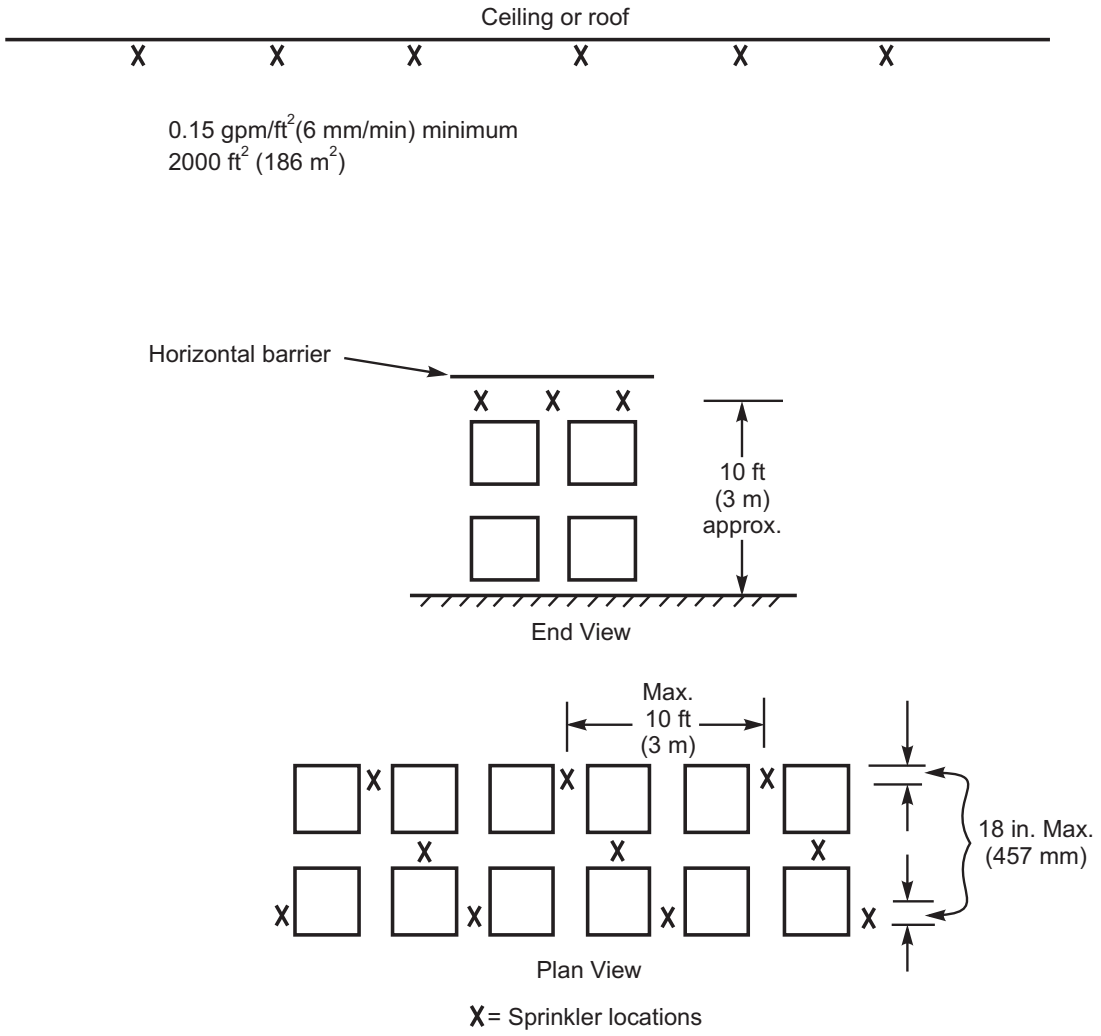

1. In-rack sprinklers should be placed within 18 in. (457 mm) of the storage face.
2. In-rack sprinklers should be staggered.

*Fig. 1. Double-row racks under 20 ft (6.1 m) high*



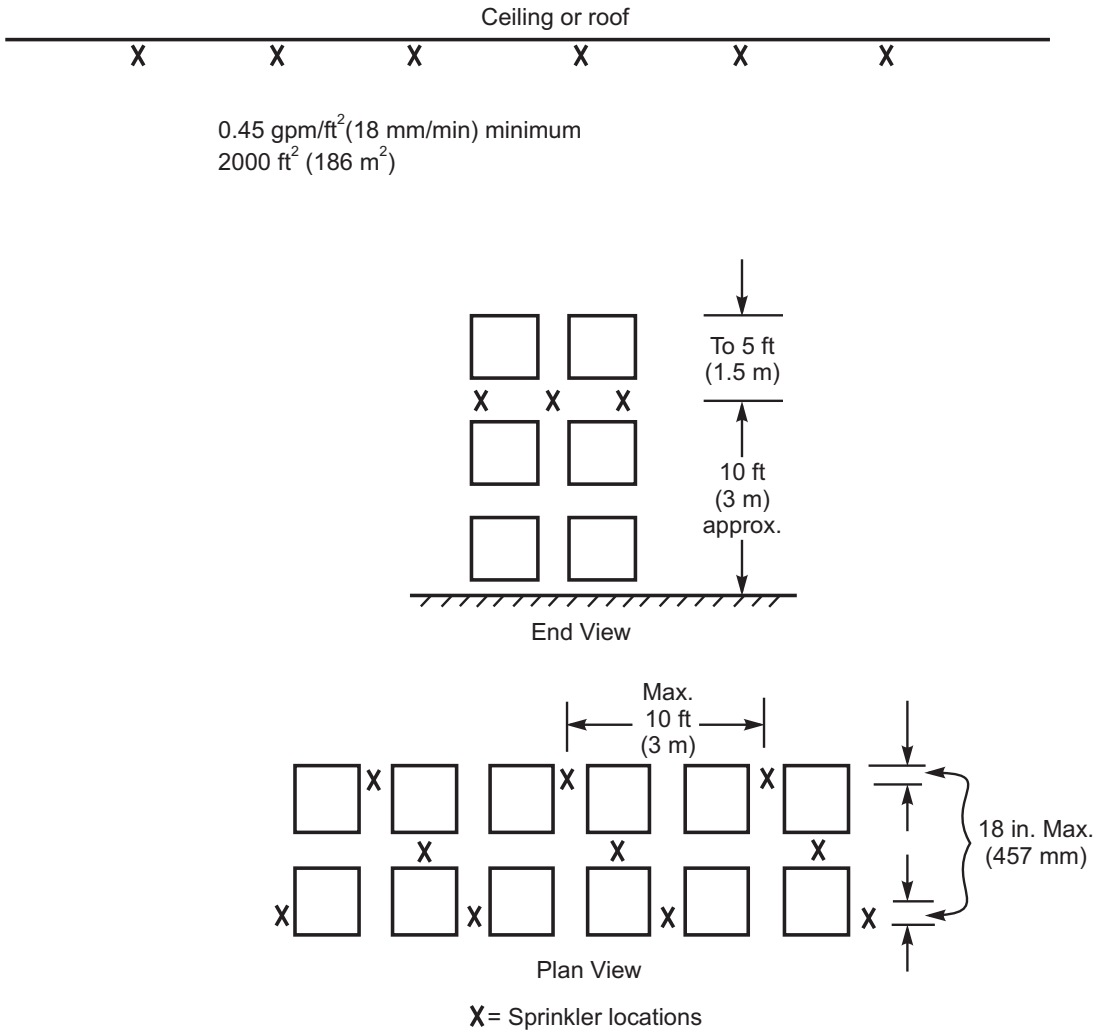

1. In-rack sprinklers should be placed within 18 in. (457 mm) of the storage face.
2. In-rack sprinklers should be staggered.

*Fig. 1a. Alternative to Fig. 1 for double-row racks under 20 ft (6.1 m) high*



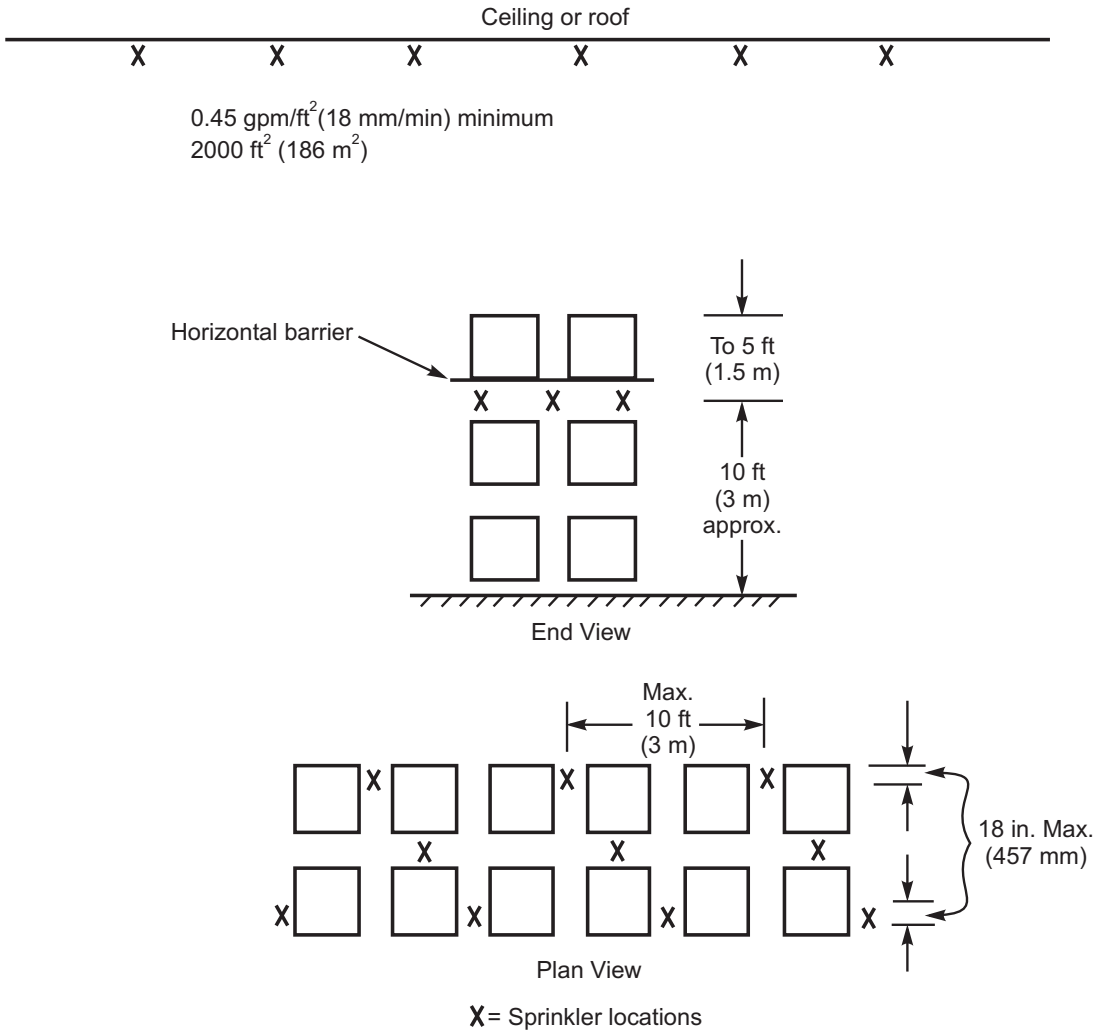

1. In-rack sprinklers should be placed within 18 in. (457 mm) of the storage face.
2. In-rack sprinklers should be staggered.

*Fig. 1b. Alternative to Fig. 1 for double-row racks under 20 ft (6.1 m) high*



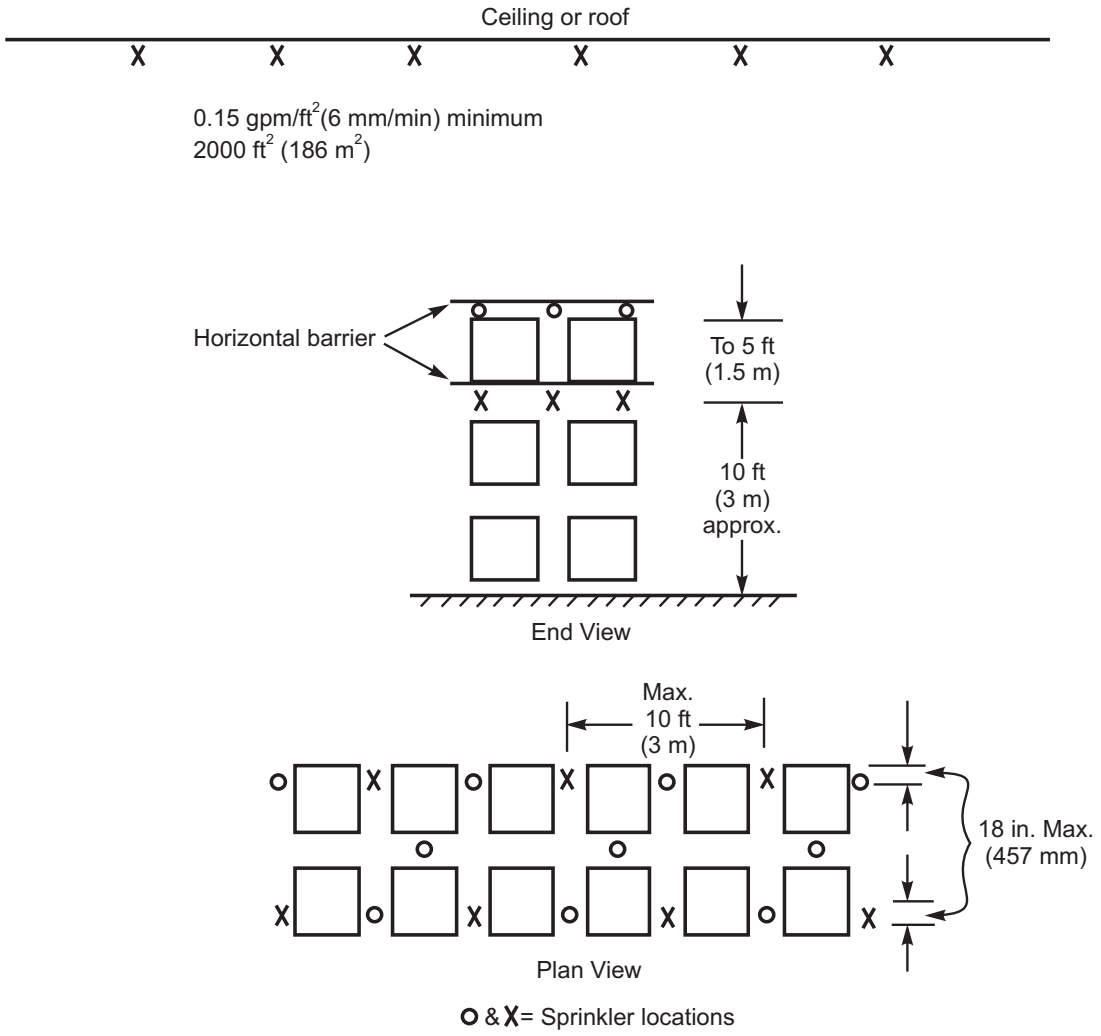

1. In-rack sprinklers should be placed within 18 in. (457 mm) of the storage face.
2. In-rack sprinklers should be staggered.

*Fig. 2. Double-row racks under 20 ft (6.1 m) high*



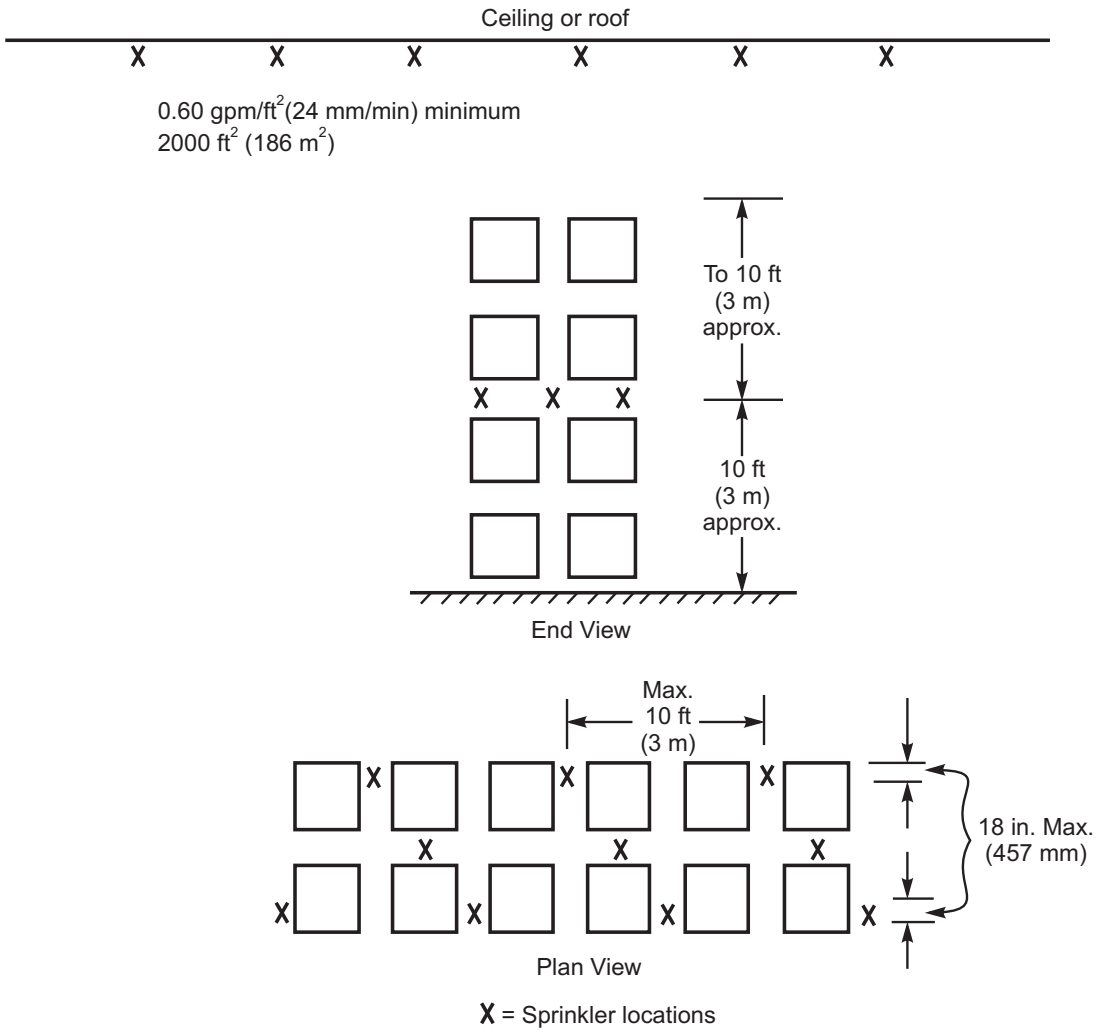

1. In-rack sprinklers should be placed within 18 in. (457 mm) of the storage face.
2. In-rack sprinklers should be staggered.

*Fig. 2a. Alternative to Fig. 2 for double-row racks under 20 ft (6.1 m) high*



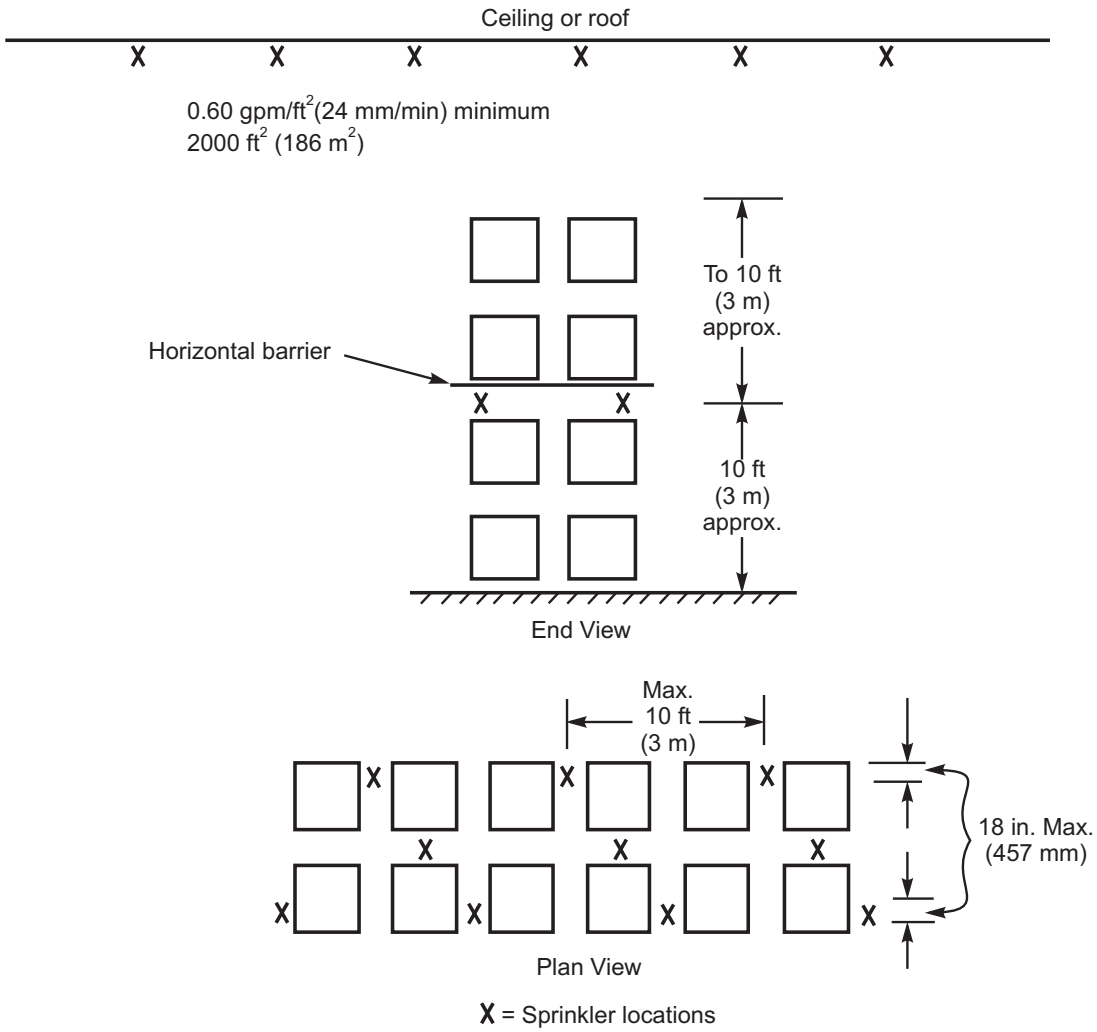

1. In-rack sprinklers should be placed within 18 in. (457 mm) of the storage face.
2. In-rack sprinklers should be staggered.

*Fig. 2b. Alternative to Fig. 2 for double-row racks under 20 ft (6.1 m) high*



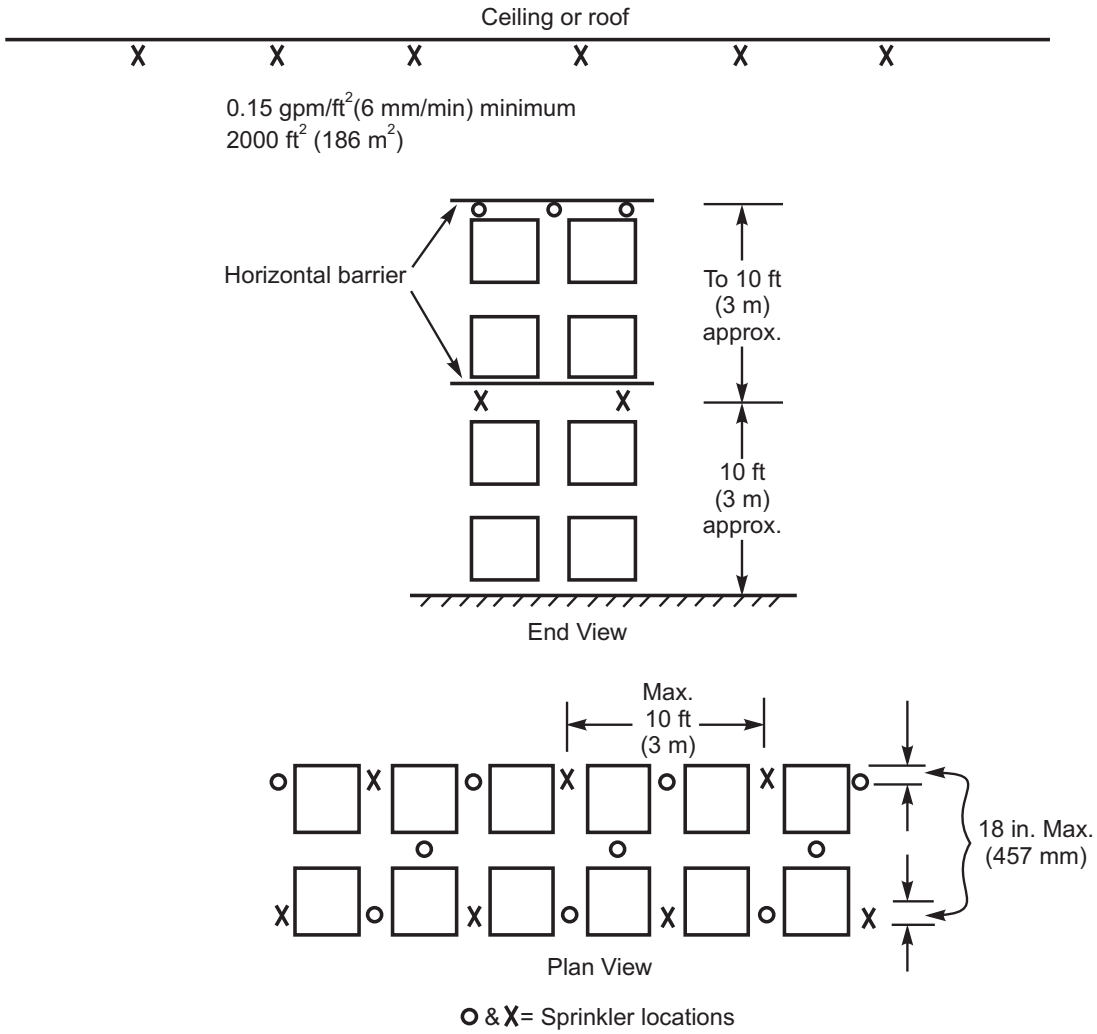

1. In-rack sprinklers should be placed within 18 in. (457 mm) of the storage face.
2. In-rack sprinklers should be staggered.

*Fig. 3. Double-row racks under 25 ft (7.6 m) high*



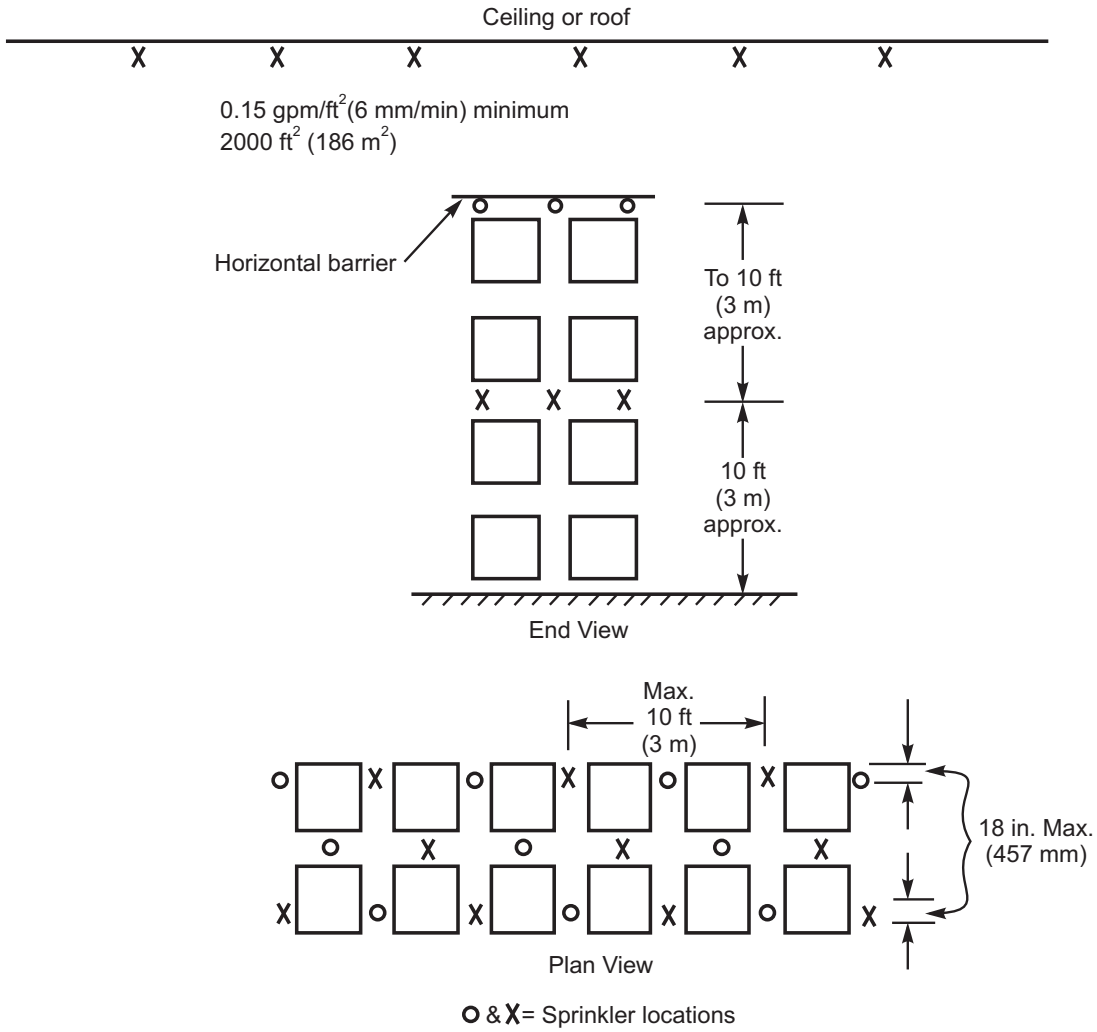

1. In-rack sprinklers should be placed within 18 in. (457 mm) of the storage face.
2. In-rack sprinklers should be staggered.

*Fig. 3a. Alternative to Fig. 3 for double-row racks under 25 ft (7.6 m) high*



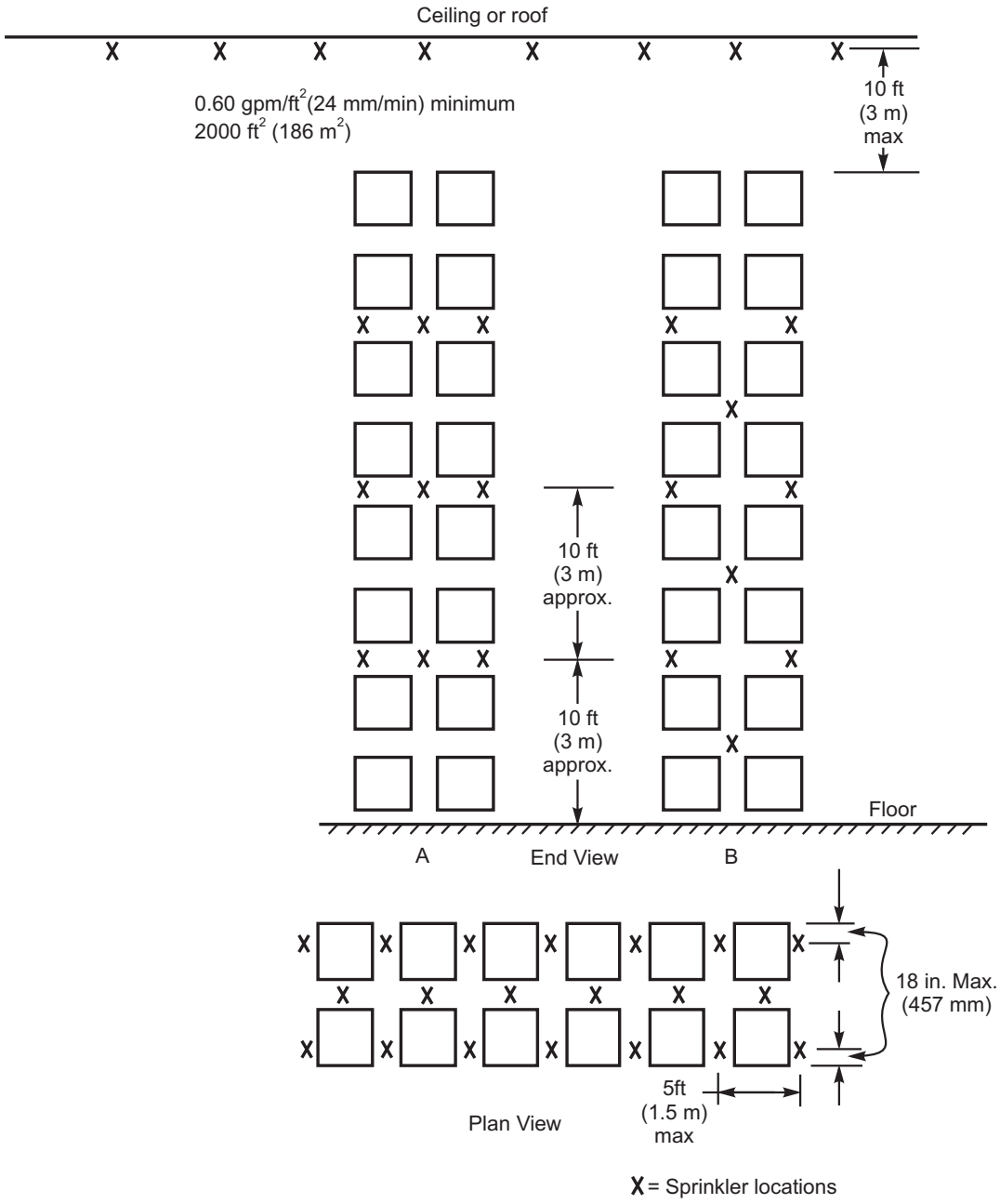

1. In-rack sprinklers should be placed within 18 in. (457 mm) of the storage face.
2. In-rack sprinklers should be staggered.

*Fig. 3b. Alternative to Figure 3 for double-row racks under 25 ft (7.6 m) high*



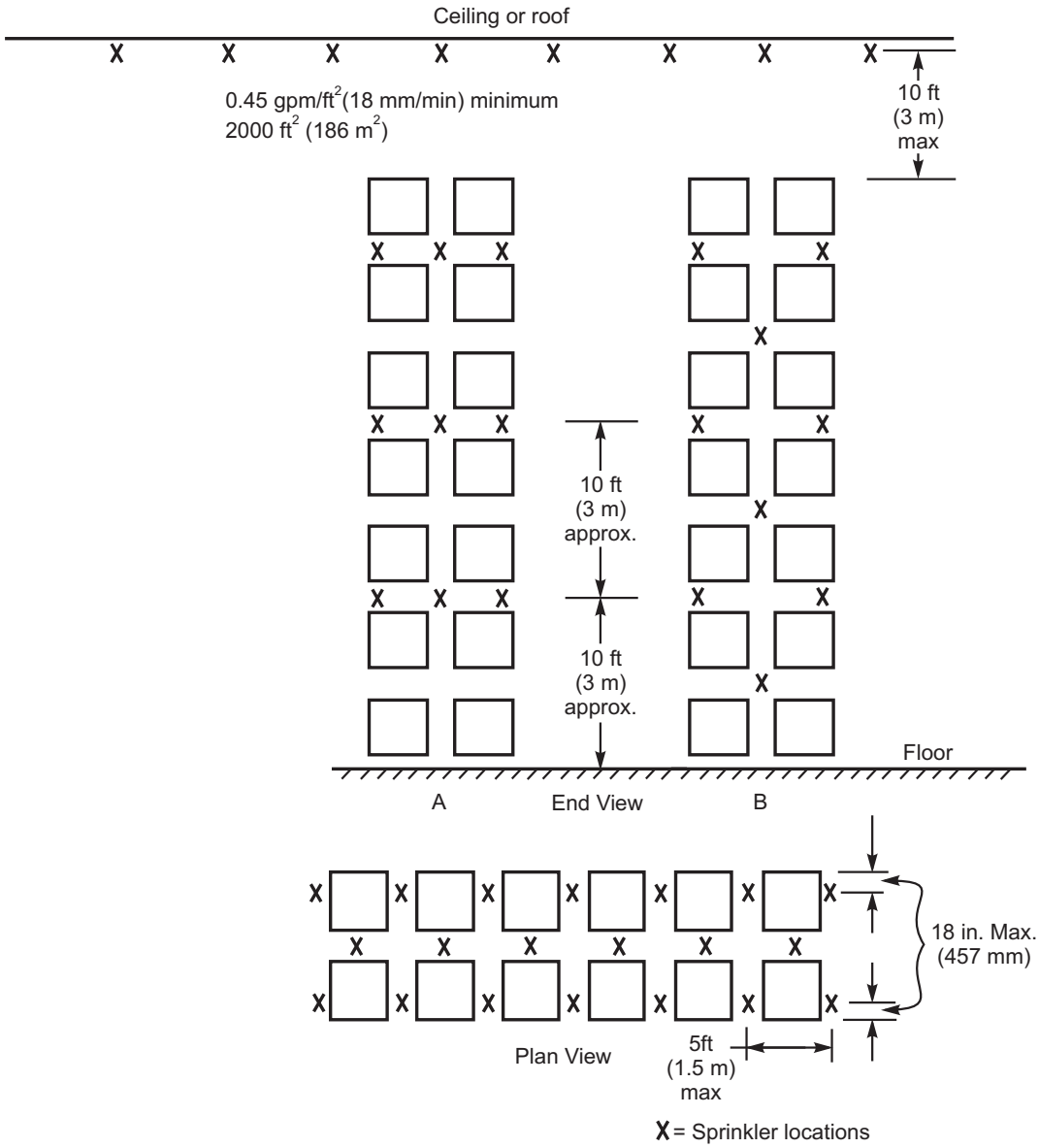

1. In-rack sprinklers should be placed within 18 in. (457 mm) of the storage face.
2. In-rack sprinklers should be staggered.

*Fig. 3c. Alternative to Fig. 3 for double-row racks under 25 ft (7.6 m) high*



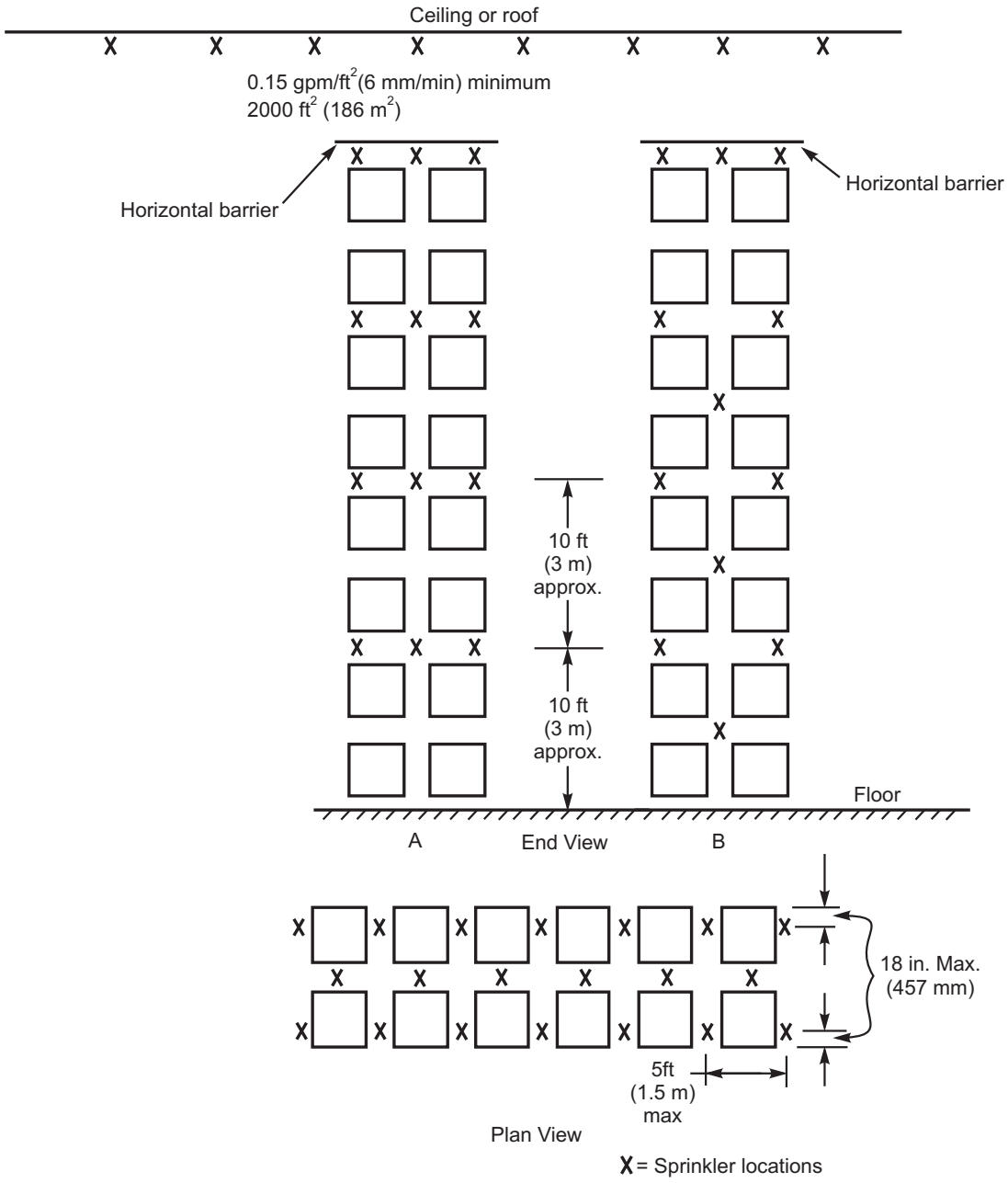

1. In-rack sprinklers should be placed within 18 in. (457 mm) of the storage face.
2. Alternate levels of in-rack sprinklers should be staggered.
3. Distance between the top level of in-rack sprinklers and top of storage should be no more than 10 ft (3 m).

*Fig. 4. Double-row racks above 20 ft (6.1 m) high*




1. In-rack sprinklers should be placed within 18 in. (457 mm) of the storage face.
2. Alternate levels of in-rack sprinklers should be staggered.
3. Distance between the top level of in-rack sprinklers and top of storage should be no more than 5 ft (1.5 m).

*Fig. 5. Double-row racks above 20 ft (6.1 m) high*




1. In-rack sprinklers should be placed within 18 in. (457 mm) of the storage face.
2. Alternate levels of in-rack sprinklers should be staggered.

*Fig. 6. Double-row racks above 20 ft (6.1 m) high*

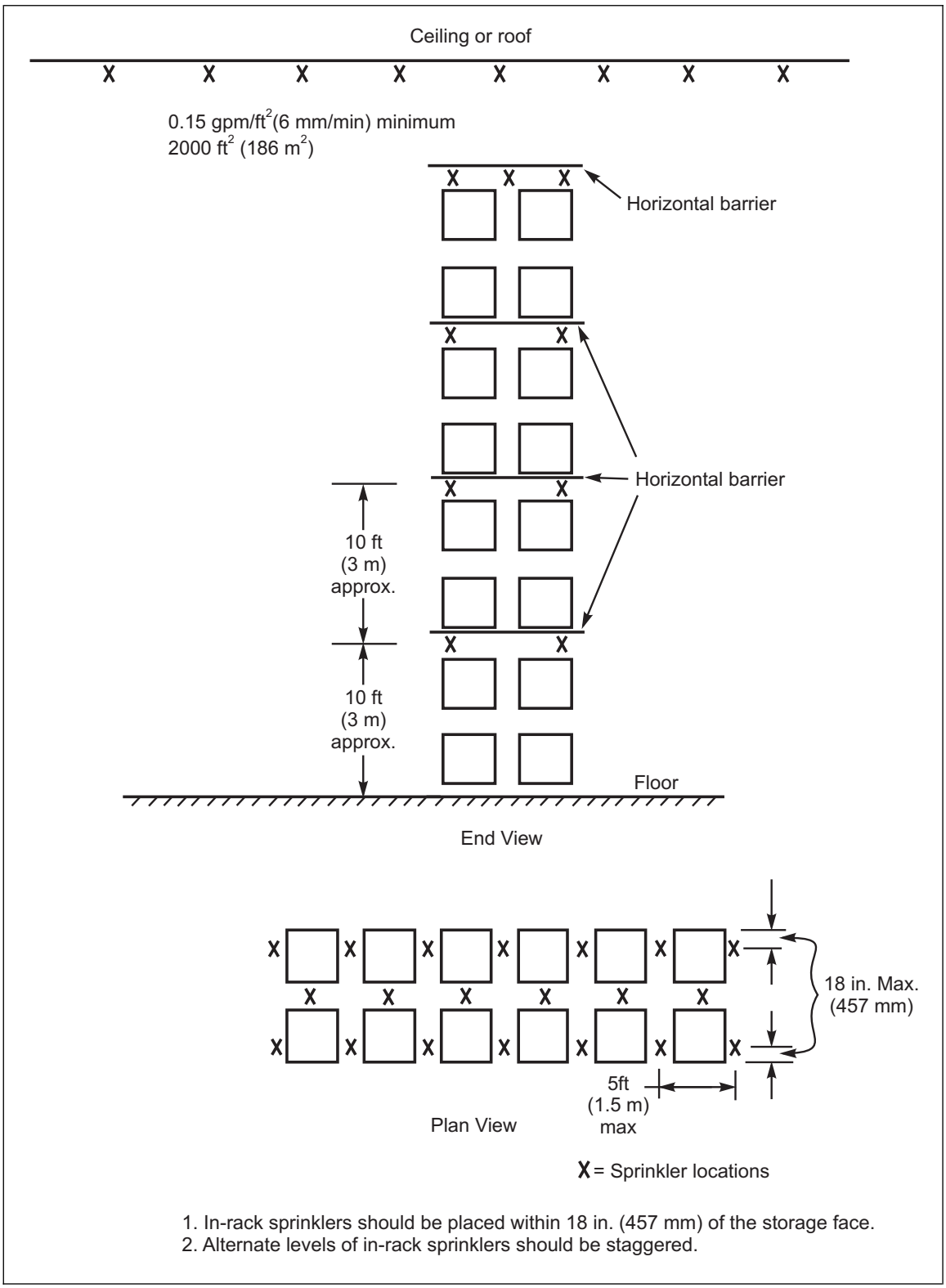
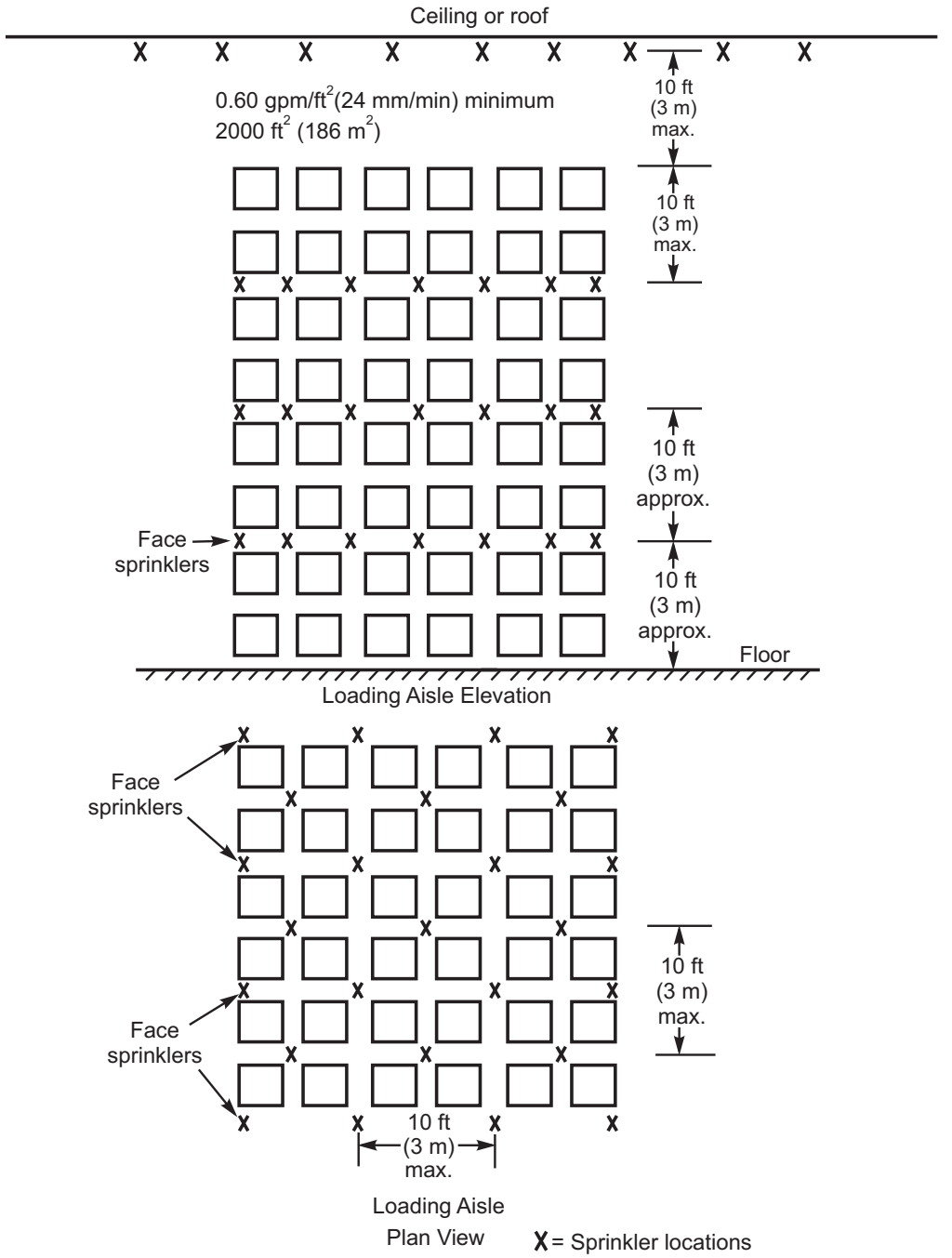
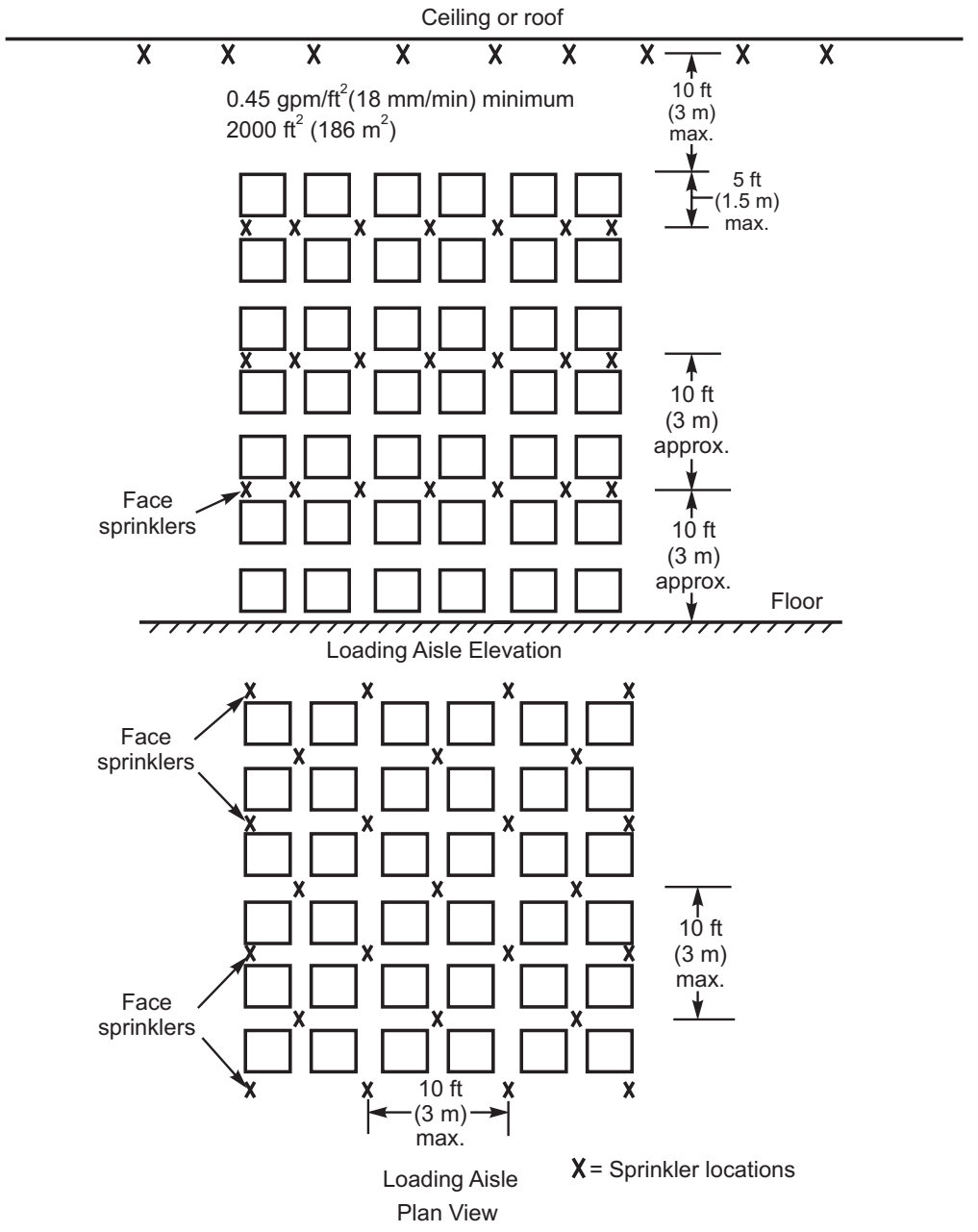



*Fig. 7. Double-row racks above 20 ft (6.1 m) high*



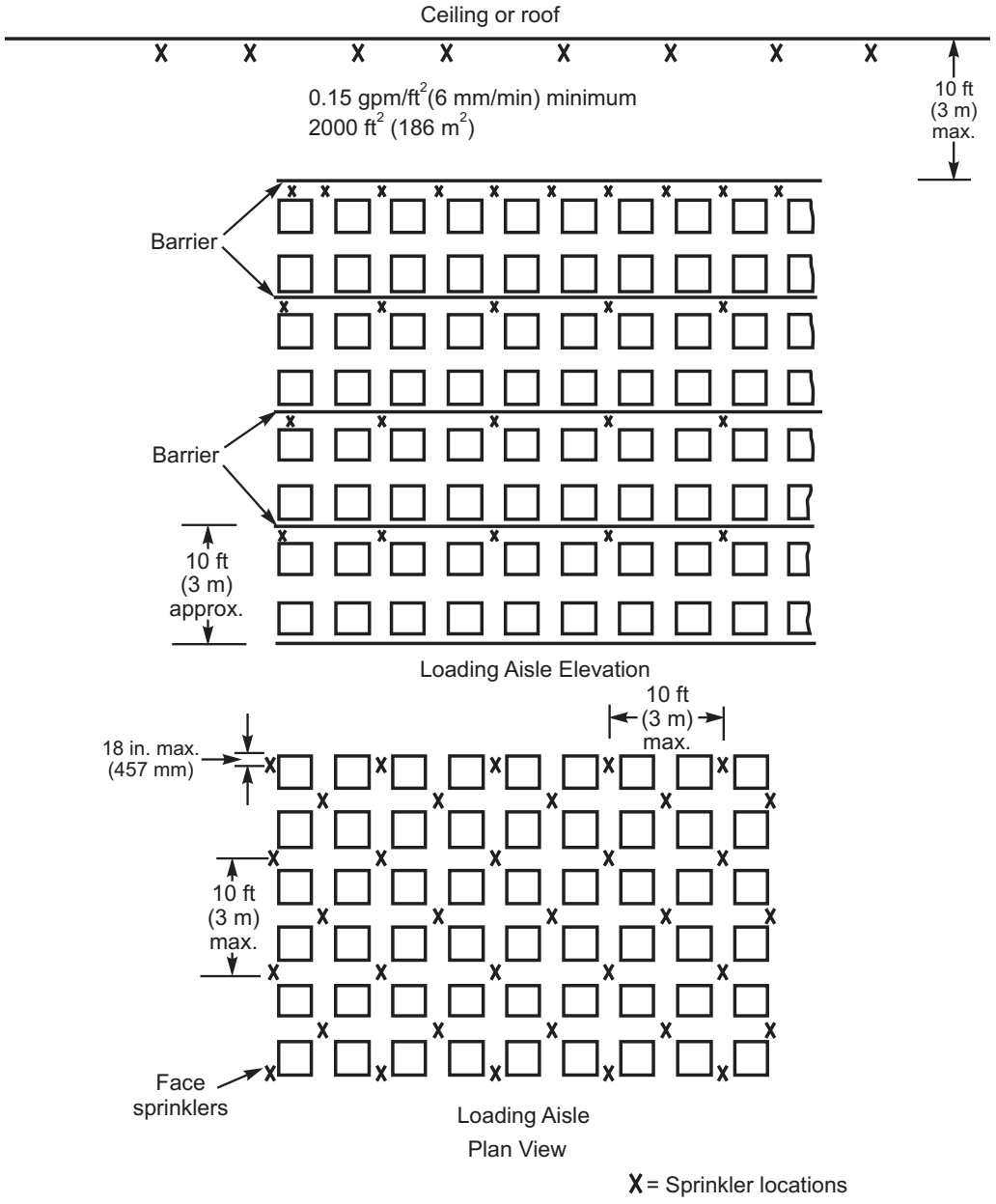

1. In-rack sprinklers should be placed within 18 in. (457 mm) of the storage face.
2. Alternate levels of in-rack sprinklers should be staggered.
3. Distance between the top of in-rack sprinklers and top of storage should be no more than 10 ft (3 m).

*Fig. 8. Multiple-row racks of any height*




1. In-rack sprinklers should be placed within 18 in. (457 mm) of the storage face.
2. Alternate levels of in-rack sprinklers should be staggered.
3. Distance between the top of in-rack sprinklers and top of storage should be no more than 5 ft (1.5 m).

*Fig. 9. Multiple-row racks of any height*




1. In-rack sprinklers should be placed within 18 in. (457 mm) of the storage face.
2. Alternate levels of in-rack sprinklers should be staggered.
3. Distance between the top of in-rack sprinklers and top of storage should be no more than 5 ft (1.5 m).

*Fig. 10. Multiple-row racks of any height; protection using horizontal barriers and in-rack sprinklers*

### 2.3 Human Element

2.3.1 There is no substitute for a well-trained emergency response team. Early detection and effective action by personnel during a rolled nonwoven fabric fire can greatly reduce fire and water damage. Controlling possible ignition sources, maintaining proper aisle spacing, and practicing good housekeeping are other recommended safe practices. See Data Sheet 8-0, *General Storage Safeguards*.

## 3.0 SUPPORT FOR RECOMMENDATIONS

### 3.1 Test Data

Numerous laboratory, fire products collector (FPC), and intermediate-scale fire tests as well as one a large-scale fire test have been conducted on rolled nonwoven fabrics. Except for batting, fiberfill, and highloft materials, there are no obvious differences, at this time, in the level of protection required (once burning is established) between various nonwoven fabrics (low vs. high heat of combustion, low vs. high density).

In most cases, rolled nonwoven fabrics display moderate to heavy dripping of molten plastic as they burn, which increases fire intensity and, to some extent, fire spread.

Intermediate-scale, on-floor, on-end fire tests with K11.2 (K160) sprinklers discharging 0.60 gpm/ft$^2$ (24.5 mm/min) were not controlled when stacks were 20 ft (6.1 m) and 18 ft (5.5 m) high.

A 21 ft (6.4 m) high, intermediate-scale, on-floor, on-end fire test with K11.2 (K160) sprinklers operating at 25 psi (1.7 bar) was not controlled.

A 21 ft (6.4 m) high full-scale, on-floor, on-end fire test with K14.0 (K200), quick response 165°F (74°C), pendent sprinklers operating at 50 psi (3.4 bar) was not adequately suppressed.

Tests conducted on batting, fiberfill, and highloft materials indicate that K11.2 (K160) ceiling-only sprinklers discharging at 75 psi (5.1 bar) did not control a fire in a 16 ft (4.9 m) high rack storage array.

If rolled nonwoven fabric storage is inadequately protected, fire development and spread is extremely severe and rapid. Exposed building steel can quickly heat to temperatures at which it fails structurally. Excessive steel deflection can break sprinkler piping and deprive the building contents of fire protection at a time of maximum need.

### 3.2 Variables Affecting Fire Behavior

There are many variables in rolled nonwoven fabric arrangements that can affect fire severity. A few of the major factors are discussed below.

#### 3.2.1 Storage Height

Testing has shown that the fire hazard increases with the increase in storage height. In general there is more damage and larger numbers of sprinklers operate.

#### 3.2.2 Clearance

Both testing and loss experience have shown that low clearance between the top of storage and ceiling sprinklers is advantageous in fire control. In general, the number of operating sprinklers and amount of damage increases with increasing clearances.

#### 3.2.3 Storage Methods

##### 3.2.3.1 On-Floor and On-End Storage

On-floor/on-end storage is more varied and more widely used than on-side storage.

Where clamp-jaw equipment is used, jaw clearance space of at least 4 in. (100 mm) is usual, resulting in an open or standard array storage arrangement.

Rolls varying in diameter provide spaces between stacks that may reach several feet. Fire can grow rapidly in such storage; air supply is favorable for burning in flue-like spaces. In addition, heat radiated and reradiated from one stack to another promotes intense fires.

Individual stacks consisting of rolls with assorted diameters, such as butt rolls, are considered an open array and should be stored in a separate cutoff area.

When all rolls in a sector of storage are of the same diameter, adjacent stacks should be placed in, or nearly in contact (or nearly in contact) in both directions. Close stacking or butting requires extra care and effort by equipment operators and their supervisors, particularly where clamp-jaw equipment is used. Less effort is needed where vacuum clamp equipment is used, but some rolls cannot be handled by suction.

#### 3.2.3.2 On-Floor and On-Side Storage

Rolls stored on-side may be nested between rolls of a lower tier or separated by dunnage placed between tiers. Where dunnage is used, there is opportunity for fire to burrow into a pile and make extinguishment more difficult than for nested rolls. Fires well shielded from firefighting efforts can involve a large portion of the storage. Also, fires can become quite severe in vertical flues between roll ends.

#### 3.2.3.3 Storage on Axial Rods

Rolled nonwoven fabric is sometimes supported horizontally on racks by rods that run axially through the rolls. Store rolls as close together as possible, in at least one direction, to reduce flue spaces and minimize reradiation. Limit storage height to not more than 10 ft (3 m).

#### 3.2.3.4 On-Rack Storage

Rolled nonwoven fabric is sometimes stored on racks on pallets, either on end or on side.

## 4.0 REFERENCES

### 4.1 FM

Data Sheet 2-0, *Installation Guidelines for Automatic Sprinklers*
Data Sheet 8-9, *Storage of Class 1, 2, 3, 4 and Plastic Commodities*
Data Sheet 8-21, *Roll Paper Storage*

## APPENDIX A GLOSSARY OF TERMS

*Closed array:* An on-end storage arrangement of vertical stacks in which the stack spacing in all directions is less than 4 in. (100 mmm).

*FM Approved:* A product or service that has satisfied the criteria for FM Approval. Refer to the *Approval Guide*, an online resource of FM Approvals, for a complete listing of products and services that are FM Approved.

*Nonwoven fabric:* A relatively low-to-moderate density fiber web construction product usually having the appearance of tissue paper, medium-weight paper, or felt. The more common fibers are wood pulp, rayon, polyester, and polypropylene. Polyethylene is less commonly used. Plastic fibers are used alone, in combination with each other or with wood pulp. It can be made using various processes, such as hydroentanglement, thermal bonding, needle punch, and adhesive bonding. It is used for: interfacing in shirts, suits, jackets, dresses; soil erosion control; disposable baby and adult personal care products; health care products; carpet backing; and many other purposes.

*Open array:* An on-end storage arrangement in which vertical stack spacing in all directions is 4 in. (100 mm) or more. Open array storage is usually found where rolls are not uniform in diameter, or in locations that use overhead cranes to move the rolls.

*Standard array:* An on-end storage arrangement in which vertical stacks are butted in one direction and separated by 4 in. (100 mm) or more in the other direction. The standard array is usually found where rolls are uniform in diameter and clamp trucks are used to move the rolls.

*Storage sprinkler:* A sprinkler that has been categorized by FM as acceptable for protecting storage-type occupancies and/or any other high heat-release type fires as permitted in an occupancy-specific data sheet.

Definitions for aisle, clearance, encapsulation, flue space, horizontal barrier, pallets, rack storage sprinklers, solid shelving, storage height, racks storage, tier, etc., can be found in Data Sheet 8-9, *Storage of Class 1, 2, 3, 4 and Plastic Commodities.*

## APPENDIX B DOCUMENT REVISION HISTORY

January 2015. Completely revised the document to be technically consistent with other data sheets. Removed references to obsolete data sheets and terminology.

May 2008. Section 2.2.3, Suppression Mode Sprinkler Protection for Rack and Palletized Storage of Nonwoven Rolls, was revised.

May 2003. Minor editorial changes were made for this edition.

January 2000. This revision of the document was reorganized to provide a consistent format.

## APPENDIX C SUPPLEMENTARY INFORMATION

### C.1 Loft Factor

A relatively low-density, fiber web construction, high-bulk nonwoven product having the physical appearance of fiberglass insulation commonly ¼ to 3 in. (6 to 76 mm) thick, usually white in color and generally made from polyester fibers with acrylic or latex binder. It is used as clothing insulation, filling for comforters, filters, furniture padding, and sound-deadening insulation.

$$\text{Roll loft factor} = \frac{\pi L (D_o^2 - D_i^2)\, pf}{4 (W_o - W_c)} - 1$$

| *Where* | *US* | *(Metric)* |
|---|---|---|
| *L = roll length* | *ft* | *(m)* |
| $D_o$ = roll outer diameter | ft | (m) |
| $D_i$ = roll inner diameter | ft | (m) |
| pf = density | $lb/ft^3$ | $(kg/m^3)$ |
| $W_o$ = roll weight | lb | (kg) |
| $W_c$ = weight of inner core | lb | (kg) |
| $\pi$=3.1416 | | |

A roll loft factor of 25 or above indicates batting, fiberfill, highloft. Roll loft factor is an FM Global derived number for comparison purposes.