

Stored Palletized, Solid Piled, Bin Boxes, or Shelf Storage (12.2)

- Formally part of NFPA 231
- 12.2.1 General
- 12.2.2 Protection of Class I - IV Commodities
- 12.2.3 Protection of Plastic & Rubber Commodities



12.2.2.1 Control Mode Density-Area Sprinkler Protection Criteria for Palletized, Solid Piled, Bin Box, or Shelf Storage of Class I - IV Commodities

- Maximum Storage Height:
 - Non-encapsulated solid pile, palletized, or bin box:
 - 30 ft (9.1 m)
 - Non-encapsulated shelf storage:
 - 15 ft (4.6 m)
 - Encapsulated solid pile, palletized, bin box:
 - 15 ft (4.6 m)

Table 12.2.1.2 Hose Stream Demand & Water Supply Duration Requirements

Commodity Classification	Storage Height		Inside Hose		Total Combined Inside and Outside Hose		Duration (minutes)
	ft	m	gpm	L/min	gpm	L/min	
Class I, II, and III	Over 12 up to 20	Over 3.7 up to 6.1	0, 50, or 100	0, 190, 380	500	1900	90
	Over 20 up to 30	Over 6.1 up to 9.1	0, 50, or 100	0, 190, 380	500	1900	120
Class IV	Over 12 up to 20	Over 3.7 up to 6.1	0, 50, or 100	0, 190, 380	500	1900	120
	Over 20 up to 30	Over 6.1 up to 9.1	0, 50, or 100	0, 190, 380	500	1900	150
Group A plastic	< 5	< 1.5	0, 50, or 100	0, 190, 380	500	1900	90
	Over 5 up to 20	Over 1.5 up to 6.1	0, 50, or 100	0, 190, 380	500	1900	120
	Over 20 up to 25	Over 6.1 up to 7.6	0, 50, or 100	0, 190, 380	500	1900	150

- **12.2.2.1.3** 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.

12.2.2 Protection Criteria for Palletized, Solid Piled, Bin Box, or Shelf Storage of Class I - IV Commodities.

- **12.2.2.1 Control Mode Density-Area Sprinkler Protection Criteria for Palletized, Solid Piled, Bin Box, or Shelf Storage of Class I - IV Commodities**
- **12.2.2.2 Large Drop Sprinklers and Specific Application Control Mode Sprinklers for Palletized or Solid Piled Storage of Class I - IV Commodities.**
- **12.2.2.3 Early Suppression Fast-Response (ESFR) Sprinklers for Palletized or Solid Piled Storage of Class I - IV Commodities**
- **12.2.2.4 Special Design for Palletized, Solid Piled, Bin Box, or Shelf Storage of Class I - IV Commodities**

12.2.2.1.4 Minimum System Requirements

- **Min. Design Density:** 0.15 gpm/ft² (6.1 mm/min)
 - The sprinkler design density for any given area of operation for a Class III or Class IV commodity shall not be less than the density for the corresponding area of operation for ordinary hazard Group 2.
- **Min. Design Area:**
 - 2000 ft² (186m²) for wet systems
 - 2600 ft² (242m²) for dry systems

FIGURE 12.2.2.1.5.1 Sprinkler System Design Curves, 20-ft (6.1-m) High Storage — Ordinary Temp. Rated Sprinklers (K 5.6 & 8.)

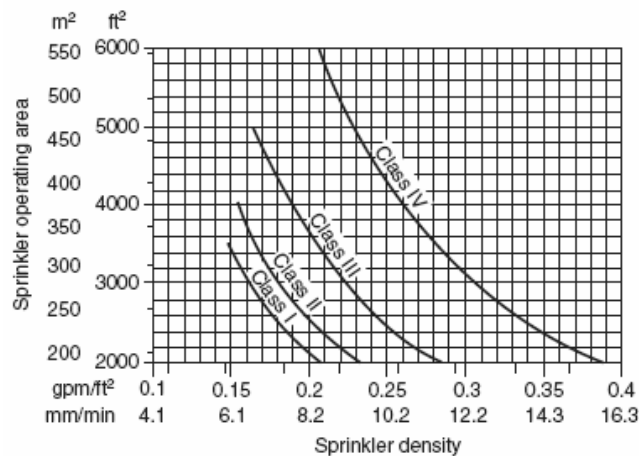
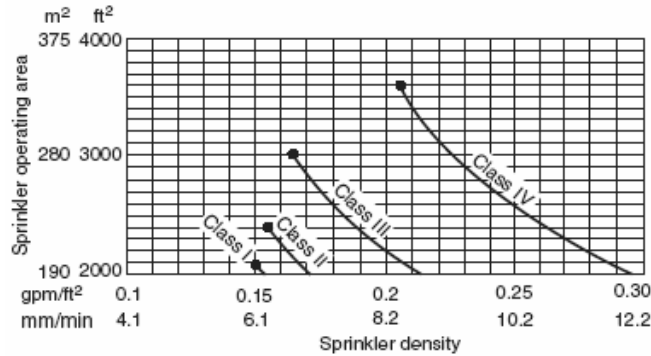


FIGURE 12.2.2.1.5.2 Sprinkler System Design Curves, 20-ft (6.1-m) High Storage—High Temp. Rated Sprinklers

Ordinary- and intermediate-temp. sprinklers with K-factors of 11.2 or larger, where listed for storage, shall be permitted to use the densities from the high temperature curves (12.2.2.1.7)



Design Modifications

- Density Modification (12.2.2.1.5.3):
 - See Figure 12.2.2.1.5.3
- Metal bin boxes with face areas > 16 ft² (1.5 m²) & metal closed shelves with face areas > 16 ft² (1.5 m²) (12.2.2.1.6):
 - Reduce area of application 50 %
 - Don't forget 12.2.2.4
- Ordinary- and intermediate-temperature sprinklers with K-factors of 11.2 or larger, where listed for storage are permitted to use the densities from the high temperature curves

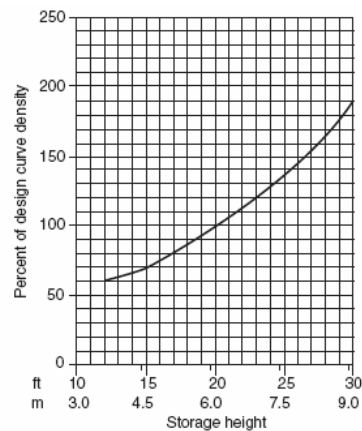


FIGURE 12.2.2.1.5.3 Ceiling Sprinkler Density vs. Storage Height.

12.2.2 Protection Criteria for Palletized, Solid Piled, Bin Box, or Shelf Storage of Class I - IV Commodities.

- 12.2.2.1 Control Mode Density-Area Sprinkler Protection Criteria for Palletized, Solid Piled, Bin Box, or Shelf Storage of Class I - IV Commodities
- 12.2.2.2 Large Drop Sprinklers and Specific Application Control Mode Sprinklers for Palletized or Solid Piled Storage of Class I - IV Commodities.
- 12.2.2.3 Early Suppression Fast-Response (ESFR) Sprinklers for Palletized or Solid Piled Storage of Class I - IV Commodities
- 12.2.2.4 Special Design for Palletized, Solid Piled, Bin Box, or Shelf Storage of Class I - IV Commodities

12.2.2.2 Large Drop Sprinklers & Specific Application Control Mode Sprinklers for Palletized or Solid Piled Storage of Class I - IV Commodities

- Protection Requirements:
 - Table 12.2.2.2.1(a) and Table 12.2.2.2.1(b)
- Min. number of design sprinklers for ordinary hazard & miscellaneous storage:
 - 15 wet pipe systems
 - 25 double interlock preaction systems & dry pipe systems
- Max. discharge pressure at the hydraulically most remote sprinkler:
 - 95 psi (6.6 bar)
- Structural Steel Protection: Not Required

**Table 12.2.2.2.1(a) Large-Drop Sprinkler
Design Criteria for Palletized & Solid-
Piled Storage of Class I - IV Commodities**

Storage Arrangement	Commodity Class	Nominal K-Factor	Maximum Storage Height		Maximum Ceiling/ Roof Height		Type of System	Number of Design Sprinklers / Minimum Pressure		Hose Stream Demand		Water Supply Duration (hours)
			ft	m	ft	m		/psi	/bar	gpm	L/min	
Palletized	I, II, III	11.2	25	7.6	35	10.7	Wet	15/25	15/1.7	500	1900	2
							Dry	25/25	25/1.7	500	1900	2
	IV	11.2	20	6.1	30	9.1	Wet	20/25	20/1.7	500	1900	2
							Dry	N/A	N/A	N/A	N/A	N/A
		11.2	20	6.1	30	9.1	Wet	15/50	15/3.4	500	1900	2
							Dry	N/A	N/A	N/A	N/A	N/A
Solid Pile	I, II, III	11.2	20	6.1	30	9.1	Wet	15/25	15/1.7	500	1900	2
							Dry	25/25	25/1.7	N/A	N/A	N/A
	IV	11.2	20	6.1	30	9.1	Wet	15/50	15/3.4	500	1900	2
							Dry	N/A	N/A	N/A	N/A	N/A

**Table 12.2.2.2.1(b) Specific Application
Control Mode (16.8 K-Factor) Sprinkler
Design Criteria for Palletized & Solid-
Piled Storage of Class I - IV Commodities**

Configuration	Commodity Class	Maximum Storage Height		Maximum Building Height		Type of System	Number of Design Sprinklers by Minimum Operating Pressure		Hose Stream Demand		Water Supply Duration (hours)
		ft	m	ft	m		10 psi (0.7 bar)	22 psi (1.5 bar)	gpm	L/min	
Palletized	I or II	25	7.6	30	9.1	Wet	15	—	500	1900	2
Palletized	III or IV	25	7.6	30	9.1	Wet	—	15	500	1900	2
Solid pile	I or II	25	7.6	30	9.1	Wet	15	—	500	1900	1½
Solid pile	III or IV	25	7.6	30	9.1	Wet	—	15	500	1900	1½

12.2.2 Protection Criteria for Palletized, Solid Piled, Bin Box, or Shelf Storage of Class I - IV Commodities.

- 12.2.2.1 Control Mode Density-Area Sprinkler Protection Criteria for Palletized, Solid Piled, Bin Box, or Shelf Storage of Class I - IV Commodities
- 12.2.2.2 Large Drop Sprinklers and Specific Application Control Mode Sprinklers for Palletized or Solid Piled Storage of Class I - IV Commodities.
- 12.2.2.3 Early Suppression Fast-Response (ESFR) Sprinklers for Palletized or Solid Piled Storage of Class I - IV Commodities
- 12.2.2.4 Special Design for Palletized, Solid Piled, Bin Box, or Shelf Storage of Class I - IV Commodities

Table 12.2.2.3.1 ESFR Protection of Palletized and Solid-Pile Storage of Class I - IV Commodities

Commodity	Maximum Storage Height		Maximum Ceiling / Roof Height		Nominal R-Factor	Orientation	Minimum Operating Pressure		Hose Stream Demand		Water Supply Duration (hours)
	ft	m	ft	m			psi	bar	gpm	L/min	
Class I, II, III, or IV, encapsulated (no open-top containers or solid shelves)	20	6.1	25	7.6	11.2	Upright	50	3.4	250	946	1
					14.0	Upright or pendent	50	3.4			
					16.8	Pendent	35	2.4			
					25.2	Pendent	15	1.0			
	25	7.6	30	9.1	14.0	Upright or pendent	50	3.4			
					16.8	Pendent	35	2.4			
					25.2	Pendent	15	1.0			
					14.0	Upright or pendent	60	4.1			
	30	9.1	35	10.7	16.8	Pendent	42	2.9			
					14.0	Upright or pendent	75	5.2			
	35	10.7	40	12.2	16.8	Pendent	52	3.6			
					25.2	Pendent	25	1.7			
					14.0	Pendent	75	5.2			
					16.8	Pendent	52	3.6			
	35	12.2	45	13.7	25.2	Pendent	25	1.4			
					25.2	Pendent	40	2.8			
	40	12.2	45	13.7	25.2	Pendent	40	2.8			

12.2.2 Protection Criteria for Palletized, Solid Piled, Bin Box, or Shelf Storage of Class I - IV Commodities.

- 12.2.2.1 Control Mode Density-Area Sprinkler Protection Criteria for Palletized, Solid Piled, Bin Box, or Shelf Storage of Class I - IV Commodities
- 12.2.2.2 Large Drop Sprinklers and Specific Application Control Mode Sprinklers for Palletized or Solid Piled Storage of Class I - IV Commodities.
- 12.2.2.3 Early Suppression Fast-Response (ESFR) Sprinklers for Palletized or Solid Piled Storage of Class I - IV Commodities
- 12.2.2.4 Special Design for Palletized, Solid Piled, Bin Box, or Shelf Storage of Class I - IV Commodities

12.2.2.4 Bin Box or Shelf Storage of Class I - IV Commodities

- Storage over 12 ft (3.7 m) but not over the general storage limits with walkways at vertical intervals of not over 12 ft (3.7 m)
 - Automatic sprinklers shall be installed under the walkway(s)
 - Ceiling design density shall be based on the total height of storage within the building.
 - Sprinklers under walkways: Min. pressure of 15 psi (1 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.

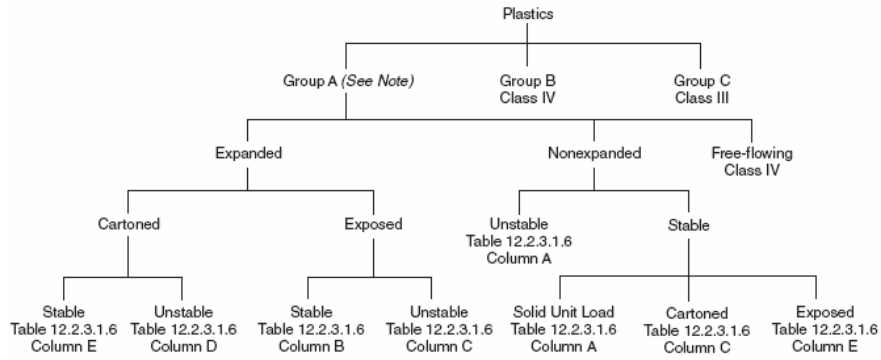
12.2.3 Protection Criteria for Palletized, Solid Piled, Bin Box, or Shelf Storage of Plastic & Rubber Commodities.

- **12.2.3.1 Control Mode Density-Area Sprinkler Protection Criteria for Palletized, Solid Piled, Bin Box, or Shelf Storage of Plastic & Rubber Commodities.**
- **12.2.3.2 Large Drop Sprinklers and Specific Application Control Mode Sprinklers for Palletized or Solid Piled of Plastic & Rubber Commodities.**
- **12.2.3.3 Early Suppression Fast-Response (ESFR) Sprinklers for Palletized, Solid Piled of Plastic & Rubber Commodities.**
- **12.2.3.4 Special Design for Palletized, Solid Piled, Bin Box, or Shelf Storage of Plastic & Rubber Commodities. (Reserved)**

12.2.3.1 Control Mode Density-Area Sprinkler Protection Criteria for Palletized, Solid Piled, Bin Box, or Shelf Storage of Plastic & Rubber Commodities

- **Protection Requirements:**
 - FIGURE 12.2.3.1.1 & Table 12.2.3.1.6
- **Storage Conditions:**
 - Sprinkler system design shall be based on conditions that routinely or periodically exist in a building that create the greatest water demand
 - Pile height
 - Clearance
 - Pile stability
 - Array

FIGURE 12.2.3.1.1 Decision Tree



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

- (a) There shall be multiple layers of corrugation or equivalent outer material that would significantly delay fire involvement of the Group A plastic
- (b) The amount and arrangement of Group A plastic material within an ordinary carton would not be expected to significantly increase the fire hazard

Storage Height		Roof/Ceiling Height		Density									
				A		B		C		D		E	
ft	m	ft	m	gpm/ft ²	mm/min	gpm/ft ²	mm/min	gpm/ft ²	mm/min	gpm/ft ²	mm/min	gpm/ft ²	mm/min
≤ 5	1.52	up to 25	up to 7.62	Curve 3	Curve 3	Curve 3	Curve 3	Curve 3	Curve 3	Curve 3	Curve 3	Curve 3	Curve 3
≤ 12	3.66	up to 15	up to 4.57	0.2	8.2	Curve 5	Curve 5	0.3	12.2	Curve 4	Curve 4	Curve 5	Curve 5
		>15 to 20	>4.57 to 6.1	0.3	12.2	0.6	24.5	0.5	20.4	Curve 5	Curve 5	Curve 5	Curve 5
15	4.5	>20 to 25	>6.1 to 7.62	0.4	16.3	0.8	32.6	0.6	24.5	0.45	18.3	0.7	28.5
		>25 to 35	>7.62 to 10.67	0.25	10.2	0.5	20.4	0.4	16.3	0.3	12.2	0.45	18.3
20	6.1	up to 25	up to 7.62	0.3	12.2	0.6	24.5	0.45	18.3	0.35	14.3	0.55	22.4
		>25 to 30	>7.62 to 9.14	0.45	18.3	0.9	36.7	0.7	28.5	0.55	22.4	0.85	34.6
25	7.62	>30 to 35	>9.14 to 10.67	0.6	24.5	1.2	48.9	0.85	34.6	0.7	28.5	1.1	44.8
		up to 30	up to 9.14	0.4	16.3	0.75	30.6	0.55	22.4	0.45	18.3	0.7	28.5
25	7.62	>30 to 35	>9.14 to 10.67	0.6	24.5	1.2	48.9	0.85	34.6	0.7	28.5	1.1	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, cartonned
 - D: Expanded, cartonned, unstable
 - (1) Expanded, cartonned, stable
 - (2) Nonexpanded, stable, exposed
3. Curve 3 = Density required by Figure 12.1.10 for Curve 3
 Curve 4 = Density required by Figure 12.1.10 for Curve 4
 Curve 5 = Density required by Figure 12.1.10 for Curve 5
4. Hose streams and durations shall be as follows: ≤ 5 ft 250 gpm and 90 minutes; >5 ft to ≤ 20 ft 500 gpm and 120 minutes; >20 ft to ≤ 25 ft 500 gpm and 150 minutes.

**Table 12.2.3.1.6
Design Densities for
Palletized, Solid
Piled, Bin Box, or
Shelf Storage of
Plastic & Rubber
Commodities**

Design Considerations

- Where the distance between roof/ceiling height & top of storage exceeds 20 ft (6.1 m), protection shall be provided for the storage height that would result in a 20-ft (6.1-m) distance between the roof/ceiling height & top of storage.
- Design Area:
 - Min. design area: 2500 ft² (232 m²)
 - Where densities & areas are allowed to be selected using with Figure 12.1.10, Curve 3, any density-area from Curve 3 shall be permitted
 - For closed arrays, min. design area: 2000 ft² (186 m²)
- Interpolation of densities between storage heights shall be permitted.
 - Densities shall be based on 2500 ft² (232 m²) design area
 - The “up to” in the table is intended to aid in the interpolation of densities between storage heights
 - Interpolation of ceiling/roof heights shall not be permitted.

12.2.3 Protection Criteria for Palletized, Solid Piled, Bin Box, or Shelf Storage of Plastic & Rubber Commodities.

- **12.2.3.1 Control Mode Density-Area Sprinkler Protection Criteria for Palletized, Solid Piled, Bin Box, or Shelf Storage of Plastic & Rubber Commodities.**
- **12.2.3.2 Large Drop Sprinklers and Specific Application Control Mode Sprinklers for Palletized or Solid Piled of Plastic & Rubber Commodities.**
- **12.2.3.3 Early Suppression Fast-Response (ESFR) Sprinklers for Palletized, Solid Piled of Plastic & Rubber Commodities.**
- **12.2.3.4 Special Design for Palletized, Solid Piled, Bin Box, or Shelf Storage of Plastic & Rubber Commodities. (Reserved)**

Table 12.2.3.2.1(a) Large-Drop Sprinkler Design Criteria for Palletized and Solid-Piled Storage of Plastic & Rubber Commodities

Storage Arrangement	Commodity Class	Nominal K-Factor	Maximum Storage Height		Maximum Ceiling/Roof Height		Type of System	Number of Design Sprinklers / Minimum Pressure		Hose Stream Demand		Water Supply Duration (hours)
			ft	m	ft	m		/psi	/bar	gpm	L/min	
Palletized	Cartoned or exposed unexpanded plastics	11.2	20	6.1	30	9.1	Wet	25/25	25/1.7	500	1900	2
							Dry	N/A	N/A	N/A	N/A	N/A
	Cartoned or exposed expanded plastics	11.2	18	5.5	26	7.9	Wet	15/50	15/3.4	500	1900	2
							Dry	N/A	N/A	N/A	N/A	N/A
Solid pile	Cartoned or exposed unexpanded plastics	11.2	20	6.1	30	9.1	Wet	15/50	15/3.4	500	1900	2
							Dry	N/A	N/A	N/A	N/A	N/A

Table 12.2.3.2.1(b) Specific Application Control Mode (16.8 K-Factor) Sprinkler Design Criteria for Palletized & Solid-Piled Storage of Plastic and Rubber Commodities

Configuration	Commodity Class	Maximum Storage Height		Maximum Building Height		Type of System	Number of Design Sprinklers by Minimum Operating Pressure		Hose Stream Demand		Water Supply Duration (hours)
		ft	m	ft	m		10 psi (0.7 bar)	22 psi (1.5 bar)	gpm	L/min	
Palletized	Cartoned or exposed unexpanded plastics	25	7.6	30	9.1	Wet	—	15	500	1900	2
Solid pile	Cartoned or exposed unexpanded plastics	25	7.6	30	9.1	Wet	—	15	500	1900	1½

12.2.3 Protection Criteria for Palletized, Solid Piled, Bin Box, or Shelf Storage of Plastic & Rubber Commodities.

- 12.2.3.1 Control Mode Density-Area Sprinkler Protection Criteria for Palletized, Solid Piled, Bin Box, or Shelf Storage of Plastic & Rubber Commodities.
- 12.2.3.2 Large Drop Sprinklers and Specific Application Control Mode Sprinklers for Palletized or Solid Piled of Plastic & Rubber Commodities.
- **12.2.3.3 Early Suppression Fast-Response (ESFR) Sprinklers for Palletized, Solid Piled of Plastic & Rubber Commodities.**
- 12.2.3.4 Special Design for Palletized, Solid Piled, Bin Box, or Shelf Storage of Plastic & Rubber Commodities. (Reserved)

Table 12.2.3.3.1 ESFR Protection of Palletized & Solid-Pile Storage of Plastic & Rubber Commodities

12.2.3.3.1 ESFR Protection of Palletized and Solid-Pile Storage of Plastic and Rubber Commodities											
Storage arrangement	Commodity	Minimum required ESFR			Minimum ESFR	Minimum ESFR	Minimum ESFR	Minimum ESFR	Minimum ESFR	Minimum ESFR	
		W, ft	D, ft	H, ft							
Palletized and solid pile storage of plastic and rubber commodities	Control mode ESFR	20	7.5	11.2	11.2	11.2	11.2	11.2	11.2	1	
				11.2	11.2	11.2	11.2	11.2	11.2		
				11.2	11.2	11.2	11.2	11.2	11.2		
				11.2	11.2	11.2	11.2	11.2	11.2		
				11.2	11.2	11.2	11.2	11.2	11.2		
				11.2	11.2	11.2	11.2	11.2	11.2		
		30	15	11.2	11.2	11.2	11.2	11.2	11.2		11.2
				11.2	11.2	11.2	11.2	11.2	11.2		
				11.2	11.2	11.2	11.2	11.2	11.2		
				11.2	11.2	11.2	11.2	11.2	11.2		
				11.2	11.2	11.2	11.2	11.2	11.2		
				11.2	11.2	11.2	11.2	11.2	11.2		
	Control mode ESFR	20	7.5	11.2	11.2	11.2	11.2	11.2	11.2	1	
				11.2	11.2	11.2	11.2	11.2	11.2		
				11.2	11.2	11.2	11.2	11.2	11.2		
				11.2	11.2	11.2	11.2	11.2	11.2		
				11.2	11.2	11.2	11.2	11.2	11.2		
				11.2	11.2	11.2	11.2	11.2	11.2		
		30	15	11.2	11.2	11.2	11.2	11.2	11.2		11.2
				11.2	11.2	11.2	11.2	11.2	11.2		
				11.2	11.2	11.2	11.2	11.2	11.2		
				11.2	11.2	11.2	11.2	11.2	11.2		
				11.2	11.2	11.2	11.2	11.2	11.2		
				11.2	11.2	11.2	11.2	11.2	11.2		

12.3 Protection of Commodities Stored on Racks

- Formally NFPA 231C
- 12.3.1 Protection Criteria - General
- 12.3.2 Class I - IV Commodities Stored Up to & Including 25' (7.6 m) in Height
- 12.3.3 Plastics Commodities Stored Up to & Including 25' (7.6 m) in Height
- 12.3.4 Class I - IV Commodities Stored Over 25' (7.6 m) in Height
- 12.3.5 Plastics Commodities Stored Over 25' (7.6 m) in Height



12.3.1 Protection Criteria — General

- 12.3.1.2 Sprinkler Protection Criteria.
 - Where protection schemes are based on plastic storage, any Class I - IV commodities of the same storage height & configuration will also be covered
- 12.3.1.3 Hose connections
 - Not required for Class I - IV commodities stored 12 ft (3.7 m) or less in height
- 12.3.1.4 & 12.3.1.5 Temperature Ratings & Design Criteria
 - Where design criteria is specified for ordinary temperature-rated sprinklers the criteria will also apply to intermediate-temperature sprinklers
 - Ordinary- and intermediate-temperature sprinklers with K-factors of 11.2 or larger, where listed for storage, are permitted to use the densities for high-temperature sprinklers.
- 12.3.1.6 Movable Racks.
 - Rack storage in movable racks shall be protected in the same manner as multiple-row racks.

12.3.1.7 Fire Protection of Steel Columns — Columns within Storage Racks of Class I - IV & Plastic Commodities

● Fireproofing Alternatives

- Sidewall sprinklers at the 15-ft (4.6-m) elevation, pointed toward one side of the steel column
- Ceiling sprinkler density for a minimum of 2000 ft² (186 m²) with ordinary or high temperature rated sprinklers as shown in Table 12.3.1.7.1 for storage heights above 15 ft (4.6 m), up to & including 20 ft (6.1 m)
- Large drop, specific application control mode or ESFR ceiling sprinkler protection

Table 12.3.1.7.1 Ceiling Sprinkler Densities for Protection of Steel Building

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	13.5
Class II	0.44	17.9	0.37	15.1
Class III	0.49	20	0.42	17.1
Class IV and Plastics	0.68	27.7	0.57	23.2

12.3.1.8 High-Expansion Foam.

- Designed and installed in accordance with NFPA 11A, Standard for Medium- and High-Expansion Foam
- They shall be automatic in operation, unless modified
- In-rack sprinklers shall not be required where high-expansion foam systems are used in combination with ceiling sprinklers.
- Detectors for High-Expansion Foam Systems.
 - Detectors shall be listed and shall be installed in one of the following configurations:
 - At the ceiling only where installed at one-half the listed linear spacing [e.g., 15 ft x 15 ft (4.6 m x 4.6 m) rather than at 30 ft x 30 ft (9.1 m x 9.1 m)]; at the ceiling at the listed spacing and in racks at alternate levels
 - 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
 - Ceiling detectors alone shall not be used where the ceiling/roof clearance from the top of the storage exceeds 10 ft (3.1 m) or the height of the storage exceeds 25 ft (7.6 m).
- Detectors for preaction systems shall be installed in the same as detectors for high-expansion foam systems

12.3.1.9 Solid Shelving

- Where the area of the solid shelving is less than 20 ft²:
 - In-rack sprinklers are not required
- Where the area of solid shelving is 20 - 64 ft²:
 - In-rack sprinklers are not required below every shelf
 - In-rack sprinklers shall be installed at the ceiling & below shelves at intermediate levels not more than 6 ft apart vertically.
- Where the area of solid shelving is greater than 64 ft²:
 - In-rack sprinklers shall be installed at the ceiling & below each level of shelving.



12.3.1.10 Open-Top Combustible Containers

- NFPA 13
 - No Criteria
 - Recommendation: Installation of in-rack sprinklers or an increase in ceiling sprinkler density (C.12)
- FM 8-9
 - Protect the same as racks with 20-64 sq.ft. (1.9 -5.9 m²) solid shelves, except that at least one level of in-rack sprinklers is needed for all storages higher than 8 ft (2.4 m) with more than one level of containers.



12.3.1.11 - 12.3.1.14 In-Rack Sprinklers

- In-rack sprinklers systems must be hydraulic calculated. They cannot be pipe scheduled
- When in-rack sprinklers are necessary to protect a higher hazard commodity that occupies only a portion of the length of a rack:
 - Extended the in-rack sprinklers a minimum of 8 ft or one bay, whichever is greater, in each direction along the rack on either side of the higher hazard
 - In-rack sprinklers protecting the higher hazard need not be extended across the aisle
- Where a storage rack, due to its length, requires less than the number of in-rack sprinklers specified, only those in-rack sprinklers in a single rack need to be included in the calculation.
- Horizontal barriers used in conjunction 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 width of the rack. Barriers shall be fitted within 2 in. (51 mm) horizontally around rack uprights.

- For Storage Up to and Including 25 ft (7.6 m):
 - In double- & multiple-row racks without solid shelves, a longitudinal flue space is not be required.
 - Nominal 6" (152.4-mm) transverse flue spaces between loads & at-rack uprights shall be maintained in single-, double- & multiple-row racks.
 - Random variations in the width of flue spaces or in their vertical alignment shall be permitted.
- For Storage over 25 ft (7.6 m):
 - Nominal 6" (152.4-mm) transverse flue spaces between loads & at rack uprights shall be maintained in single-, double- & multiple-row racks.
 - Nominal 6" (152.4-mm) longitudinal flue spaces shall be provided in double-row racks.
 - Random variations in the width of the flue spaces or in their vertical alignment shall be permitted.
 - In single-, double- or multiple-row racks, a min. 6" (152.4-mm) vertical clear space shall be maintained between the sprinkler deflectors & the top tier of storage. Face sprinklers in such racks shall be located a min. of 3" (76 mm) from rack uprights & no more than 18" (460 mm) from the aisle face of storage. Longitudinal flue in-rack sprinklers shall be located at the intersection with the transverse flue space & with the deflector located at or below the bottom of horizontal load beams or above or below other adjacent horizontal rack members. Such in-rack sprinklers shall be a minimum of 3" (76 mm) radially from the side of the rack uprights.

12.3.2 Protection Criteria for Rack Storage of Class I – IV Commodities Stored Up to & Including 25 ft (7.6 m) in Height.

- 12.3.2.1 Control Mode Density-Area Sprinkler Protection Criteria for Rack Storage of Class I - IV Commodities Stored Up to & Including 25 ft (7.6 m) in Height.
- 12.3.2.2 Large Drop Sprinklers and Specific Application Control Mode Sprinklers for Rack Storage of Class I - IV Commodities Stored Up to & Including 25 ft (7.6 m) in Height.
- 12.3.2.3 Early Suppression Fast-Response (ESFR) Sprinklers for Rack Storage of Class I - IV Commodities Stored Up to & Including 25 ft (7.6 m) in Height.
- 12.3.2.4 In-Rack Sprinklers for Rack Storage of Class I – IV Commodities Stored Up to & Including 25 ft (7.6 m) in Height.
- 12.3.2.5 Special Design for Rack Storage of Class I - IV Commodities Stored Up to & Including 25 ft (7.6 m) in Height.

**Table 12.3.2.1.2
Single- or Double-
Row Racks —
Storage Height Up
to & Including 25 ft
(7.6 m) Without
Solid Shelves**

Height	Commodity Class	Encapsulated	Aisle*		Sprinkler Protection In Rack	Ceiling Sprinkler Water Demand						
			ft	m		With In-Rack Sprinklers			Without In-Rack Sprinklers			
						Figure	Column	Apply Figure 12.3.2.1.3.1	Figure	Column	Apply Figure 12.3.2.1.3.1	
Over 12 ft (3.7 m), up to and including 25 ft (7.6 m)	I	No	4	1.2	No	12.3.2.1.2(a)	Column D	—	—	12.3.2.1.2(a)	Foot H, E and F	Yes
		Yes	4	1.2	No	12.3.2.1.2(b)	Column D	—	—	12.3.2.1.2(b)	Foot H, E and F	Yes
		No	4	1.2	No	12.3.2.1.2(a)	Column D	—	—	12.3.2.1.2(a)	Foot H, E and F	Yes
		Yes	4	1.2	No	12.3.2.1.2(b)	Column D	—	—	12.3.2.1.2(b)	Foot H, E and F	Yes
	II	No	4	1.2	No	12.3.2.1.2(a)	Column D	—	—	12.3.2.1.2(a)	Foot H, E and F	Yes
		Yes	4	1.2	No	12.3.2.1.2(b)	Column D	—	—	12.3.2.1.2(b)	Foot H, E and F	Yes
		No	4	1.2	No	12.3.2.1.2(a)	Column D	—	—	12.3.2.1.2(a)	Foot H, E and F	Yes
		Yes	4	1.2	No	12.3.2.1.2(b)	Column D	—	—	12.3.2.1.2(b)	Foot H, E and F	Yes
	III	No	4	1.2	No	12.3.2.1.2(a)	Column D	—	—	12.3.2.1.2(a)	Foot H, E and F	Yes
		Yes	4	1.2	1 level	12.3.2.1.2(b)	Column D	—	—	—	—	—
		No	4	1.2	No	12.3.2.1.2(a)	Column D	—	—	12.3.2.1.2(a)	Foot H, E and F	Yes
		Yes	4	1.2	No	12.3.2.1.2(b)	Column D	—	—	12.3.2.1.2(b)	Foot H, E and F	Yes
IV	No	4	1.2	No	12.3.2.1.2(a)	Column D	—	—	12.3.2.1.2(a)	Foot H, E and F	Yes	
	Yes	4	1.2	1 level	12.3.2.1.2(b)	Column D	—	—	—	—	—	
	No	4	1.2	No	12.3.2.1.2(a)	Column D	—	—	12.3.2.1.2(a)	Foot H, E and F	Yes	
	Yes	4	1.2	No	12.3.2.1.2(b)	Column D	—	—	12.3.2.1.2(b)	Foot H, E and F	Yes	
Over 20 ft (6.1 m), up to and including 25 ft (7.6 m)	I	No	4	1.2	No	12.3.2.1.2(a)	Column D	—	—	12.3.2.1.2(a)	Foot H, E and C	Yes
		Yes	4	1.2	No	12.3.2.1.2(b)	Column D	—	—	12.3.2.1.2(b)	Foot H, E and C	Yes
		No	4	1.2	1 level	12.3.2.1.2(a)	Column D	—	—	—	—	—
		Yes	4	1.2	1 level	12.3.2.1.2(b)	Column D	—	—	—	—	—
	II	No	4	1.2	No	12.3.2.1.2(a)	Column D	—	—	12.3.2.1.2(a)	Foot H, E and F	Yes
		Yes	4	1.2	No	12.3.2.1.2(b)	Column D	—	—	12.3.2.1.2(b)	Foot H, E and F	Yes
		No	4	1.2	1 level	12.3.2.1.2(a)	Column D	—	—	—	—	—
		Yes	4	1.2	1 level	12.3.2.1.2(b)	Column D	—	—	—	—	—
	III	No	4	1.2	No	12.3.2.1.2(a)	Column D	—	—	12.3.2.1.2(a)	Foot H, E and F	Yes
		Yes	4	1.2	No	12.3.2.1.2(b)	Column D	—	—	12.3.2.1.2(b)	Foot H, E and F	Yes
		No	4	1.2	1 level	12.3.2.1.2(a)	Column D	—	—	—	—	—
		Yes	4	1.2	1 level	12.3.2.1.2(b)	Column D	—	—	—	—	—
IV	No	4	1.2	No	12.3.2.1.2(a)	Column D	—	—	12.3.2.1.2(a)	Foot H, E and F	Yes	
	Yes	4	1.2	No	12.3.2.1.2(b)	Column D	—	—	12.3.2.1.2(b)	Foot H, E and F	Yes	
	No	4	1.2	1 level	12.3.2.1.2(a)	Column D	—	—	—	—	—	
	Yes	4	1.2	1 level	12.3.2.1.2(b)	Column D	—	—	—	—	—	
Over 15 ft (4.6 m), up to and including 25 ft (7.6 m)	I	No	4	1.2	No	12.3.2.1.2(a)	Column D	—	—	12.3.2.1.2(a)	Foot H, E and C	Yes
		Yes	4	1.2	No	12.3.2.1.2(b)	Column D	—	—	12.3.2.1.2(b)	Foot H, E and C	Yes
		No	4	1.2	1 level	12.3.2.1.2(a)	Column D	—	—	—	—	—
		Yes	4	1.2	1 level	12.3.2.1.2(b)	Column D	—	—	—	—	—
	II	No	4	1.2	No	12.3.2.1.2(a)	Column D	—	—	12.3.2.1.2(a)	Foot H, E and F	Yes
		Yes	4	1.2	No	12.3.2.1.2(b)	Column D	—	—	12.3.2.1.2(b)	Foot H, E and F	Yes
		No	4	1.2	1 level	12.3.2.1.2(a)	Column D	—	—	—	—	—
		Yes	4	1.2	1 level	12.3.2.1.2(b)	Column D	—	—	—	—	—
	III	No	4	1.2	No	12.3.2.1.2(a)	Column D	—	—	12.3.2.1.2(a)	Foot H, E and F	Yes
		Yes	4	1.2	No	12.3.2.1.2(b)	Column D	—	—	12.3.2.1.2(b)	Foot H, E and F	Yes
		No	4	1.2	1 level	12.3.2.1.2(a)	Column D	—	—	—	—	—
		Yes	4	1.2	1 level	12.3.2.1.2(b)	Column D	—	—	—	—	—
IV	No	4	1.2	No	12.3.2.1.2(a)	Column D	—	—	12.3.2.1.2(a)	Foot H, E and F	Yes	
	Yes	4	1.2	No	12.3.2.1.2(b)	Column D	—	—	12.3.2.1.2(b)	Foot H, E and F	Yes	
	No	4	1.2	1 level	12.3.2.1.2(a)	Column D	—	—	—	—	—	
	Yes	4	1.2	1 level	12.3.2.1.2(b)	Column D	—	—	—	—	—	

*See 12.3.2.1.2.1 for interpretation of aisle widths.

Table 12.3.2.1.3 Multiple-Row Racks - Rack Depth Up to & Including 16' (4.9 m), Aisles 8' (2.4 m) or Wider, Storage Height to 25' (7.6 m)

Height	Commodity Class	Escape-rotated	Sprinklers Mandatory In-Racks	Ceiling Sprinkler Water Demand							
				With In-Rack Sprinklers				Without In-Rack Sprinklers			
				Figure	Curves	Apply Figure 12.3.2.1.5.1	1.25 × Density	Figure	Curves	Apply Figure 12.3.2.1.5.1	1.25 × Density
Over 12 ft (3.7 m), up to and including 15 ft (4.6 m)	I	No	No	12.3.2.1.2(a)	C and D	Yes	No	12.3.2.1.2(a)	I and J	No	No
		Yes	No	12.3.2.1.2(a)			Yes	12.3.2.1.2(a)	I and J	Yes	Yes
		No	No	12.3.2.1.2(b)			No	12.3.2.1.2(b)	I and J	Yes	No
		Yes	No	12.3.2.1.2(b)			Yes	12.3.2.1.2(b)	I and J	Yes	Yes
	II	No	No	12.3.2.1.2(c)	C and D	Yes	No	12.3.2.1.2(c)	I and J	Yes	No
		Yes	1 level	12.3.2.1.2(c)			Yes	12.3.2.1.2(c)	NA	NA	NA
		No	No	12.3.2.1.2(d)			No	12.3.2.1.2(d)	C and D	No	NA
		Yes	1 level	12.3.2.1.2(d)			1.50 × density	NA	NA	NA	NA
Over 15 ft (4.6 m), up to and including 20 ft (6.1 m)	I	No	No	12.3.2.1.2(a)	C and D	Yes	No	12.3.2.1.2(a)	I and J	Yes	No
		Yes	No	12.3.2.1.2(a)			Yes	12.3.2.1.2(a)	I and J	Yes	Yes
		No	No	12.3.2.1.2(b)			No	12.3.2.1.2(b)	I and J	Yes	No
		Yes	1 level	12.3.2.1.2(b)			Yes	12.3.2.1.2(b)	I and J	Yes	Yes
	III	No	No	12.3.2.1.2(c)	C and D	Yes	No	12.3.2.1.2(c)	I and J	Yes	No
		Yes	1 level	12.3.2.1.2(c)			Yes	NA	NA	NA	NA
		No	No	12.3.2.1.2(d)			No	1.50 × density	NA	NA	NA
		Yes	1 level	12.3.2.1.2(d)			1.50 × density	NA	NA	NA	NA
Over 20 ft (6.1 m), up to and including 25 ft (7.6 m)	I	No	No	12.3.2.1.2(a)	C and D	No	No	12.3.2.1.2(a)	I and J	Yes	No
		Yes	1 level	12.3.2.1.2(a)			Yes	NA	NA	NA	NA
		No	No	12.3.2.1.2(b)			No	NA	NA	NA	NA
		Yes	1 level	12.3.2.1.2(b)			Yes	NA	NA	NA	NA
	II	No	No	12.3.2.1.2(c)	C and D	No	No	NA	NA	NA	NA
		Yes	1 level	12.3.2.1.2(c)			Yes	NA	NA	NA	NA
		No	No	12.3.2.1.2(d)			No	1.50 × density	NA	NA	NA
		Yes	2 levels	12.3.2.1.2(d)			1.50 × density	NA	NA	NA	NA

Table 12.3.2.1.4 Multiple-Row Racks - Rack Depth Over 16' (4.9 m) or Aisles Narrower than 8' (2.4 m), Storage Height Up to & Including 25' (7.6 m)

Height	Commodity Class	Escape-rotated	Sprinklers Mandatory In-Racks	Ceiling Sprinkler Water Demand							
				With In-Rack Sprinklers				Without In-Rack Sprinklers			
				Figure	Curves	Apply Figure 12.3.2.1.5.1	1.25 × Density	Figure	Curves	Apply Figure 12.3.2.1.5.1	1.25 × Density
Over 12 ft (3.7 m), up to and including 15 ft (4.6 m)	I	No	No	12.3.2.1.2(a)	C and D	Yes	No	12.3.2.1.2(a)	I and J	No	No
		Yes	No	12.3.2.1.2(a)			Yes	12.3.2.1.2(a)	I and J	Yes	Yes
		No	No	12.3.2.1.2(b)			No	12.3.2.1.2(b)	I and J	Yes	No
		Yes	No	12.3.2.1.2(b)			Yes	12.3.2.1.2(b)	I and J	Yes	Yes
	II	No	No	12.3.2.1.2(c)	C and D	Yes	No	12.3.2.1.2(c)	I and J	Yes	No
		Yes	1 level	12.3.2.1.2(c)			Yes	12.3.2.1.2(c)	NA	NA	NA
		No	No	12.3.2.1.2(d)			No	1.50 × density	C and D	No	No
		Yes	1 level	12.3.2.1.2(d)			1.50 × density	NA	NA	NA	NA
Over 15 ft (4.6 m), up to and including 20 ft (6.1 m)	I	No	No	12.3.2.1.2(a)	C and D	Yes	No	12.3.2.1.2(a)	I and J	Yes	No
		Yes	No	12.3.2.1.2(a)			Yes	12.3.2.1.2(a)	I and J	Yes	Yes
		No	No	12.3.2.1.2(b)			No	12.3.2.1.2(b)	I and J	Yes	No
		Yes	1 level	12.3.2.1.2(b)			Yes	12.3.2.1.2(b)	I and J	Yes	Yes
	III	No	No	12.3.2.1.2(c)	C and D	Yes	No	12.3.2.1.2(c)	I and J	Yes	No
		Yes	1 level	12.3.2.1.2(c)			Yes	NA	NA	NA	NA
		No	No	12.3.2.1.2(d)			No	1.50 × density	C and D	No	No
		Yes	1 level	12.3.2.1.2(d)			1.50 × density	NA	NA	NA	NA
Over 20 ft (6.1 m), up to and including 25 ft (7.6 m)	I	No	No	12.3.2.1.2(a)	C and D	No	No	12.3.2.1.2(a)	I and J	Yes	No
		Yes	1 level	12.3.2.1.2(a)			Yes	NA	NA	NA	NA
		No	No	12.3.2.1.2(b)			No	NA	NA	NA	NA
		Yes	1 level	12.3.2.1.2(b)			Yes	NA	NA	NA	NA
	II	No	No	12.3.2.1.2(c)	C and D	No	No	NA	NA	NA	NA
		Yes	1 level	12.3.2.1.2(c)			Yes	NA	NA	NA	NA
		No	No	12.3.2.1.2(d)			No	1.50 × density	C and D	No	No
		Yes	2 levels	12.3.2.1.2(d)			1.50 × density	NA	NA	NA	NA

Figure 12.3.2.1.2(a) - 12.3.2.1.2(g)

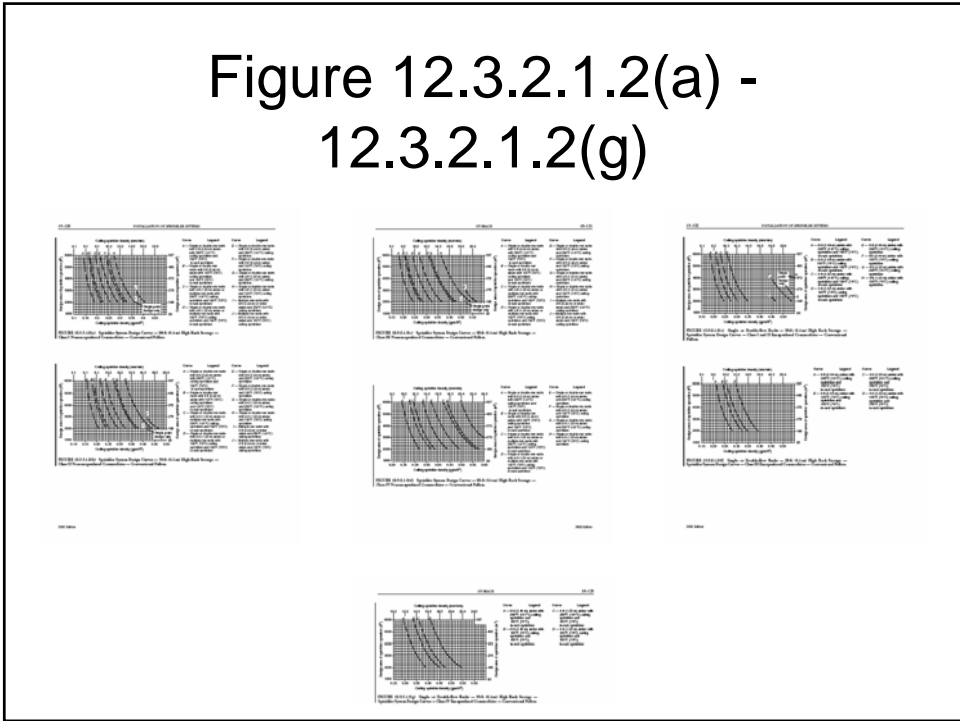


FIGURE 12.3.2.1.5.1 Ceiling Sprinkler Density vs. Storage Height

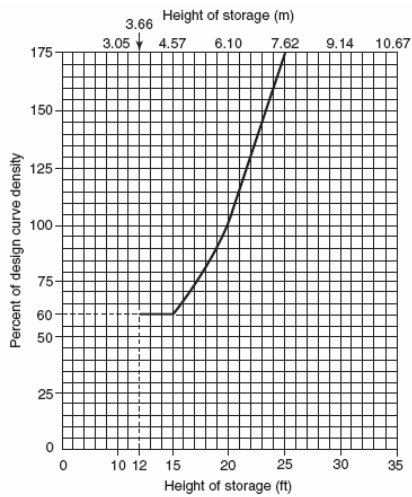


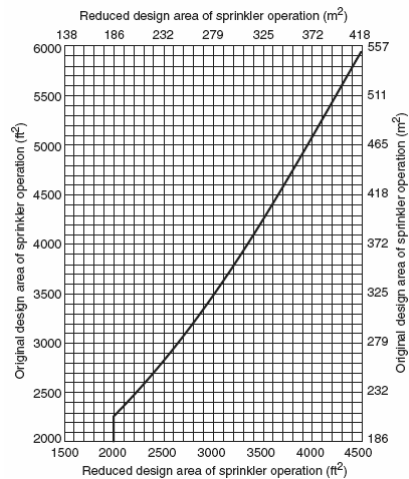
Table 12.3.2.1.5.3 Adjustment to Ceiling Sprinkler Density for Storage Height & In-Rack Sprinklers

Storage Height	In-Rack Sprinklers	Apply Figure 12.3.2.1.5.1 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	Yes	Reduce density 40% from that of minimum in-rack sprinklers
Over 20 ft (6.1 m) through 24 ft (7.5 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	No	Reduce density 40% from that of minimum in-rack sprinklers

Clearance from ceiling to top of storage less than 4-½ ft (1.37 m)

- The sprinkler operating area indicated in curves E, F, G & H in Figure 12.3.2.1.2(a) - Figure 12.3.2.1.2(e) may be reduced (See Figure 12.3.2.1.5.7) but not less than 2000 ft² (185.8 m²)

FIGURE 12.3.2.1.5.7 Adjustment of Design Area of Sprinkler Operation for Clearance from Top of Storage to Ceiling.



12.3.2.1.5 Ceiling Sprinkler Density Adjustments

- Where clearance from ceiling to top of Class I or Class I encapsulated storage is 1.5' – 3' (0.46 m to 0.91 m), the sprinkler operating area indicated in curve F only of Figure 12.3.2.1.2(e) may be reduced by 50% but cannot be reduced to less than 2000 ft² (186 m²).
- Where solid, flat-bottom, combustible pallets are used with storage height up to and including 25' (7.6 m), the densities that are indicated in the design curves shown in Figure 12.3.2.1.2(a) - Figure 12.3.2.1.2(g), based on conventional pallets, shall be increased 20% for the given area. The percentage shall be applied to the density determined in accordance with Figure 12.3.2.1.5.1. The increase in density shall not apply where in-rack sprinklers are installed.

Hose Stream Demand & Water Supply Duration

- Water supply requirements shall be determined by adding the hose stream demand to the water supply for sprinklers. This supply shall be available for the minimum duration specified
- An allowance for inside & outside hose shall not be required where tanks supply sprinklers only
- Where pumps taking suction from a private fire service main supply sprinklers only, the pump need not be sized to accommodate inside and outside hose. Such hose allowance shall be considered in evaluating the available water supplies.

Table 12.3.2.1.6 Hose Stream Demand and Water Supply Duration Requirements for Rack Storage of Class I through Class IV Commodities Stored Up to and Including 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	
Class I, II, and III	Over 12	Over 3.7	0, 50, or 100	0, 190, 380	500	1900	90
Class IV	Over 12	Over 3.7	0, 50, or 100	0, 190, 380	500	1900	120

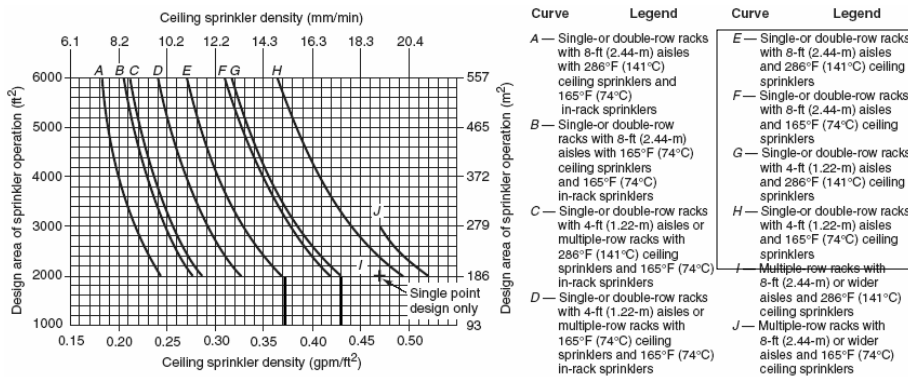
Class III Nonencapsulated Commodity in heated warehouse.

Build.: 22' (6.7 m) Storage: 17' (5.2 m)

Double Row Rack with 6' (1.8 m) Aisle

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 12.3.2.1.5.1	Figure	Curves	Apply Figure 12.3.2.1.5.1	
Over 12 ft (3.7 m), up to and including 20 ft (6.1m)	I	No	4	1.2	No	12.3.2.1.2(a)	C and D	Yes	12.3.2.1.2(a)	F and H	Yes	
			8	2.4			A and B			E and G		
		Yes	4	1.2	No	12.3.2.1.2(c)	C and D	Yes	12.3.2.1.2(c)	G and H	Yes	
			8	2.4			A and B			E and F		
	II	No	No	4	1.2	No	12.3.2.1.2(b)	C and D	Yes	12.3.2.1.2(b)	G and H	Yes
				8	2.4			A and B			E and F	
		Yes	No	4	1.2	No	12.3.2.1.2(c)	C and D	Yes	12.3.2.1.2(c)	G and H	Yes
				8	2.4			A and B			E and F	
	III	No	No	4	1.2	No	12.3.2.1.2(c)	C and D	Yes	12.3.2.1.2(c)	G and H	Yes
				8	2.4			A and B			E and F	
		Yes	1 level	4	1.2	1 level	12.3.2.1.2(f)	C and D	—	—	—	
				8	2.4			A and B				
	IV	No	No	4	1.2	No	12.3.2.1.2(d)	C and D	Yes	12.3.2.1.2(d)	G and H	Yes
				8	2.4			A and B			E and F	
		Yes	1 level	4	1.2	1 level	12.3.2.1.2(g)	C and D	—	—	—	
				8	2.4			A and B				

FIGURE 12.3.2.1.2(c) Sprinkler System Design Curves - 20-ft (6.1-m) High Rack Storage - Class III Nonencapsulated Commodities - Conventional Pallets



E - 8' (2.4m) Aisle - .37 gpm/sq.ft. / 2000 sq.ft. (15.1 mm/min / 184 m²)

G - 4' (1.2m) Aisle - .43 gpm/sq.ft. / 2000 sq.ft. (17.5 mm/min / 184 m²)

Design Adjustments - 12.3.2.1.2.1

- Design densities for single- & double-row racks shall be selected to correspond to aisle width.
- For aisle widths between 4 ft (1.2 m) & 8 ft (2.4 m), a direct linear interpolation between densities shall be made.

E - 8' (2.4m) Aisle - .37 gpm/sq.ft. / 2000 sq.ft. (15.1 mm/min / 184 m²)

G - 4' (1.2m) Aisle - .43 gpm/sq.ft. / 2000 sq.ft. (17.5 mm/min / 184 m²)

6' (1.2m) Aisle - .40 gpm/sq.ft. / 2000 sq.ft. (16.3 mm/min / 184 m²)

Design Adjustments – FIGURE 12.3.2.1.5.1 Ceiling Sprinkler Density vs. Storage Height

.40 gpm/sq.ft. / 2000 sq.ft.

X 0.75

.30 gpm/sq.ft. / 2000 sq.ft.

16.3 mm/min / 184 m²

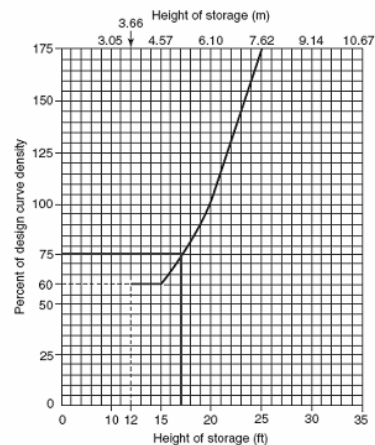
X 0.75

12.2 mm/min / 184 m²

Design Requirement:

.30 gpm/sq.ft. / 2000 sq.ft.

(12.2 mm/min / 184 m²)



12.3.2 Protection Criteria for Rack Storage of Class I – IV Commodities Stored Up to & Including 25 ft (7.6 m) in Height.

- 12.3.2.1 Control Mode Density-Area Sprinkler Protection Criteria for Rack Storage of Class I - IV Commodities Stored Up to & Including 25 ft (7.6 m) in Height.
- 12.3.2.2 Large Drop Sprinklers and Specific Application Control Mode Sprinklers for Rack Storage of Class I - IV Commodities Stored Up to & Including 25 ft (7.6 m) in Height.
- 12.3.2.3 Early Suppression Fast-Response (ESFR) Sprinklers for Rack Storage of Class I - IV Commodities Stored Up to & Including 25 ft (7.6 m) in Height.
- 12.3.2.4 In-Rack Sprinklers for Rack Storage of Class I – IV Commodities Stored Up to & Including 25 ft (7.6 m) in Height.
- 12.3.2.5 Special Design for Rack Storage of Class I - IV Commodities Stored Up to & Including 25 ft (7.6 m) in Height.

Table 12.3.2.2.1(a) Large Drop Sprinkler Design Criteria for Single-, Double- & Multiple-Row

Racks without Solid Shelves of Class I - IV Commodities Stored Up to & including 25 ft (7.6 m) in Height

and

Table 12.3.2.2.1(b) Specific Application Control Mode (16.8 K-factor) Sprinkler Design Criteria for Single-, Double-, & Multiple-Row Racks without Solid Shelves of Class I - IV Commodities Stored Up to & Including 25 ft (7.6 m) in Height

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Table 12.3.2.2.1(a) Large Drop Sprinkler Design Criteria for Single-, Double-, and Multiple-Row Racks without Solid Shelves of Class I through Class IV Commodities Stored Up to and Including 25 ft (7.6 m) in Height

Commodity Class	Minimum Storage Depth	Minimum Storage Depth		Maximum Ceiling Rise Height	Type of System	Number of Design Sprinklers per Rack		Minimum Sprinkler Spacing	Minimum Sprinkler Spacing	Minimum Sprinkler Spacing	Minimum Sprinkler Spacing
		ft	m			ft	m				
A, B	11.2	25	7.6	10	Wet	15	15	10	10	10	10
						15	15				
1, 1B, 1C	11.2	25	6.1	10	Wet	15	15	10	10	10	10
						15	15				
1, 1B, 1C	11.2	25	7.6	10	Wet	15	15	10	10	10	10
						15	15				
R ¹	11.2	25	6.1	25	Wet	15	15	10	10	10	10
						15	15				
R ²	11.2	25	6.1	30	Wet	15	15	10	10	10	10
						15	15				
R ³	11.2	25	6.1	30	Wet	15	15	10	10	10	10
						15	15				
R ⁴	11.2	25	6.1	30	Wet	15	15	10	10	10	10
						15	15				
R ⁵	11.2	25	7.6	30	Wet	15	15	10	10	10	10
						15	15				

Table 12.3.2.2.1(b) Specific Application Control Mode (16.8 K-factor) Sprinkler Design Criteria for Single-, Double-, and Multiple-Row Racks without Solid Shelves of Class I through Class IV Commodities Stored Up to and Including 25 ft (7.6 m) in Height

Commodity Class	Minimum Storage Depth		Maximum Ceiling Rise Height	Type of System	Number of Design Sprinklers per Rack		Minimum Sprinkler Spacing	Minimum Sprinkler Spacing	Minimum Sprinkler Spacing	Minimum Sprinkler Spacing
	ft	m			ft	m				
1 or R ¹	25	7.6	10	Wet	15	15	10	10	10	10
R ² or R ³	25	7.6	10	Wet	15	15	10	10	10	10

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12.3.2 Protection Criteria for Rack Storage of Class I – IV Commodities Stored Up to & Including 25 ft (7.6 m) in Height.

- 12.3.2.1 Control Mode Density-Area Sprinkler Protection Criteria for Rack Storage of Class I - IV Commodities Stored Up to & Including 25 ft (7.6 m) in Height.
- 12.3.2.2 Large Drop Sprinklers and Specific Application Control Mode Sprinklers for Rack Storage of Class I - IV Commodities Stored Up to & Including 25 ft (7.6 m) in Height.
- 12.3.2.3 Early Suppression Fast-Response (ESFR) Sprinklers for Rack Storage of Class I - IV Commodities Stored Up to & Including 25 ft (7.6 m) in Height.
- 12.3.2.4 In-Rack Sprinklers for Rack Storage of Class I – IV Commodities Stored Up to & Including 25 ft (7.6 m) in Height.
- 12.3.2.5 Special Design for Rack Storage of Class I - IV Commodities Stored Up to & Including 25 ft (7.6 m) in Height.

Table 12.3.2.3.1 ESFR Protection of Rack Storage without Solid Shelves of Class I - IV Commodities Stored Up to & Including 25 ft (7.6 m) in Height

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Table 12.3.2.3.1 ESFR Protection of Rack Storage without Solid Shelves of Class I through Class IV Commodities Stored Up to and Including 25 ft (7.6 m) in Height

Storage Arrangement	Commodity	Minimum Height	Maximum Ceiling/Truss Height		Sprinkler Protection	Minimum Clearance		ESFR Sprinkler	ESFR Protection	ESFR Protection	ESFR Protection	ESFR Protection	ESFR Protection	
			ft	m		ft	m							
Rack Storage without Solid Shelves	Class I, II, III, and IV	10	10	20	ESFR Protection	0	0	ESFR Sprinkler	ESFR Protection	ESFR Protection	ESFR Protection	ESFR Protection	ESFR Protection	
						0	0	ESFR Sprinkler	ESFR Protection	ESFR Protection	ESFR Protection	ESFR Protection		
						0	0	ESFR Sprinkler	ESFR Protection	ESFR Protection	ESFR Protection	ESFR Protection		
		15	15	30	ESFR Protection	0	0	ESFR Sprinkler	ESFR Protection	ESFR Protection	ESFR Protection	ESFR Protection	ESFR Protection	ESFR Protection
						0	0	ESFR Sprinkler	ESFR Protection	ESFR Protection	ESFR Protection	ESFR Protection		
						0	0	ESFR Sprinkler	ESFR Protection	ESFR Protection	ESFR Protection	ESFR Protection		
	Class I, II, III, and IV	20	20	40	ESFR Protection	0	0	ESFR Sprinkler	ESFR Protection	ESFR Protection	ESFR Protection	ESFR Protection	ESFR Protection	
						0	0	ESFR Sprinkler	ESFR Protection	ESFR Protection	ESFR Protection	ESFR Protection		
						0	0	ESFR Sprinkler	ESFR Protection	ESFR Protection	ESFR Protection	ESFR Protection		
		25	25	50	ESFR Protection	0	0	ESFR Sprinkler	ESFR Protection	ESFR Protection	ESFR Protection	ESFR Protection	ESFR Protection	
						0	0	ESFR Sprinkler	ESFR Protection	ESFR Protection	ESFR Protection	ESFR Protection		
						0	0	ESFR Sprinkler	ESFR Protection	ESFR Protection	ESFR Protection	ESFR Protection		

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12.3.5 Protection Criteria for Rack Storage of Plastics Commodities Stored Over 25 ft (7.6 m) in Height

- 12.3.5.1 Control Mode Density-Area Sprinkler Protection Criteria for Rack Storage of Plastics Commodities Stored Over 25 ft (7.6 m) in Height for Single-, Double-, and Multiple-Row Racks
- 12.3.5.2 Large Drop Sprinklers and Specific Application Control Mode Sprinklers for Rack Storage of Plastics Commodities Stored Over 25 ft (7.6 m) in Height
- 12.3.5.3 Early Suppression Fast-Response (ESFR) Sprinklers for Rack Storage of Plastics Commodities Stored Over 25 ft (7.6 m) in Height
- 12.3.5.4 In-Rack Sprinklers for Rack Storage of Plastics Commodities Stored Over 25 ft (7.6 m) in Height

12.3.5.1 Control Mode Density-Area Sprinkler Protection Criteria for Rack Storage of Plastics Commodities Stored Over 25 ft (7.6 m) in Height for Single-, Double-, & Multiple-Row Racks

Table 12.3.5.1.1 Control Mode Density-Area Sprinkler Discharge Criteria for Single-, Double-, and Multiple-Row Racks of Plastics Commodities with Storage Over 25 ft (7.6 m) in Height

Storage Height above Top Level In-Rack Sprinklers	Ceiling Sprinklers Density (gpm/ft ²)
5 ft or less	0.30/2000
Over 5 ft up to 10 ft	0.45/2000

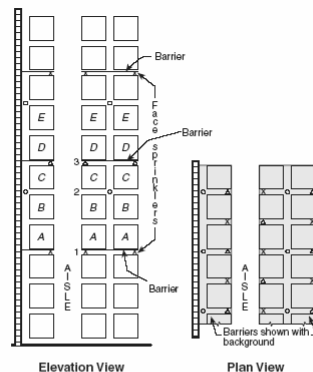
In-Rack Sprinkler Arrangement & Hose Stream Demand

- Single-row rack mixed with double-row racks
 - Figure 12.3.5.1.2(a) or Figure 12.3.5.1.2(b)
- Single-row rack
 - Figure 12.3.5.1.2.1(a) - Figure 12.3.5.1.2.1(c)
- Water supply requirements shall be determined by adding the hose stream demand to the water supply for sprinklers. This supply shall be available for the minimum duration specified

Table 12.3.5.1.3 Hose Stream Demand and Water Supply Duration Requirements for Rack Storage of Plastics Commodities Stored Above 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, 100	0, 190, 380	500	1900	120

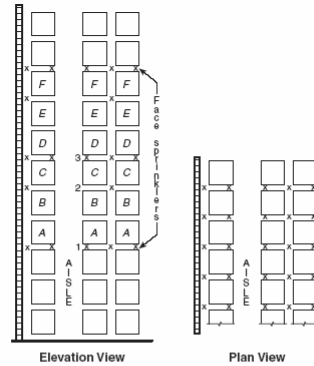
FIGURE 12.3.5.1.2(a) In-Rack Sprinkler Arrangement, Group A Plastic Commodities, Storage Height Over 25' (7.6 m) - Option 1



Notes:

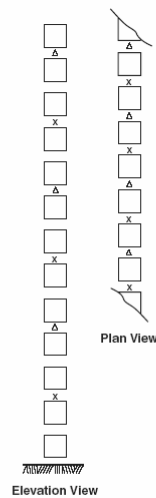
1. Sprinklers and barriers labeled 1 shall be required where loads labeled A or B represent top of storage.
2. Sprinklers labeled 1 and 2 and barriers labeled 1 shall be required where loads labeled C represent top of storage.
3. Sprinklers and barriers labeled 1 and 3 shall be required where loads labeled 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 slagger.
6. Symbol o indicates longitudinal flue space sprinklers.
7. Each square represents a storage cube measuring 4 ft to 5 ft (1.22 m to 1.53 m) on a side. Actual load heights can vary from approximately 18 in. (0.46 m) up to 10 ft (3.05 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 (3.05 m) apart vertically.

FIGURE
12.3.5.1.2(b) In-Rack Sprinkler Arrangement, Group A Plastic Commodities, Storage Height Over 25' (7.6 m) - Option 2



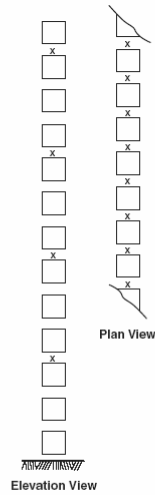
- Notes:
1. Sprinklers labeled 1 shall be required where loads labeled A or B represent top of storage.
 2. Sprinklers labeled 1 and 2 shall be required where loads labeled C represent top of storage.
 3. Sprinklers labeled 1 and 3 shall be required where loads labeled D or E represent top of storage.
 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 (1.22 m to 1.53 m) on a side. Actual load heights can vary from approximately 18 in. (0.46 m) up to 10 ft (3.05 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 (3.05 m) apart vertically.

FIGURE
12.3.5.1.2.1(a) In-Rack Sprinkler Arrangement, Group A Plastic Commodities, Single-Row Racks, Storage Height Over 25' (7.6 m) - Option 1



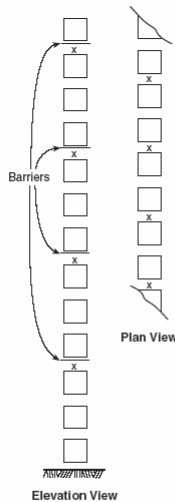
- Note: Each square represents a storage cube measuring 4 ft to 5 ft (1.22 m to 1.53 m) on a side. Actual load heights can vary from approximately 18 in. (0.46 m) up to 10 ft (3.05 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.05 m) apart vertically.

FIGURE
12.3.5.1.2.1(b)
In-Rack Sprinkler
Arrangement,
Group A Plastic
Commodities,
Single-Row
Racks, Storage
Height Over 25'
(7.6 m) - Option
2



Note: Each square represents a storage cube measuring 4 ft to 5 ft (1.22 m to 1.53 m) on a side. Actual load heights can vary from approximately 18 in. (0.46 m) up to 10 ft (3.05 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 (3.05m) apart vertically.

FIGURE
12.3.5.1.2.1(c)
In-Rack Sprinkler
Arrangement,
Group A Plastic
Commodities,
Single-Row Racks,
Storage Height
Over 25' (7.6 m) -
Option 3



Note: Each square represents a storage cube measuring 4 ft to 5 ft (1.22 m to 1.53 m) on a side. Actual load heights can vary from approximately 18 in. (0.46 m) up to 10 ft (3.05 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 (3.05 m) apart vertically.

12.3.5 Protection Criteria for Rack Storage of Plastics Commodities Stored Over 25 ft (7.6 m) in Height

- 12.3.5.1 Control Mode Density-Area Sprinkler Protection Criteria for Rack Storage of Plastics Commodities Stored Over 25 ft (7.6 m) in Height for Single-, Double-, and Multiple-Row Racks
- 12.3.5.2 Large Drop Sprinklers and Specific Application Control Mode Sprinklers for Rack Storage of Plastics Commodities Stored Over 25 ft (7.6 m) in Height
- 12.3.5.3 Early Suppression Fast-Response (ESFR) Sprinklers for Rack Storage of Plastics Commodities Stored Over 25 ft (7.6 m) in Height
- 12.3.5.4 In-Rack Sprinklers for Rack Storage of Plastics Commodities Stored Over 25 ft (7.6 m) in Height

12.3.5.2 Large Drop Sprinklers and Specific Application Control Mode Sprinklers for Rack Storage of Plastics Commodities Stored Over 25 ft (7.6 m) in Height

- Neither NFPA 13 nor FM 8-9 have protection criteria for Large Drop Sprinklers or Specific Application Control Mode Sprinklers for Rack Storage of Plastics Commodities Stored Over 25 ft (7.6 m) in Height



12.3.5 Protection Criteria for Rack Storage of Plastics Commodities Stored Over 25 ft (7.6 m) in Height

- 12.3.5.1 Control Mode Density-Area Sprinkler Protection Criteria for Rack Storage of Plastics Commodities Stored Over 25 ft (7.6 m) in Height for Single-, Double-, and Multiple-Row Racks
- 12.3.5.2 Large Drop Sprinklers and Specific Application Control Mode Sprinklers for Rack Storage of Plastics Commodities Stored Over 25 ft (7.6 m) in Height
- 12.3.5.3 Early Suppression Fast-Response (ESFR) Sprinklers for Rack Storage of Plastics Commodities Stored Over 25 ft (7.6 m) in Height
- 12.3.5.4 In-Rack Sprinklers for Rack Storage of Plastics Commodities Stored Over 25 ft (7.6 m) in Height

Table 12.3.5.3.1
ESFR Protection
of Rack Storage
without Solid
Shelves of
Plastics
Commodities
Stored Over 25 ft
(7.6 m) in Height

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Table 12.3.5.3.1 ESFR Protection of Rack Storage without Solid Shelves of Plastics Commodities Stored Over 25 ft (7.6 m) in Height

Storage Arrangement	Commodity	Minimum Storage Height (ft)	Minimum Clear Height (ft)	Minimum Clear Height (m)	Nozzle Elevation	Nozzle Orientation	Minimum Spacing (ft)	Minimum Spacing (m)	ESFR Application	Minimum Response Time (sec)	Minimum K Factor		
Single-Row Rack	Control Mode	16	16	16	16	15°	15	15	ESFR	15	15		
						30°	15	15	ESFR	15	15		
		40	40	40	40	15°	15	15	15	ESFR	15	15	
						30°	15	15	ESFR	15	15		
			80	80	80	80	15°	15	15	15	ESFR	15	15
							30°	15	15	ESFR	15	15	
	Multiple-Row	16	16	16	16	15°	15	15	ESFR	15	15		
						30°	15	15	ESFR	15	15		
		40	40	40	40	15°	15	15	15	ESFR	15	15	
						30°	15	15	ESFR	15	15		
			80	80	80	80	15°	15	15	15	ESFR	15	15
							30°	15	15	ESFR	15	15	

12.3.5 Protection Criteria for Rack Storage of Plastics Commodities Stored Over 25 ft (7.6 m) in Height

- 12.3.5.1 Control Mode Density-Area Sprinkler Protection Criteria for Rack Storage of Plastics Commodities Stored Over 25 ft (7.6 m) in Height for Single-, Double-, and Multiple-Row Racks
- 12.3.5.2 Large Drop Sprinklers and Specific Application Control Mode Sprinklers for Rack Storage of Plastics Commodities Stored Over 25 ft (7.6 m) in Height
- 12.3.5.3 Early Suppression Fast-Response (ESFR) Sprinklers for Rack Storage of Plastics Commodities Stored Over 25 ft (7.6 m) in Height
- 12.3.5.4 In-Rack Sprinklers for Rack Storage of Plastics Commodities Stored Over 25 ft (7.6 m) in Height

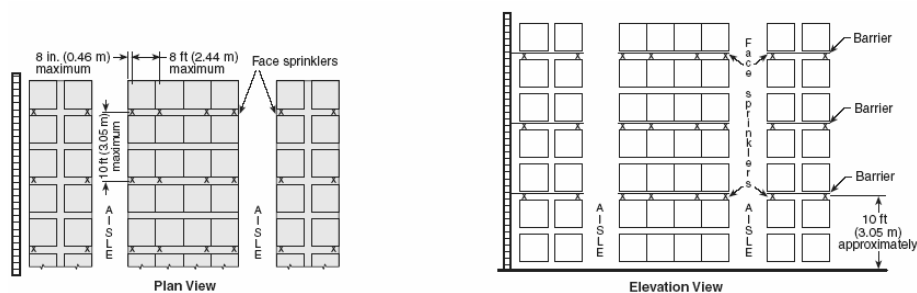
12.3.5.4.1 In-Rack Sprinkler Location for Rack Storage of Plastics Commodities Stored Over 25 ft (7.6 m) in Height

- Double-row racks without solid shelves with a max. 10' (3.1 m) between the top of storage & the ceiling:
 - Figure 12.3.5.1.2(a) or Figure 12.3.5.1.2(b)
 - The highest level of in-rack sprinklers shall be not more than 10' (3.1 m) below the top of storage
- Single-row racks without solid shelves with storage height over 25' (7.6 m) & max. of 10' (3.1 m) between the top of storage & the ceiling:
 - Figure 12.3.5.1.2.1(a), Figure 12.3.5.1.2.1(b), or Figure 12.3.5.1.2.1(c)
- Multiple-row racks without solid shelves with storage height over 25' (7.6 m) & max. of 10' (3.1 m) between the top of storage and the roof/ceiling:
 - Figure 12.3.5.4.1.3(a) - Figure 12.3.5.4.1.3(f)

12.3.5.4.2 In-Rack Sprinkler Spacing for Rack Storage of Plastics Commodities Stored Over 25 ft (7.6 m) in Height.

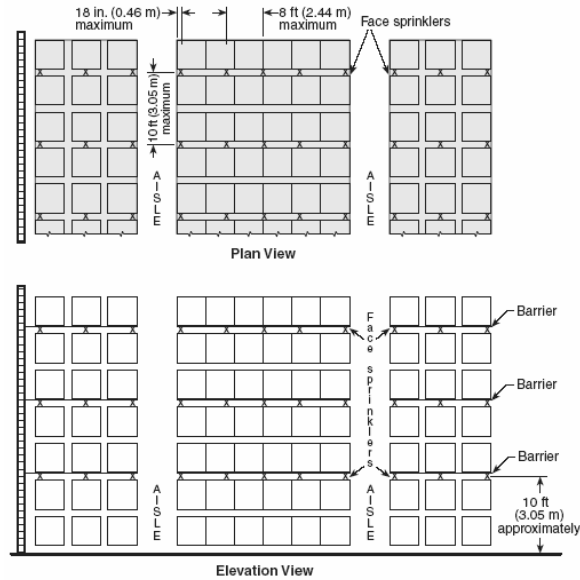
- In-rack sprinklers for storage higher than 25 ft (7.6 m) in double-row racks shall be spaced horizontally and shall be located in the horizontal space nearest the vertical intervals specified in Figure 12.3.5.1.2(a) or Figure 12.3.5.1.2(b).
- A min. of 6" (152.4-mm) vertical clear space shall be maintained between the sprinkler deflectors and the top of a tier of storage.

FIGURE 12.3.5.4.1.3(a) In-Rack Sprinkler Arrangement, Cartoned Plastic & Uncartoned Unexpanded Plastic, Multiple-Row Racks, Storage Height Over 25 ft (7.6 m) - Option 1 (10 ft Maximum Spacing)



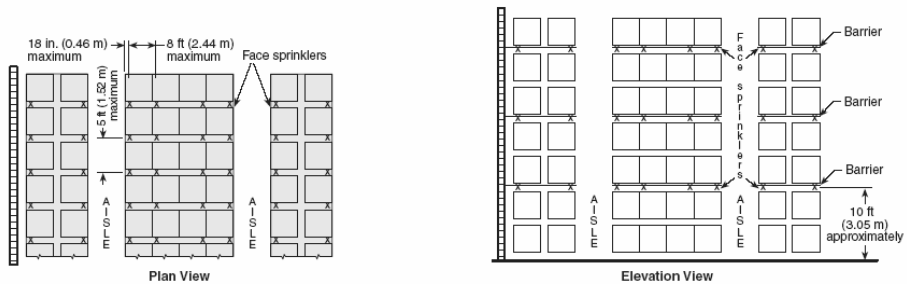
Note: Each square represents a storage cube measuring 4 ft to 5 ft (1.22 m to 1.53 m) on a side. Actual load heights can vary from approximately 18 in. (0.46 m) up to 10 ft (3.05 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.05 m) apart vertically.

FIGURE 12.3.5.4.1.3(b) In-Rack Sprinkler Arrangement, Cartoned Plastic and Uncartoned Unexpanded Plastic, Multiple-Row Racks, Storage Height Over 25' (7.6 m) - Option 2 (10' Maximum Spacing)



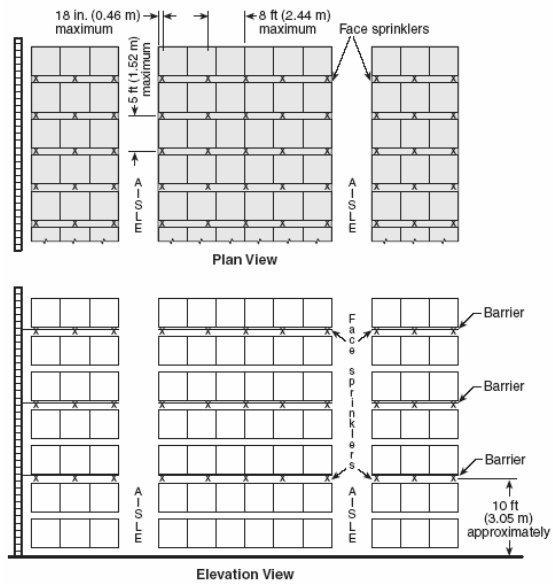
Note: Each square represents a storage cube measuring 4 ft to 5 ft (1.22 m to 1.53 m) on a side. Actual load heights can vary from approximately 18 in. (0.46 m) up to 10 ft (3.05 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.05 m) apart vertically.

FIGURE 12.3.5.4.1.3(c) In-Rack Sprinkler Arrangement, Cartoned Plastic and Uncartoned Unexpanded Plastic, Multiple-Row Racks, Storage Height Over 25' (7.6 m) — Option 1 (5' Maximum Spacing)



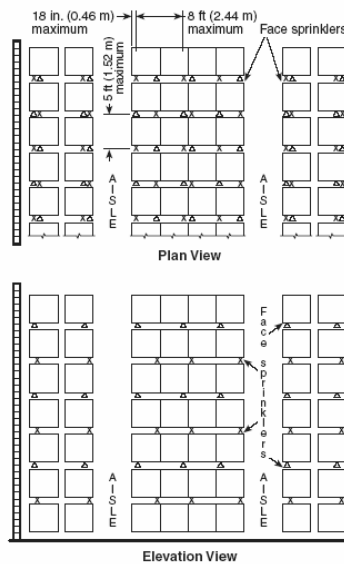
Note: Each square represents a storage cube measuring 4 ft to 5 ft (1.22 m to 1.53 m) on a side. Actual load heights can vary from approximately 18 in. (0.46 m) up to 10 ft (3.05 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.05 m) apart vertically.

FIGURE 12.3.5.4.1.3(d)
In-Rack Sprinkler Arrangement, Cartoned Plastic & Uncartoned Unexpanded Plastic, Multiple-Row Racks, Storage Height Over 25' (7.6 m) - Option 2 (5' Maximum Spacing)



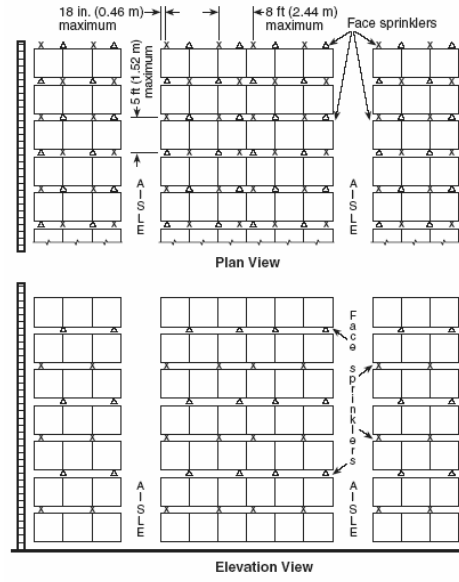
Note: Each square represents a storage cube measuring 4 ft to 5 ft (1.22 m to 1.53 m) on a side. Actual load heights can vary from approximately 18 in. (0.46 m) up to 10 ft (3.05 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.05 m) apart vertically.

FIGURE 12.3.5.4.1.3(e)
In-Rack Sprinkler Arrangement, Cartoned Plastic and Uncartoned Unexpanded Plastic, Multiple-Row Racks, Storage Height Over 25 ft (7.6 m) - Option 3 (5 ft Maximum Spacing)



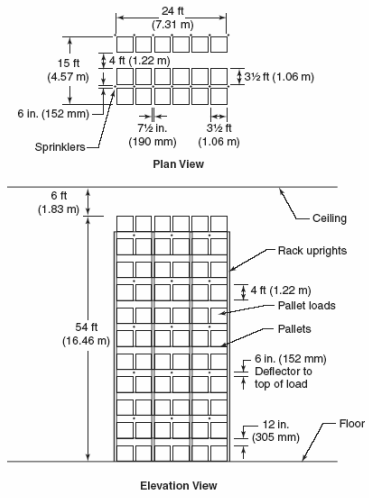
Note: Each square represents a storage cube measuring 4 ft to 5 ft (1.22 m to 1.53 m) on a side. Actual load heights can vary from approximately 18 in. (0.46 m) up to 10 ft (3.05 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.05 m) apart vertically.

FIGURE 12.3.5.4.1.3(f)
In-Rack Sprinkler
Arrangement, Cartoned
Plastic & Uncartoned
Unexpanded Plastic,
Multiple- Row Racks,
Storage Height Over 25
ft (7.6 m) - Option 4
(5 ft Maximum Spacing)



Note: Each square represents a storage cube measuring 4 ft to 5 ft (1.22 m to 1.53 m) on a side. Actual load heights can vary from approximately 18 in. (0.46 m) up to 10 ft (3.05 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 (3.05 m) apart vertically.

12.3.5.4.1.4 In single-row & double-row racks without solid shelves with storage height over 25' (7.6 m) with aisles greater than 4' (1.2 m), in-rack sprinklers shall be located in accordance with Figure 12.3.5.4.1.4 & the ceiling sprinklers shall be designed for 0.45 gpm/ft² over a min. design area of 2000 ft² (18.3mm/min / 186m²)



Notes:
 1. Sprinklers in alternate tiers at every transverse flue space.
 2. Each square represents a storage cube measuring 4 ft to 5 ft (1.22 m to 1.53 m) on a side. Actual load heights can vary from approximately 18 in. (0.46 m) up to 10 ft (3.05 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 (3.05 m) apart vertically.

FIGURE 12.3.5.4.1.4

12.3.5.4.3 In-Rack Sprinkler Water Demand & 12.3.5.4.4 In- Rack Sprinkler Discharge Pressure

- The water demand for sprinklers installed in racks shall be based on simultaneous operation of the most hydraulically remote:
 - Eight sprinklers where only one level is installed in racks
 - Fourteen sprinklers (seven on each top two levels) where more than one level is installed in racks
- Sprinklers in racks shall discharge at not less than 30 gpm (113.6 L/min)

12.4 Protection of Rubber Tire Storage

- Formally NFPA 231D
- 12.4.1 General.
- 12.4.2 Ceiling Systems.
- 12.4.3 In-Rack Sprinkler System Requirements for Protection of Rubber Tires
- 12.4.4 High-expansion foam systems Requirements for Protection of Rubber Tires



Rubber Tire Definitions

● Storage Methods:

- **On-Side Tire Storage.** Tires stored horizontally or flat.
- **On-Tread Tire Storage.** Tires stored vertically or on their treads.
- **Palletized Tire Storage.** Storage on portable racks of various types utilizing a conventional pallet as a base.
- **Laced Tire Storage.** Tires stored where the sides of the tires overlap, creating a woven or laced appearance.

General Protection Criteria

● Hose Demand:

- Control Mode Density/Area:
 - On floor storage $\geq 5'$ (1.5m): 250 gpm (947 L/min)
 - All other arrangements: 750 gpm (2835 L/min)
- Control Mode Specific Application:
 - 500 gpm (1893 L/min)
- ESFR (Dependent on building height & storage arrangement):
 - : 250 gpm (947 L/min) or 500 gpm (1893 L/min)

● Water Supply Duration:

- Control Mode Density/Area:
 - On floor storage $\geq 5'$ (1.5m): 3 hours
 - All other arrangements: 3 hours
- Control Mode Specific Application: 3 hours
- ESFR: 1 hour

- Column protection required when columns are not fireproofed. Rack upright protection not required when in-rack sprinklers are present

Control Mode Density-Area Sprinkler Protection Criteria - Rubber Tire

Piling Method	Piling Height (ft)	Sprinkler Discharge Density (gpm/ft ²) (see Note 1)	Areas of Application (ft ²) (see Note 1)	
			Ordinary Temperature	High Temperature
(1) Outdoor storage	Up to 5	0.19	5000	2000
(a) Pyramid piles, on-side	Over 5 to 12	0.30	5000	3500
(b) Other arrangements such that no horizontal channels are formed (see Note 2)	Over 12 to 18	0.60	Not allowed	2500
(2) Outdoor storage	Up to 5	0.19	5000	2000
Tires on-tread	Over 5 to 12	0.30	5000	2500
(3) Palletized portable rack storage	Up to 5	0.19	2000	2000
Outside or on-tread	Over 5 to 20	See Table 12.4.2(b)	—	—
	Over 20 to 30	0.30 plus high-expansion foam	5000	3000
(4) Palletized portable rack storage Outside	Up to 5	0.19	2000	2000
	Over 5 to 20	See Table 12.4.2(b)	—	—
	20 to 25	0.60 and 0.90 (see Note 3) or 0.75 with 1-hour fire-resistive rating of roof and ceiling assembly	Not allowed	5000
			Not allowed	3000
			Not allowed	4000
(5) Open portable rack storage, on-side or on-tread	Up to 5	0.19	2000	2000
	Over 5 to 12	0.60	5000	3000
	Over 12 to 20	0.60 and 0.90 (see Note 3) or 0.30 plus high-expansion foam	Not allowed	5000
			Not allowed	3000
(6) Single, double, and multiple-row fixed rack storage on pallets, on-side or on-tread	Up to 5	0.19	2000	2000
	Over 5 to 20	See Table 12.4.2(b) or 0.40 plus one level in-rack sprinklers or 0.30 plus high-expansion foam	3000	3000
	Over 20 to 30	0.30 plus high-expansion foam	Not allowed	3000
(7) Single, double, and multiple-row fixed rack storage without pallets or shelves, on-side or on-tread	Up to 5	0.19	2000	2000
	Over 5 to 12	0.60	5000	3000
	Over 12 to 20	0.60 and 0.90 (see Note 3) or 0.40 plus one level in-rack sprinklers or 0.30 plus high-expansion foam	Not allowed	5000
			Not allowed	3000
			Not allowed	5000
	Over 20 to 30	0.30 plus high-expansion foam	Not allowed	3000

For SI units, 1 ft = 0.3048 m; 1 ft² = 0.0929 m²; 1 gpm/ft² = 40.746 mm/min.

Notes:
1. Sprinkler discharge densities and areas of application are based on a maximum clearance of 10 ft (3.1 m) between sprinkler deflectors and the maximum available height of storage. The maximum clearance is noted from actual testing and is not a definitive measurement.
2. Laced tires on floor, vertical stacking on-side (typical truck tires), and off-road tires. Laced tires are not tested 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.

Control Mode Specific Application Sprinkler Protection Criteria - Rubber Tire

Piling Method	Pile Height	Number of Sprinklers and Minimum Operating Pressures (see Note 2)	Maximum Building Height
Rubber tire storage, on-side or on-tread, in palletized portable racks, or open portable racks, or fixed racks without solid shelves	Up to 25 ft (7.6 m)	15 sprinklers at 75 psi (5.2 bar) (see Note 3)	32 ft (9.8 m)

Notes:

1. Wet systems only.
2. Sprinkler operating pressures and number of sprinklers in the design are based on tests in which the clearance was 5 ft to 7 ft (1.5 m to 2.1 m) between the sprinkler deflector and the maximum height of storage.
3. The design area shall consist of the most hydraulically demanding area of 15 sprinklers, consisting of five sprinklers on each of three branch lines. The design shall include a minimum operating area of 1200 ft² (112 m²) and a maximum operating area of 1500 ft² (139 m²) and shall utilize a high temperature-rated sprinkler.

ESFR Sprinkler Protection Criteria - Rubber Tire

Piling Method	Pile Height	Maximum Building Height		Nominal K-factor	Orientation	Number of Sprinklers (see Note 2)	Minimum Operating Pressure (see Note 2)		Duration (hours)	Hose Demand	
		ft	m				psi	bar		gpm	L/min
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)	90	9.1	14.0	Upright or pendent	12 (see Note 3)	50	3.5	1	250	946
				16.8	Pendent	12 (see Note 3)	35	2.4	1	250	946
				25.2	Pendent	12 (see Note 3)	15	1.0	1	250	946
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)	95	10.7	14.0	Upright or pendent	12 (see Note 3)	75	5.2	1	250	946
				16.8	Pendent	12 (see Note 3)	52	3.6	1	250	946
				25.2	Pendent	12 (see Note 3)	25	1.7	1	250	946
Laced tires in open portable steel racks	Up to 25 ft (7.6 m)	90	9.1	14.0	Pendent	20 (see Notes 4 and 5)	75	5.2	3	500	1892
Rubber tire storage, on-side, in palletized portable racks	Up to 25 ft (7.6 m)	40	12.2	14.0	Pendent	12	75	5.2	1	250	946

Notes:

1. Wet systems only.
2. Sprinkler operating pressures and number of sprinklers in the design are based on tests in which the clearance was 5 ft to 7 ft (1.5 m to 2.1 m) between the sprinkler deflector and the maximum height of storage.
3. The shape of the design area shall be in accordance with 12.2.2.3.3 and 12.2.2.3.4.
4. Where used in this application, ESFR protection is expected to control rather than to suppress the fire.
5. 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).

Other Design Criteria – Rubber Tire

- **In-Rack Sprinkler System Requirements:**
 - Same as rack storage of Class i-IV & Group A plastic except:
 - Max. distance between in-rack sprinklers: 8' (2.4 m).
 - Demand: 12 sprinklers where only one level is installed in racks
 - Min Discharge Pressure: 30 psi (2.1 bar)
- **High Expansion Foam Systems:**
 - Where high-expansion foam systems are installed in accordance with NFPA 11A, *Standard for Medium- and High- Expansion Foam Systems*, a reduction in sprinkler discharge density to one-half the density specified in the table for control mode density/area sprinklers or 0.24 gpm/ft² (9.78 mm/min), whichever is higher, shall be permitted.

12.5 Protection of Baled Cotton Storage

- Formally NFPA 231E
- 12.5.1 General.
- 12.5.2 Control Mode Density-Area Sprinkler Protection Criteria for Baled Cotton Storage



Control Mode Density-Area Sprinkler Protection Criteria - Baled Cotton

Baled Cotton Storage Up to and Including 15 ft			
System Type	Tiered Storage	Rack Storage	Untiered Storage
Wet	0.25/3000	0.33/3000	0.15/3000
Dry	0.25/3900	0.33/3900	0.15/3900

- Where roof or ceiling heights prohibit storage above a nominal 10' (3.1 m), sprinkler discharge density can be reduced by 20 % of that indicated in the table, but shall not be reduced to less than 0.15 gpm/ft² (6.1 mm/min).
- Hose Demand: 500 gpm (1893 L/min)
- Water Supply Duration: 2 hours

12.6 Protection of Roll Paper Storage

- Formally NFPA 231F
- 12.6.1 General.
- 12.6.2 Protection Criteria for the Protection of Roll Paper Storage.



Roll Paper Definitions

- **Paper (General Term):** The term for 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.
- **Array (Paper):**
 - **Closed Array (Paper):** A vertical storage arrangement in which the distances between columns in both directions are short not more than 2" (50 mm) in one direction & 1" (25 mm) in the other.
 - **Open Array (Paper):** A vertical storage arrangement in which the distance between columns in both directions is lengthy (all vertical arrays other than closed or standard).
 - **Standard Array (Paper):** A vertical storage arrangement in which the distance between columns in one direction is short 1" (25 mm) or less & is in excess of 2" (50 mm) in the other direction.
- **Banded Roll Paper Storage:** Rolls provided with a circumferential steel strap 3/8" (9.5 mm) or wider at each end of the roll.
- **Wrapped Roll Paper Storage:** Rolls provided with a complete heavy kraft covering around both sides and ends.
- **Column:** A single vertical stack of rolls.
- **Core:** The central tube around which paper is wound to form a roll.



- Storage is normally
 - On side (Horizontal)
 - On end (Vertical)
- Paper Classification
 - Heavy weight
 - Medium weight
 - Light weight
 - Tissue

General Protection Criteria

- Hose Demand:
 - Control Mode: 500 gpm (1893 L/min)
 - ESFR: 250 gpm (947 L/min)
- Water Supply Duration:
 - Control Mode: 2 hours
 - ESFR: 1 hour
- Tissue Storage: Wet System Only
- Horizontal storage of heavyweight or mediumweight paper protected as closed array
- Mediumweight paper permitted to be protected as heavyweight paper where wrapped completely on sides & both ends, or wrapped on the sides only with steel bands. Wrapping material shall be heavyweight paper
- Lightweight paper or tissue paper permitted to be protected as mediumweight paper where wrapped completely on sides and both ends, or where wrapped on sides only with steel bands. Wrapping material shall be heavyweight paper
- Lightweight class paper shall be protected as tissue

Control Mode Density-Area Sprinkler Protection Criteria - Roll Paper

Storage Height (ft)	Clearance (ft)	Heavyweight						Mediumweight						Tissue All Storage Array
		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	0.3/2000	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	0.3/2000	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	0.45/2500	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	0.60/2000	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			
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.

- Heavyweight or mediumweight paper up to 10' (3.1 m) protected as OH II
- Tissue & lightweight paper up to 10' (3.1 m) protected as EH I
- High temp. sprinklers for storage 15' (4.6 m) or higher
- Area of Coverage per Sprinkler:
 - Max: 100 ft² (9.3 m²)
 - Min: 70 ft² (6.5 m²)
- High Expansion Foam Systems (Heavyweight or mediumweight):
 - 0.24 gpm/ft² / 2000 ft² (9.8 mm/min / 186 m²)

Control Mode Specific Application Sprinkler Protection Criteria - Roll Paper

Storage Height	Clearance				System Type	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	Unbanded	Banded	Unbanded		Banded	Unbanded		Banded	
20	6.1	<10	<3.1	W	15	15	15	15	NA	15	15	15	NA	NA	See Note 3	
20	6.1	<10	<3.1	D	25	25	25	NA	NA	25	25	25	NA	NA	NA	
26	7.9	<34	<10.4	W	15	15	15	15	NA	NA	NA	NA	NA	NA	NA	
26	7.9	<34	<10.4	D	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	

- Normal Minimum Design Pressure:
 - 50 psi (3.4 bar)
- Tissue Minimum Design:
 - Twenty-five large drop sprinklers @ 75 psi (5.2 bar) for closed or standard array; other arrays NA

ESFR Sprinkler Protection Criteria - Roll Paper

ESFR K-Factor	Orientation	System Type	Pressure		Building Height		Heavyweight						Mediumweight						Tissue All Arrays		
			psi	bar	ft	m	Closed		Standard		Open		Closed		Standard		Open				
							ft	m	ft	m	ft	m	ft	m	ft	m	ft	m			
11.2	Upright	Wet	50	3.4	25	7.6	20	6.1	20	6.1	20	6.1	20	6.1	20	6.1	20	6.1	20	6.1	NA
14.0	Upright or 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	25	7.6	NA
14.0	Pendent	Wet	75	5.2	40	12.2	30	9.1	30	9.1	30	9.1	NA	NA	NA	NA	NA	NA	NA	NA	
25.2	Pendent	Wet	15	1.0	30	9.1	25	7.6	25	7.6	25	7.6	25	7.6	25	7.6	25	7.6	25	7.6	NA
25.2	Pendent	Wet	25	1.7	40	12.2	30	9.1	30	9.1	30	9.1	NA	NA	NA	NA	NA	NA	NA	NA	
25.2	Pendent	Wet	50	3.4	45	13.7	30	9.1	30	9.1	30	9.1	NA	NA	NA	NA	NA	NA	NA	NA	

12.7 Special Designs



● 12.7.1 Plastic Motor Vehicle Components.



● 12.7.2 Sprinkler Design Criteria for Storage & Display of Class I - IV Commodities, Cartoned Non-Expanded Group A Plastics & Non-Expanded Exposed Group A Plastics in Retail Stores.

Protecting portable rack storage of motor vehicle components

- The protection of portable rack storage of motor vehicle components has always been outside the scope of NFPA
- Full-scale testing with Ford Motor Corp. demonstrated that the 25.2 K ESFR's are not only the best option for the protection of this arrangement, but are the only option recognized by NFPA 13 (2002).



Storage height: 25'
Ceiling height: 35'
Design Pressure: 37 psi
Number of Design Sprinklers: 16

Table 12.7.1 K-25.2 ESFR Sprinkler Design Criteria for Portable Racks (Closed Array) without Solid Shelves Containing Automotive Components

Commodity	Maximum Storage Height		Maximum Ceiling/Roof Height		Type of System	Maximum Sprinkler Spacing ²		Number of Design Sprinklers by Minimum Operating Pressure ³		Maximum Deflector Distance Below Ceiling ⁴		Hose Stream Demand		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	10.7	Wet	100	9.3	16 at 37 psi	16 at 2.5 bar	18	457	500	1900	2

¹Portable rack array shall be tightly nested without any flue spaces.

²Sprinkler spacing can exceed 100 ft² (9.3 m²) where sprinklers are listed for larger spacing.

³System hydraulic design shall also be capable of delivering a discharge density of 0.60 gpm/ft² over the most hydraulically remote 4000 ft² area.

⁴Maximum deflector distance below ceiling shall be permitted to exceed 18 in.² where sprinklers are listed for greater distances.

The Home Depot (12.7.2.1)



- Max. Storage height: 22' (6.7 m)
- Max. Ceiling height: 30' (9.1 m)
- Design (EC-25 sprinklers only):
 - 0.6 gpm/ft² - 2000 ft² (24.5mm/min-186m²)
 - 0.7 gpm/ft² (28.5mm/min) for the four most demanding sprinklers
- Min. aisle width: 8' (2.4 m)
 - Storage in aisle permissible where aisle storage is 4' (1.2) or less high & min. clear aisle of 4' (1.2) is maintained.
- Slatted shelves using 2x6 slats with spacers maintaining a min. 2" (51 mm) opening between each slat.
- No slatted shelf levels in the rack above 12' (3.7 m) level.
- Wire mesh over 50% open permitted for shelf levels above 12' (3.7 m).
- Solid shelving 3.5'x8.25' (1.1mx2.5m) allowed over slats at 5' (1.5m) level.
- Perforated metal over 40% open allowed over slats to 60" (1.5m) level.
- Solid veneered displays allowed when all flues are maintained & only one display is installed per bay. Other solid plywood or similar materials shall not be placed on the slatted shelves.
- Min. 6" (162mm) long. flue & 3" (76mm) tran. flue at rack uprights

Wal-Mart (12.7.2.2)



- Max. Storage height: 12' (3.7 m) on gondola shelving with metal shelves
- Max. Ceiling height: 22' (6.7 m)
- Design (EC-25 sprinklers only):
 - **0.425 gpm/ft² / 2000 ft² (17.3mm/min-186m²)**
 - **0.5 gpm/ft² (20.4 mm/min) for the four most demanding sprinklers**
- Min. aisle width: 5' (1.5 m)
- Gondola structure does not exceed 48" (1.2 m) aggregate depth, or 78" (2 m) height
- Max. Rack length: 70' (21.3 m)

WAL-MART®

Best Buy (12.7.2.3)

- Max. Storage height: 15' (4.6 m) on gondola shelving with metal shelves
- Max. Ceiling height: 25' (7.6 m)
- Design (EC-25 sprinklers only):
 - **0.425 gpm/ft² / 2000 ft² (17.3mm/min-186m²)**
 - **0.5 gpm/ft² (20.4 mm/min) for the four most demanding sprinklers**
- Min. aisle width: 6' (1.8 m)
- Gondola rack structure shall not exceed 60" (1.5 m) aggregate depth or 8' (2.4m) height.
- A perforated metal deck at 8' (2.4m) level permissible with storage placed on top with or without flue spaces to a max. height from floor of 15' (4.6 m)
- Max. Rack length: 70' (21.3 m)



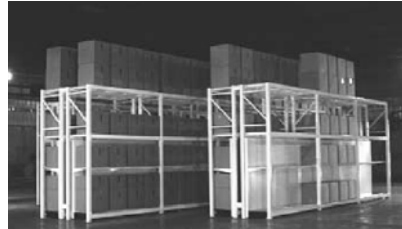
Target Stock Room (12.7.2.4)

- Max. Storage height: 15' (4.6 m)
- Max. Ceiling height: 20.5' (6.3 m)
- Design (EC-25 sprinklers only):
 - **0.45 gpm/ft² / 2000 ft² (18.3mm/min-186m²)**
 - **0.55 gpm/ft² (22.4 mm/min) for the four most demanding sprinklers**
- Min. aisle width: 3' (0.9 m)
- Shelving structure shall not exceed 48" (1.2 m) aggregate depth or 12' (3.7 m) height.
- Shelving shall be permitted to be made of solid particleboard.
- Max. Rack length: 70' (21.3 m)



Office Depot (12.7.2.5)

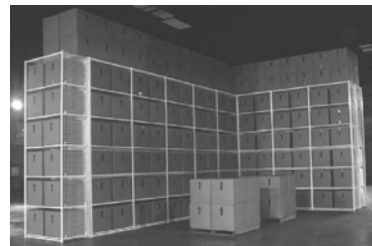
- Max. Storage height: 14' (4.3 m)
- Max. Ceiling height: 20' (6.1 m)
- Design (EC-25 sprinklers only):
 - **0.38 gpm/ft² / 2000 ft² (15.5mm/min-186m²)**
 - **0.45 gpm/ft² (18.3mm/min) for the four most demanding sprinklers**
- Min. aisle width: 5' (1.5 m)
- Solid metal shelving permissible up to the 72" (1.8 m) level & wire shelving shall be permissible up to the 10' (3.1 m) level.
- The solid metal shelving shall not exceed 66" (1.7 m) aggregate depth and shall have a min. 6" (150 mm) longitudinal flue between two 30" (762 mm) deep shelves.
- Max. Rack length: 70' (21.3 m)



**Office
DEPOT®**

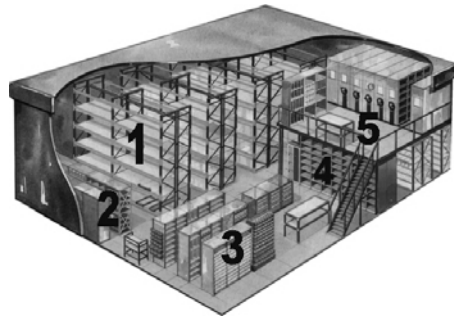
Bed Bath & Beyond (12.7.2.6)

- Max. Storage height: 16.5' (5.0 m)
- Max. Ceiling height: 22' (6.7 m)
- Design (EC-25 sprinklers only):
 - **0.49 gpm/ft² / 2000 ft² (20.0mm/min-186m²)**
 - **0.55 gpm/ft² (22.4 mm/min) for the four most demanding sprinklers**
- Min. aisle width: 4' (1.2 m) between shelf units and other displays
- Shelving structure shall not exceed 51" (1.3 m) aggregate depth or 148" (3.8 m) height.
- 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.
- The top shelf shall be wire mesh.



**BED BATH &
BEYOND**

One occupancy may have many different fire challenges. Knowing the protection requirements & your design alternatives simplifies design selection for your application.



1. Pallet Racking
2. Shelving
3. Small Parts Storage

4. Storage under mezzanine floor
5. Mezzanine Floor
6. Mobile Shelving