

**FIGURE 21.4.1.2(e) Single- or Double-Row Racks — 20 ft (6.1 m) High Rack Storage — Sprinkler System Design Curves — Class I and Class II Encapsulated Commodities — Conventional Pallets.**

**21.7.5** The protection area per sprinkler shall not exceed 100 ft<sup>2</sup> (9.3 m<sup>2</sup>) or be less than 70 ft<sup>2</sup> (6.5 m<sup>2</sup>).

**21.7.6** Where high-expansion foam systems are installed in heavyweight class and mediumweight class storage areas, sprinkler discharge design densities shall be permitted to be reduced to not less than 0.24 gpm/ft<sup>2</sup> (9.8 mm/min) with a minimum operating area of 2000 ft<sup>2</sup> (185 m<sup>2</sup>).

**21.7.7** Where high-expansion foam systems are installed in tissue storage areas, sprinkler discharge densities and areas of application shall not be reduced below those provided in Table 21.7.3(a) and Table 21.7.3(b).

**21.8 Special Design for Rack Storage of Class I Through Class IV Commodities and Group A Plastics Stored Up to and Including 25 ft (7.6 m) in Height.**

**21.8.1 Slatted Shelves.**

**21.8.1.1\*** Slatted rack shelves shall be considered equivalent to solid rack shelves where the shelving is not considered open rack shelving or where the requirements of 21.8.1.2 are not met. (See Section C.20.)

**21.8.1.2** A wet pipe system that is designed to provide a minimum of 0.6 gpm/ft<sup>2</sup> (24.5 mm/min) density over a minimum area of 2000 ft<sup>2</sup> (185 m<sup>2</sup>) shall be permitted to protect single-row and double-row racks with slatted rack shelving where all of the following conditions are met:

- (1) Sprinklers shall be K-11.2 (160), K-14.0 (200), or K-16.8 (240) orifice spray sprinklers with a temperature rating of ordinary, intermediate, or high and shall be listed for storage occupancies.
- (2) The protected commodities shall be limited to Class I through Class IV, Group B plastics, Group C plastics, cartoned (expanded and nonexpanded) Group A plastics, and exposed (nonexpanded) Group A plastics.
- (3) Slats in slatted rack shelving shall be a minimum nominal 2 in. (50 mm) thick by maximum nominal 6 in. (150 mm) wide, with the slats held in place by spacers that maintain a minimum 2 in. (50 mm) opening between each slat.
- (4) Where K-11.2 (160), K-14.0 (200), or K-16.8 (240) orifice sprinklers are used, there shall be no slatted shelf levels in the rack above 12 ft (3.7 m). Open rack shelving

using wire mesh shall be permitted for shelf levels above 12 ft (3.7 m).

- (5) Transverse flue spaces at least 3 in. (75 mm) wide shall be provided at least every 10 ft (3.0 m) horizontally.
- (6) Longitudinal flue spaces at least 6 in. (150 mm) wide shall be provided for double-row racks.
- (7) The aisle widths shall be at least 7½ ft (2.3 m).
- (8) The maximum roof height shall be 27 ft (8.2 m).
- (9) The maximum storage height shall be 20 ft (6.1 m).
- (10) Solid plywood or similar materials shall not be placed on the slatted shelves so that they block the 2 in. (50 mm) spaces between slats, nor shall they be placed on wire mesh shelves.

**21.9 Sprinkler Design Criteria for Storage and Display of Class I Through Class IV Commodities, Cartoned Nonexpanded Group A Plastics and Nonexpanded Exposed Group A Plastics in Retail Stores.**

**21.9.1** A wet pipe system designed to meet two separate design points — 0.6 gpm/ft<sup>2</sup> (24.5 mm/min) density over 2000 ft<sup>2</sup> (185 m<sup>2</sup>) and 0.7 gpm/ft<sup>2</sup> (28.5 mm/min) density for the four hydraulically most demanding sprinklers with 500 gpm (1900 L/min) hose stream allowance for a 2-hour duration — shall be permitted to protect single- and double-row slatted shelf racks when the following conditions are met:

- (1) An extended coverage sprinkler with a nominal K-factor of K-25.2 (360) listed for storage occupancies shall be provided.
- (2) Shelves shall be either open shelving or slatted using a 2 in. (50 mm) thick by maximum 6 in. (150 mm) wide slat held in place by spacers that maintain a minimum 2 in. (50 mm) opening between each slat.
- (3) There shall be no slatted shelf levels in the rack above nominal 12 ft (3.7 m) level. Wire mesh (greater than 50 percent opening) shall be permitted for shelf levels above 12 ft (3.7 m).
- (4) A single level of solid shelving 3½ ft × 8 ft 3 in. (1.1 m × 2.5 m) shall be permissible at an elevation of not more than 5 ft (1.5 m).
- (5) Perforated metal (open area of 40 percent or more) shall be permitted over either the open shelving or the slatted shelves up to the 60 in. (1500 mm) level.

**Table 21.4.1.3.1 Multiple-Row Racks — Rack Depth Up to and Including 16 ft (4.9 m), Aisles 8 ft (2.4 m) or Wider and Storage Height Over 12 ft (3.7 m) Up to 25 ft (7.6 m)**

Height	Commodity Class	Encapsulated	Ceiling Sprinkler Water Demand			
			Figure	Curves	Apply Figure 21.4.1.4.1	1.25 × Density
Over 12 ft (3.7 m) up to and including 15 ft (4.6 m)	I	No	21.4.1.2(a)	E and F	Yes	No
		Yes	21.4.1.2(a)	E and F		Yes
	II	No	21.4.1.2(b)	E and F	Yes	No
		Yes	21.4.1.2(b)	E and F		Yes
	III	No	21.4.1.2(c)	E and F	Yes	No
		Yes	In-rack sprinklers required. See Chapter 25.	NA	NA	NA
	IV	No	In-rack sprinklers required. See Chapter 25.	NA	No	No
		Yes	In-rack sprinklers required. See Chapter 25.	NA	NA	NA
Over 15 ft (4.6 m) up to and including 20 ft (6.1 m)	I	No	21.4.1.2(a)	E and F	Yes	No
		Yes	21.4.1.2(a)	E and F		Yes
	II	No	21.4.1.2(b)	E and F	Yes	No
		Yes	21.4.1.2(b)	E and F		Yes
	III	No	21.4.1.2(c)	E and F	Yes	No
		Yes	In-rack sprinklers required. See Chapter 25.	NA	NA	NA
	IV	No				
		Yes				
Over 20 ft (6.1 m) up to and including 25 ft (7.6 m)	I	No	21.4.1.2(a)	E and F	Yes	No
		Yes	In-rack sprinklers required. See Chapter 25.	NA	NA	NA
	II	No				
		Yes				
	III	No				
		Yes				
	IV	No				
		Yes				

NA: Not applicable.

- (6) Other than what is allowed in this section, solid plywood or similar materials shall not be placed on the slatted shelves.
- (7) Solid displays shall be permissible, provided that all flues are maintained and only one display is installed per bay.
- (8) Maximum roof height shall be 30 ft (9.1 m) in the protected area.
- (9) Maximum storage height shall be 22 ft (6.7 m).
- (10) Aisle widths shall be a minimum of 8 ft (2.4 m).
- (11) Minimum transverse flue spaces of 3 in. every 10 ft (75 mm every 3.0 m) horizontally shall be provided.
- (12) Minimum longitudinal flue spaces of 6 in. (150 mm) shall be provided for double-row racks.
- (13) Storage in the aisle shall be permissible, provided the aisle storage is no more than 4 ft (1.2 m) high and a minimum clear aisle of 4 ft (1.2 m) is maintained.

**21.9.2** A wet pipe system designed to meet two separate design points — 0.425 gpm/ft<sup>2</sup> (17.3 mm/min) density over 2000 ft<sup>2</sup> (185 m<sup>2</sup>) and 0.50 gpm/ft<sup>2</sup> (20.4 mm/min) density for the four hydraulically most demanding sprinklers with 500 gpm (1900 L/min) hose stream allowance for a 2-hour duration — shall be permitted in solid steel cantilever-style retail shelving racks (gondola racks) when the following conditions are met:

**Table 21.4.1.3.2 Multiple-Row Racks — Rack Depth Over 16 ft (4.9 m) or Aisles Narrower Than 8 ft (2.4 m), Storage Height Over 12 ft (3.7 m) Up to and Including 25 ft (7.6 m)**

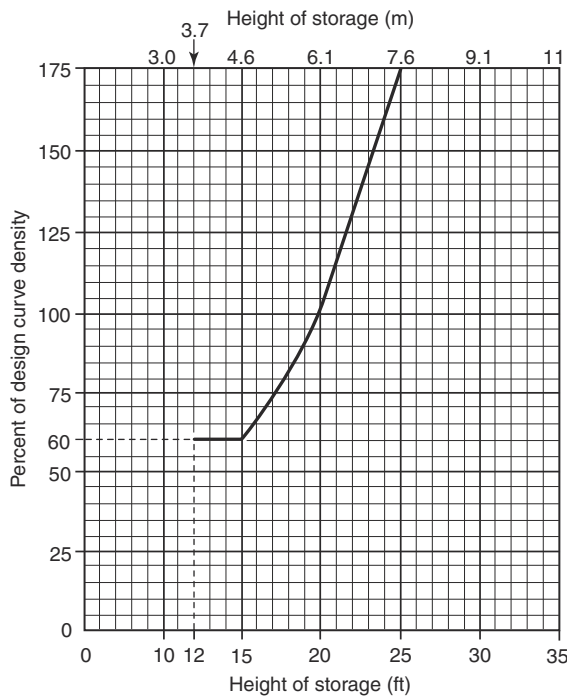
Height	Commodity Class	Encapsulated	Ceiling Sprinkler Water Demand			
			Figure	Curves	Apply Figure 21.4.1.4.1	1.25 × Density
Over 12 ft (3.7 m) up to and including 15 ft (4.6 m)	I	No	21.4.1.2(a)	E and F	Yes	No
		Yes	21.4.1.2(a)	E and F		Yes
	II	No	21.4.1.2(b)	E and F	Yes	No
		Yes	21.4.1.2(b)	E and F		Yes
	III	No	21.4.1.2(c)	E and F	Yes	No
		Yes	In-rack sprinklers required. See Chapter 25.			
	IV	No	In-rack sprinklers required. See Chapter 25.	NA	No	No
		Yes	In-rack sprinklers required. See Chapter 25.			
Over 15 ft (4.6 m) up to and including 20 ft (6.1 m)	I	No	In-rack sprinklers required. See Chapter 25.	NA	NA	NA
		Yes				
	II	No				
		Yes				
	III	No				
		Yes				
	IV	No				
		Yes				
Over 20 ft (6.1 m) up to and including 25 ft (7.6 m)	I	No	In-rack sprinklers required. See Chapter 25.	NA	NA	NA
		Yes				
	II	No				
		Yes				
	III	No				
		Yes				
	IV	No				
		Yes				

NA: Not applicable.

- (1) An extended coverage sprinkler with a nominal K-factor of K-25.2 (360) listed for storage occupancies shall be provided.
- (2) The storage height shall not exceed 12 ft (3.7 m).
- (3) The ceiling height shall not exceed 22 ft (6.7 m) in the protected area.
- (4) Gondola rack structure shall not exceed 48 in. (1200 mm) in aggregate depth or 78 in. (1950 mm) in height.
- (5) A minimum aisle of 5 ft (1.5 m) between storage shall be maintained.
- (6) Rack lengths shall be no more than 70 ft (21 m).

**21.9.3** A wet system designed to meet two separate design points — 0.425 gpm/ft<sup>2</sup> (17.3 mm/min) density over 2000 ft<sup>2</sup> (185 m<sup>2</sup>) and 0.50 gpm/ft<sup>2</sup> (20.4 mm/min) density for the four hydraulically most demanding sprinklers with 500 gpm (1900 L/min) hose stream allowance for a 2-hour duration — shall be permitted in solid steel cantilever-style retail shelving racks (gondola racks) when the following conditions are met:

- (1) An extended coverage sprinkler with a nominal K-factor of K-25.2 (360) listed for storage occupancies shall be provided.
- (2) Storage height shall not exceed 15 ft (4.6 m).



**FIGURE 21.4.1.4.1 Ceiling Sprinkler Density vs. Storage Height.**

- (3) Ceiling height shall not exceed 25 ft (7.6 m) in the protected area.
- (4) Gondola rack structure shall not exceed 60 in. (1500 mm) in aggregate depth or 8 ft (2.4 m) in height.
- (5) A perforated metal deck at the 8 ft (2.4 m) level shall be permissible with storage placed on top with or without flue spaces to a maximum height from floor of 15 ft (4.6 m).
- (6) Rack lengths shall not exceed 70 ft (21 m).
- (7) A minimum aisle space of 6 ft (1.8 m) shall be provided.

**21.9.4** A wet pipe system designed to meet two separate design points — 0.45 gpm/ft<sup>2</sup> (18.3 mm/min) density over 2000 ft<sup>2</sup> (185 m<sup>2</sup>) and 0.55 gpm/ft<sup>2</sup> (22.4 mm/min) density for the four hydraulically most demanding sprinklers with 500 gpm (1900 L/min) hose stream allowance for a 2-hour duration — shall be permitted without the use of in-rack sprinklers when the following conditions are met:

- (1) An extended coverage sprinkler with a nominal K-factor of K-25.2 (360) listed for storage occupancies shall be provided.
- (2) Storage height shall not exceed 15 ft (4.6 m).
- (3) Ceiling height shall not exceed 25 ft (7.6 m).
- (4) Shelving structure shall not exceed 48 in. (1200 mm) aggregate depth or 12 ft (3.7 m) in height.
- (5) Shelving shall be permitted to be made of solid particle-board.
- (6) A minimum aisle space of 3 ft (900 mm) shall be maintained.
- (7) Shelving length shall be a maximum of 70 ft (21 m).

**21.9.5** A wet pipe system designed to meet two separate design points — 0.38 gpm/ft<sup>2</sup> (15.5 mm/min) density over 2000 ft<sup>2</sup> (185 m<sup>2</sup>) and 0.45 gpm/ft<sup>2</sup> (18.3 mm/min) density for the four

hydraulically most demanding sprinklers with 500 gpm (1900 L/min) hose stream allowance for a 2-hour duration — shall be permitted without the use of in-rack sprinklers in steel retail sales floor shelving racks where the following conditions are met:

- (1) An extended coverage sprinkler with a nominal K-factor of K-25.2 (360) listed for storage occupancies shall be provided.
- (2) Storage height shall not exceed 14 ft (4.3 m).
- (3) Ceiling height shall not exceed 20 ft (6.1 m).
- (4) Solid metal shelving shall be permissible up to the 72 in. (1800 mm) level and wire shelving shall be permissible up to the 10 ft (3.0 m) level.
- (5) The solid metal shelving shall not exceed 66 in. (1650 mm) in aggregate depth with a 6 in. (150 mm) longitudinal flue between two 30 in. (750 mm) deep shelves.
- (6) A minimum aisle space of 5 ft (1.5 m) shall be maintained.
- (7) A minimum longitudinal flue of 6 in. (150 mm) shall be maintained.
- (8) Rack length shall be a maximum of 70 ft (21 m).

**21.9.6** A wet pipe system designed to meet two separate design points — 0.49 gpm/ft<sup>2</sup> (20 mm/min) density over 2000 ft<sup>2</sup> (185 m<sup>2</sup>) and 0.55 gpm/ft<sup>2</sup> (22.4 mm/min) density for the four hydraulically most demanding sprinklers with 500 gpm (1900 L/min) hose stream allowance for a 2-hour duration — shall be permitted without the use of in-rack sprinklers in retail solid shelved steel rack structure when the following conditions are met:

- (1) An extended coverage sprinkler with a nominal K-factor of K-25.2 (360) listed for storage occupancies shall be provided.
- (2) Storage height shall not exceed 16.5 ft (5 m).
- (3) Ceiling height shall not exceed 22 ft (6.7 m).
- (4) Shelving structure shall not exceed 51 in. (1275 mm) aggregate depth or 148 in. (3700 mm) in height.
- (5) The intersection of perpendicular steel racks shall be permissible as long as no storage is placed within the void space at the junction of the racks.
- (6) The top shelf shall be wire mesh.
- (7) A minimum aisle width of 4 ft (1.2 m) shall be maintained between shelf units and other displays.

#### **21.10\* Control Mode Density/Area Sprinkler Protection Criteria for Baled Cotton Storage.**

**21.10.1** For tiered or rack storage up to a nominal 15 ft (4.6 m) in height, sprinkler discharge densities and areas of application shall be in accordance with Table 21.10.1.

**21.10.2** Where roof or ceiling heights would prohibit storage above a nominal 10 ft (3 m), the sprinkler discharge density shall be permitted to be reduced by 20 percent of that indicated in Table 21.10.1 but shall not be reduced to less than 0.15 gpm/ft<sup>2</sup> (6.1 mm/min).

#### **21.11 Control Mode Density/Area Sprinkler Protection Criteria for Carton Records Storage with Catwalk Access.**

**21.11.1** Carton records storage shall be permitted to be protected in accordance with the succeeding subsections of Section 21.11.

**Table 21.5.1.1 Control Mode Density/Area Sprinkler Protection Criteria for Single-, Double-, and Multiple-Row Racks for Group A Plastic Commodities in Cartons Stored Up to and Including 25 ft (7.6 m) in Height**

Commodity	Storage height ft (m)	Maximum Clearance from Top of Storage to Ceiling ft (m)	Maximum Ceiling Height ft (m)	Ceiling Sprinklers Density Clearance to Ceiling Up to 10 ft gpm/ft <sup>2</sup> (mm/min)	Ceiling Sprinkler Operating Area ft <sup>2</sup> (m <sup>2</sup> )
Group A plastic commodities in cartons, encapsulated	5 ft to 10 ft (1.5 m to 3.1)	<5 ft (1.5 m)	<15 ft (4.6 m)	0.30 gpm/ft <sup>2</sup> (12.2 mm/min)	2000 ft <sup>2</sup> (185 m <sup>2</sup> )
		5 ft to 10 ft (1.5 m to 3.1 m)	20 ft (6.1 m)	0.45 gpm/ft <sup>2</sup> (18.3 mm/min)	
	15 ft (4.6 m)	≥5 ft (1.5 m)	22 ft (6.7 m)	0.45 gpm/ft <sup>2</sup> (18.3 mm/min)	
		≤10 ft (3.1 m)	25 ft (7.6 m)	0.60 gpm/ft <sup>2</sup> (24.5 mm/min)	
	20 ft (6.1 m)	<5 ft (1.5 m)	<25 ft (7.6 m)	0.60 gpm/ft <sup>2</sup> (24.5 mm/min) <sup>a,b</sup>	
		5 ft to 10 ft (1.5 m to 3.1 m)	27 ft (8.2 m)	0.60 gpm/ft <sup>2</sup> (24.5 mm/min) <sup>a</sup>	
			30 ft (9.1 m)		
	25 ft (7.6 m)	<5 ft (1.5 m)	30 ft (9.1 m)	0.8 gpm/ft <sup>2</sup> (32.6 mm/min) <sup>c</sup>	
		5 ft to 10 ft (1.5 m to 3.1 m)	35 ft (11 m)		

<sup>a</sup>Ceiling-only protection is not permitted for this storage configuration except where K-11.2 or larger spray sprinklers listed for storage use are installed.

<sup>b</sup>For the protection of single- and double-row rack only.

<sup>c</sup>Ceiling-only protection shall not be permitted for this storage configuration except where K-16.8 spray sprinklers listed for storage use are installed.

**Table 21.5.3 Control Mode Density/Area Sprinkler Protection Criteria for Exposed Nonexpanded Group A Plastics**

Commodity	Storage height ft (m)	Maximum Ceiling Height ft (m)	Ceiling Sprinklers Density Clearance to Ceiling Up to 10 ft gpm/ft <sup>2</sup> (mm/min)	Ceiling Sprinkler Operating Area ft <sup>2</sup> (m <sup>2</sup> )
Exposed nonexpanded Group A plastic	10 ft (3.1 m)	20 ft (6.1 m)	0.80 gpm/ft <sup>2</sup> (32.6 mm/min)	2500 ft <sup>2</sup> (230 m <sup>2</sup> )

**Table 21.6.1(a) Protection Criteria for Rubber Tire Storage Using Control Mode Density/Area Sprinklers**

Piling Method <sup>d</sup>	Pile Height [ft (m)]	Sprinkler Discharge Density <sup>a</sup> [gpm/ft <sup>2</sup> (mm/min)]	Areas of Application <sup>a</sup> [ft <sup>2</sup> (m <sup>2</sup> )]	
			Ordinary Temperature	High Temperature <sup>a</sup>
(1) On-floor storage	Up to 5 (1.5)	0.19 (7.7)	2000 (185)	2000 (185)
(a) Pyramid piles, on-side	Over 5 (1.5) to 12 (3.7)	0.30 (12.2)	2500 (230)	2500 (230)
(b) Other arrangements such that no horizontal channels are formed <sup>b</sup>	Over 12 (3.7) to 18 (5.5)	0.60 (24.5)	Not allowed	2500 (230)
(2) On-floor storage Tires, on-tread	Up to 5 (1.5)	0.19 (7.7)	2000 (185)	2000 (185)
	Over 5 (1.5) to 12 (3.7)	0.30 (12.2)	2500 (230)	2500 (230)
(3) Palletized portable rack storage On-side or on-tread	Up to 5 (1.5)	0.19 (7.7)	2000 (185)	2000 (185)
	Over 5 (1.5) to 20 (6.1)	See Table 18.4(b)	—	—
	Over 20 (6.1) to 30 (9.1)	0.30 (12.2) plus high-expansion foam	3000 (280)	3000 (280)
(4) Palletized portable rack storage, on-side	Up to 5 (1.5)	0.19 (7.7)	2000 (185)	2000 (185)
	Over 5 (1.5) to 20 (6.1)	See Table 18.4(b)	—	—
	Over 20 (6.1) to 25 (7.6)	0.60 (24.5) and 0.90 (36.7) <sup>c</sup> or 0.75 (2.8) with 1-hour fire-resistive rating of roof and ceiling assembly	Not allowed Not allowed Not allowed	5000 (465) 3000 (280) 4000 (370)
(5) Open portable rack storage, on-side or on-tread	Up to 5 (1.5)	0.19 (7.7)	2000 (185)	2000 (185)
	Over 5 (1.5) to 12 (3.7)	0.60 (24.5)	5000 (465)	3000 (280)
	Over 12 (3.7) to 20 (6.1)	0.60 (24.5) and 0.90 (36.7) <sup>c</sup> or 0.30 (12.2) plus high-expansion foam	Not allowed Not allowed 3000 (280)	5000 (465) 3000 (280) 3000 (280)
(6) Open portable rack storage, laced	Over 12 (3.7) to 20 (6.1)	0.60 (24.5) and 0.90 (36.7) <sup>c,c</sup>	Not allowed Not allowed	5000 (465) 3000 (280)
(7) Single-, double-, and multiple-row fixed rack storage on pallets, on-side, or on-tread without shelves	Up to 5 (1.5)	0.19 (7.7)	2000 (185)	2000 (185)
	Over 5 (1.5) to 20 (6.1)	See Table 18.4(b) or 0.30 (12.2) plus high-expansion foam	3000 (280)	3000 (280)
	Over 20 (6.1) to 30 (9.1)	0.30 (12.2) plus high-expansion foam	Not allowed	3000 (280)
(8) Single-, double-, and multiple-row fixed rack storage without pallets or shelves, on-side or on-tread	Up to 5 (1.5)	0.19 (7.7)	2000 (185)	2000 (185)
	Over 5 (1.5) to 12 (3.7)	0.60 (24.5)	5000 (465)	3000 (280)
	Over 12 (3.7) to 20 (6.1)	0.60 (24.5) and 0.90 (36.7) <sup>c</sup> or 0.30 (12.2) plus high-expansion foam	Not allowed Not allowed 3000 (280)	5000 (465) 3000 (280) 3000 (280)
	Over 20 (6.1) to 30 (9.1)	0.30 (12.2) plus high-expansion foam	Not allowed	3000 (280)

Note: Shelf storage of rubber tires shall be protected as solid rack shelving.

<sup>a</sup>Sprinkler discharge densities and areas of application are based on a maximum clearance to ceiling of 10 ft (3.0 m) with the maximum height of storage anticipated.

<sup>b</sup>Laced tires on-floor, vertical stacking on-side (typical truck tires), and off-road tires. Laced tires are not stored to a significant height by this method due to the damage inflicted on the tire (i.e., bead).

<sup>c</sup>Water supply shall fulfill both requirements.

<sup>d</sup>Shelf storage of rubber tires shall be protected as solid rack shelving.

<sup>e</sup>This protection scheme is for use with K-16.8 (240) or larger control mode sprinklers only. Maximum clearance to ceiling can be increased to 14 ft (4.3 m) with this scheme.



**Table 21.6.1(b) Control Mode Density/Area Sprinklers System Density (gpm/ft<sup>2</sup>) for Palletized Portable Rack Storage and Fixed Rack Storage of Rubber Tires with Pallets Over 5 ft (1.5 m) to 20 ft (3.7 m) in Height**

Storage Height [ft (m)]	Sprinkler Temperature	
	High Temperature	Ordinary Temperature
>5 to 10 (1.5 to 3.0)	0.32/2000 (13.0/185)	0.32/2000 (13.0/185)
>10 to 12 (3.0 to 3.7)	0.39/2000 (15.9/185)	0.39/2600 (15.9/270)
>12 to 14 (3.7 to 4.3)	0.45/2000 (18.3/185)	0.45/3200 (18.3/280)
>14 to 16 (4.3 to 4.9)	0.5/2300 (20.4/ 215)	0.5/3700 (20.4/320)
>16 to 18 (4.9 to 5.5)	0.55/2600 (22.4/270)	0.55/4400 (22.4/380)
>18 to 20 (5.5 to 6.1)	0.6/3000 (24.5/260)	0.6/5000 (24.5/465)

**Table 21.7.3(a) Control Mode Density/Area Sprinkler Protection Criteria for Roll Paper Storage for Buildings or Structures with Roof or Ceilings Up to 30 ft (Discharge Densities are gpm/ft<sup>2</sup> over ft<sup>2</sup>)**

Storage Height (ft)	Ceiling (ft)	Heavyweight					Mediumweight				Tissue All Storage Arrays
		Closed Array Banded or Unbanded	Standard Array		Open Array		Closed Array Banded or Unbanded	Standard Array		Open Array Banded or Unbanded	
			Banded	Unbanded	Banded	Unbanded		Banded	Unbanded		
10	≤5	0.3/2000	0.3/2000	0.3/2000	0.3/2000	0.3/2000	0.3/2000	0.3/2000	0.3/2000	0.3/2000	0.45/2000
10	>5	0.3/2000	0.3/2000	0.3/2000	0.3/2000	0.3/2000	0.3/2000	0.3/2000	0.3/2000	0.3/2000	0.45/2500
15	≤5	0.3/2000	0.3/2000	0.3/2000	0.3/2500	0.3/3000	0.3/2000	0.3/2000	0.45/2500	0.45/2500	0.60/2000
15	>5	0.3/2000	0.3/2000	0.3/2000	0.3/3000	0.3/3500	0.3/2000	0.3/2500	0.45/3000	0.45/3000	0.60/3000
20	≤5	0.3/2000	0.3/2000	0.3/2500	0.45/3000	0.45/3500	0.3/2000	0.45/2500	0.6/2500	0.6/2500	0.75/2500
20	>5	0.3/2000	0.3/2500	0.3/3000	0.45/3500	0.45/4000	0.3/2500	0.45/3000	0.6/3000	0.6/3000	0.75/3000
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	<i>see Note 1</i>

Notes:

- (1) Sprinkler protection requirements for tissue stored above 20 ft have not been determined.  
 (2) Densities or areas, or both, shall be permitted to be interpolated between any 5 ft storage height increment.

**Table 21.7.3(b) Control Mode Density/Area Sprinkler Protection Criteria for the Protection of Roll Paper Storage for Buildings or Structures with Roof or Ceilings Up to 9.1 m (Discharge Densities are mm/min over m<sup>2</sup>)**

Storage Height (m)	Ceiling (m)	Heavyweight					Mediumweight				Tissue All Storage Arrays
		Closed Array Banded or Unbanded	Standard Array		Open Array		Closed Array Banded or Unbanded	Standard Array		Open Array Banded or Unbanded	
			Banded	Unbanded	Banded	Unbanded		Banded	Unbanded		
3.0	≤1.5	12.2/185	12.2/185	12.2/185	12.2/185	12.2/185	12.2/185	12.2/185	12.2/185	12.2/185	18.3/185
3.0	>1.5	12.2/185	12.2/185	12.2/185	12.2/185	12.2/185	12.2/185	12.2/185	12.2/185	12.2/185	18.3/230
4.6	≤1.5	12.2/185	12.2/185	12.2/185	12.2/230	12.2/280	12.2/185	12.2/185	18.3/230	18.3/230	24.5/185
4.6	>1.5	12.2/185	12.2/185	12.2/185	12.2/280	12.2/330	12.2/185	12.2/230	18.3/280	18.3/280	24.5/280
6.1	≤1.5	12.2/185	12.2/185	12.2/230	18.3/280	18.3/325	12.2/185	18.3/230	24.5/230	24.5/230	31.0/230
6.1	>1.5	12.2/185	12.2/185	12.2/280	18.3/230	18.3/230	12.2/230	18.3/280	24.5/280	24.5/280	30.6/280
7.6	≤1.5	18.3/230	18.3/230	18.3/230	24.5/230	24.5/280	18.3/280	24.5/280	31.0/230	31.0/230	<i>see Note 1</i>

Notes:

- (1) Sprinkler protection requirements for tissue stored above 6.1 m have not been determined.  
 (2) Densities or areas, or both, shall be permitted to be interpolated between any 1.5 m storage height increment.

**Table 21.10.1 Baled Cotton Storage Up to and Including 15 ft (4.6 m)**

System Type	Discharge Density per Area [gpm/ft <sup>2</sup> over ft <sup>2</sup> (mm/min over m <sup>2</sup> )]		
	Tiered Storage	Rack Storage	Untiered Storage
Wet	0.25/3000 (10.2/280)	0.33/3000 (13.4/280)	0.15/3000 (6.1/280)
Dry	0.25/3900 (10.2/360)	0.33/3900 (13.4/360)	0.15/3900 (6.1/360)

**21.11.2** Carton records storage shall be permitted to be supported on shelving that is a minimum of 50 percent open from approved flue space to approved flue space.

**21.11.2.1** Transverse flue spaces of a nominal 6 in. (150 mm) width shall be located at each rack upright.

**21.11.2.2** Rack uprights shall be installed on a maximum of 10 ft 6 in. (3.2 m) centers.

**21.11.2.3** Longitudinal flues shall not be required.

**21.11.3** The storage rack structure for carton records storage shall consist of either of the following:

- (1) A single-row rack not greater than 72 in. (1800 mm) deep
- (2) Double-row racks having a total depth of not greater than 102 in. (2550 mm) aisle to aisle

**21.11.3.1** Each storage rack shall be separated from other storage racks by aisles that are not less than 30 in. (750 mm) and not more than 36 in. (900 mm) in width.

**21.11.3.2** Aisles used for ingress and egress shall be permitted to be up to 44 in. (1100 mm) wide when solid decking is used.

**21.11.4** Catwalk aisles between racks shall be constructed of open metal grating that is at least 50 percent open.

**21.11.4.1** Catwalk aisles at the ends of racks shall be permitted to be constructed of solid materials.

**21.11.5** Catwalks shall be installed at a maximum of 12 ft (3.7 m) apart vertically.

#### **21.11.6 Sprinkler Criteria.**

**21.11.6.1** Cartoned record storage in racks with access utilizing catwalks shall be protected in accordance with this subsection.

**21.11.6.2** The design criteria for the ceiling sprinkler system shall be in accordance with Table 21.11.6.2.

**21.11.6.2.1** Ceiling sprinklers spaced to cover a maximum of 100 ft<sup>2</sup> (9 m<sup>2</sup>) shall be standard-response spray sprinklers with K-factors in accordance with Section 21.1.

**21.11.6.3** Intermediate-level sprinklers shall be installed at each catwalk level in accordance with 21.11.6.3.1 through 21.11.6.3.4 and shall be quick-response, ordinary temperature, nominal K-5.6 (80), K-8.0 (115), or K-11.2 (160).

**21.11.6.3.1** Intermediate-level sprinklers shall be installed in the center ±4 in. (100 mm) of each aisle below each catwalk level.

**21.11.6.3.2** Intermediate-level sprinklers shall be installed a minimum 6 in. (150 mm) above the top of storage.

**21.11.6.3.3** Sprinklers shall be supplied from the in-rack sprinkler system.

**21.11.6.3.4** Spacing of sprinklers within the aisles shall be located so as to align with the transverse flues and the center of the storage unit when staggered and shall not exceed 10 ft 6 in. (3.2 m) on center.

**21.11.6.3.5\*** Sprinklers installed below each catwalk level shall be staggered vertically and horizontally. [See Figure A.21.11.6.3.5(a) and Figure A.21.11.6.3.5(b).]

**21.11.6.4** Sprinklers shall be provided in transverse flue spaces in accordance with 21.11.6.4.1 through 21.11.6.4.3.1 and Figure 21.11.6.4.

**21.11.6.4.1** For double- and multiple-row racks, in-rack sprinklers shall be installed in the transverse flues at each catwalk level and shall be staggered vertically. For single-row racks, in-rack sprinklers shall be installed in the transverse flue at each catwalk level.

**21.11.6.4.2** For double- and multiple-row racks sprinklers installed in the transverse flues shall be located not less than 18 in. (450 mm) but not greater than 24 in. (600 mm) from the face of the rack on the catwalk side.

**21.11.6.4.3** For single-row racks, sprinklers installed in the transverse flues shall be staggered horizontally such that the sprinkler at first level is not less than 18 in. (450 mm) but not greater than 24 in. (600 mm) from the face of the rack on the catwalk side.

**21.11.6.4.3.1** At the next level the sprinkler in the transverse flue shall be located not less than 6 in. (150 mm) but not greater than 12 in. (300 mm) from the back face of the rack. This staggering shall be repeated throughout all catwalk levels.

**21.11.6.4.4** In-rack sprinklers shall be installed a minimum 6 in. (150 mm) above the top of storage.

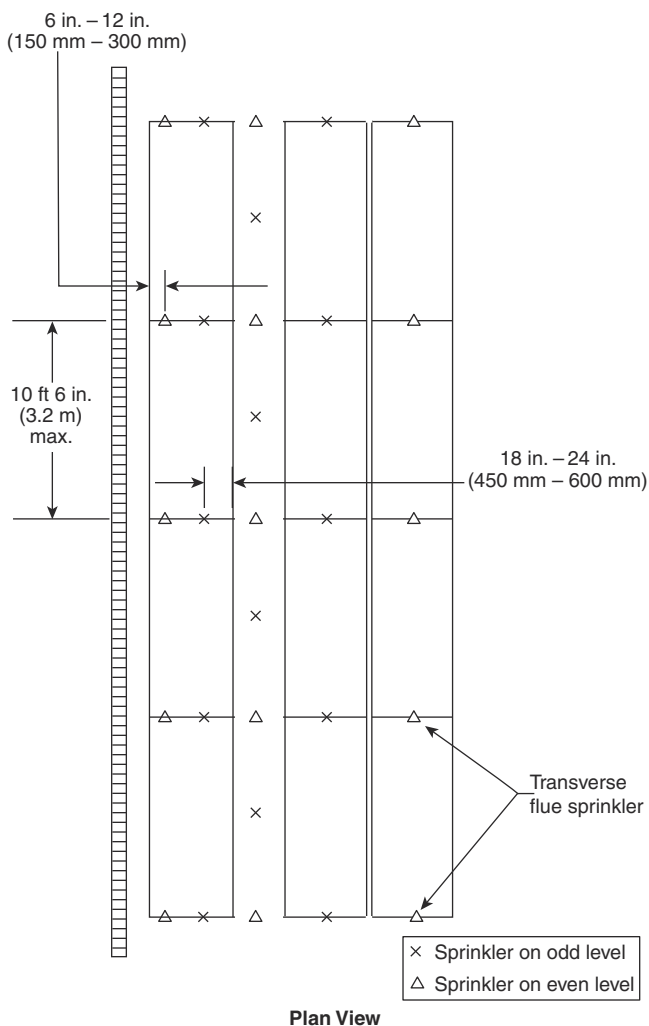
**21.11.6.4.5** Transverse flue sprinklers shall be quick-response, ordinary temperature, nominal K-5.6 (80), K-8.0 (115), or K-11.2 (160) and installed in accordance with Figure A.21.11.6.3.5(a) and Figure A.21.11.6.3.5(b).

**Table 21.11.6.2 Ceiling Sprinkler Design Criteria for Carton Record Storage**

	Up to 25 ft (7.6 m) High Storage		Over 25 ft (7.6 m) High Storage	
	Ordinary Temperature	High Temperature	Ordinary Temperature	High Temperature
Density gpm/ft <sup>2</sup> mm/min	0.33 13.4	0.29 11.8	0.3 12.2	0.4 16.3
Area ft <sup>2</sup> m <sup>2</sup>	2000 185	2000 185	2000 185	2000 185
Hose Allowance gpm L/m	500 1900	500 1900	500 1900	500 1900
Duration hours	2	2	2	2



**21.11.6.5** For multiple-level catwalk systems, a minimum of 10 sprinklers, five on each of the top two levels, shall be calculated with a minimum flow rate of 30 gpm (115 L/min) per sprinkler. Calculated sprinklers shall be the hydraulically most demanding on each level.



**FIGURE 21.11.6.4** Sprinkler Location and Spacing in Transverse Flues.

**21.11.6.5.1** For single-level catwalks, a minimum of six sprinklers shall be calculated with a minimum flow rate at 30 gpm (115 L/min) per sprinkler. Calculated sprinklers shall be the hydraulically most demanding.

**21.11.6.5.2** The in-rack sprinkler system shall be balanced in with the ceiling system.

**21.12 Control Mode Density/Area Sprinkler Protection Criteria for Compact Storage of Commodities Consisting of Paper Files, Magazines, Books, and Similar Documents in Folders and Miscellaneous Supplies with No More Than 5 Percent Plastics Up to 8 ft (2.4 m) High.**

**21.12.1\*** Compact storage modules up to 8 ft (2.4 m) high storing commodities consisting of paper files, magazines, books, and similar documents in folders and miscellaneous supplies with no more than 5 percent plastics shall be permitted to be classified as light hazard.

**21.12.2** The top of the compact storage module shall be at least 18 in. (450 mm) below the sprinkler deflector.

**21.12.3** Sprinklers shall be ordinary temperature, quick-response, standard spray upright or pendent.

**21.12.4** The compact storage module shall be provided with minimum solid steel 24 gauge (0.63 mm) metal longitudinal barriers installed every third carriage.

**21.12.5\*** Solid 24 gauge (0.63 mm) metal transverse barriers shall be spaced not more than 4 ft (1.2 m) apart.

**21.12.6** Compact storage module sizes shall not exceed 250 ft<sup>2</sup> (23 m<sup>2</sup>).

**21.12.6.1** The size of a module shall be defined as the area of compact storage bound by the length of the carriages times the distance between longitudinal barriers or to the outward edge of a fixed storage unit in the module, including the width of the aisle in the module.

**21.12.6.2** The lengths of the carriages shall be measured to the end of the carriages enclosed by solid metal transverse panels and separated by a minimum 28 in. (700 mm) aisle to a storage unit perpendicular to the carriage.

## Chapter 22 CMSA Requirements for Storage Applications

**22.1 General.** The criteria in Chapter 20 shall apply to storage protected with CMSA sprinklers.

**22.1.1** Quick-response CMSA sprinklers designed to meet any criteria in Chapter 20 through Chapter 25 shall be permitted to protect any of the following:

- (1) Light hazard occupancies
- (2) Ordinary hazard occupancies

**22.1.2** Standard-response CMSA sprinklers designed to meet any criteria in Chapter 20 through Chapter 25 shall be permitted to protect ordinary hazard occupancies.

**22.1.3** When using CMSA, the design area shall meet the requirements of 27.2.4.3.1.

**22.1.4** Protection shall be provided as specified in this chapter or appropriate NFPA standards in terms of minimum operating pressure and the number of sprinklers to be included in the design area.

### 22.1.5 Open Wood Joist Construction.

**22.1.5.1** Where CMSA sprinklers are installed under open wood joist construction, one of the following shall be provided:

- (1) A minimum pressure of 50 psi (3.4 bar) for K-11.2 (160) sprinklers
- (2) A minimum pressure of 22 psi (1.5 bar) for K-16.8 (240) sprinklers
- (3) The pressure from Table 22.4 for K-19.6 (280) or larger sprinkler.
- (4) The pressure from Table 22.4 for K-11.2 (160) or K-16.8 (240) where each joist channel is fully separated with material equal to the joist material to its full depth at intervals not exceeding 20 ft (6.1 m).

### 22.1.5.2 Preaction Systems.

**22.1.5.2.1** For the purpose of using Table 22.2, preaction systems shall be classified as dry pipe systems.

**22.1.5.3** Building steel shall not require special protection where Table 22.2 are applied as appropriate for the storage configuration.

**22.1.5.4\* Storage Conditions.** The design of the sprinkler system shall be based on those conditions that routinely or

periodically exist in a building and create the greatest water demand, which include the following:

- (1) Pile height
- (2) Clearance to ceiling
- (3) Pile stability
- (4) Array

**22.1.6\*** The ceiling design criteria for single-, double-, and multiple-row racks in Chapter 22 shall be based on open rack configurations as defined in 3.3.140.

**22.1.7** CMSA sprinklers shall not be permitted to protect storage on solid shelf racks unless the solid shelf racks are protected with in-rack sprinklers in accordance with Chapter 25.

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

**22.2 Palletized and Solid-Piled Storage of Class I Through Class IV Commodities.** Protection of palletized and solid-piled storage of Class I through Class IV commodities shall be in accordance with Table 22.2.

**22.3 Palletized and Solid-Piled Storage of Nonexpanded and Expanded Group A Plastic Commodities.** Protection of palletized and solid-piled storage of nonexpanded and expanded Group A plastic commodities shall be in accordance with Table 22.3.

**22.4 Single-, Double-, and Multiple-Row Rack Storage for Class I Through Class IV Commodities.** Protection of single-, double-, and multiple-row rack storage for Class I through Class IV commodities shall be in accordance with Table 22.4.

**22.5 Single-, Double-, and Multiple-Row Racks of Group A Plastic Commodities.** Protection of single-, double-, and multiple-row rack storage for nonexpanded Group A plastic commodities shall be in accordance with Table 22.5.

**N 22.6 Rubber Tires.** Protection of rubber tires with CMSA sprinklers shall be in accordance with Table 22.6.

**22.7 Roll Paper Storage.** Protection of roll paper storage with CMSA sprinklers shall be in accordance with Table 22.7.