21.1 General.

21.1.1

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

21.1.2 *

For storage applications with densities of 0.2 gpm/ft^2 (8.2 mm/min) or less, standard-response sprinklers with a K-factor of K-5.6 (80) or larger shall be permitted.

21.1.3

For general storage applications, rack storage, rubber tire storage, roll paper storage, and baled cotton storage being protected with upright and pendent spray sprinklers with required densities of greater than 0.2 gpm/ft^2 to 0.34 gpm/ft^2 (8.2 mm/min to 13.9 mm/min), standard-response sprinklers with a nominal K-factor of K-8.0 (115) or larger shall be used.

21.1.4

For general storage applications, rack storage, rubber tire storage, roll paper storage, and baled cotton storage being protected with upright and pendent spray sprinklers with required densities greater than 0.34 gpm/ft^2 (13.9 mm/min), standard-response spray sprinklers with a K-factor of K-11.2 (K-160) or larger that are listed for storage applications shall be used.

21.1.5

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

21.1.6

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

21.1.6.1

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

21.1.6.2

The high-temperature design densities shall be used for sprinklers with high-temperature classification.

21.1.7

Ordinary- and intermediate-temperature sprinklers with K-factors of K-11.2 (K-160) or larger, where listed for storage, shall be permitted to use the densities for high-temperature sprinklers.

21.1.8 Discharge Considerations.

21.1.8.1

The water supply for sprinklers only shall be determined either from the density/area requirements of Chapter 20, Chapter 24, and Chapter 25 or shall be based upon the room design method in accordance with Section 20.11, at the discretion of the designer.

21.1.8.2

When using the density/area method, the design area shall meet the requirements of 28.2.4.2.1.

21.1.8.3

The minimum design density shall be not less than 0.15 gpm/ft^2 (6.1 mm/min) after all adjustments are made.

21.1.9

For CMDA criteria where the clearance to ceiling exceeds those identified in Table 21.1.9, the requirements of Table 21.1.9.1 and Table 21.1.9.2 shall apply.

Table 21.1.9 Maximum Clearance from Top of Storage to Ceiling for CMDA Protection Criteria

	Class I to IV		Group A Plastic	
Commodity	ft	m	ft	m
Palletized, solid-piled, bin box, shelf, or back-to-back shelf storage	20	6.1	20	6.1
Rack storage up to 25 ft (7.6 m)	20	6.1	10	3.0
Rack storage >25 ft (7.6 m)	10	3.0	10	3.0

21.1.9.1

Protection of Class I through Class IV commodities using CMDA criteria that exceed the maximum allowable clearance in Table 21.1.9 shall be in accordance with Table 21.1.9.1.

Table 21.1.9.1 Class I Through Class IV Commodities

	Where the clearance to ceiling exceeds		Protection is based upon the storage height that would result in a clearance to ceiling of…		
Storage Configuration	ft	m	ft	m	In-rack Sprinklers*
Palletized, solid-piled, bin box, shelf, or back-to-back shelf storage	20	6.1	20	6.1	N/A
Rack storage up to and including 25 ft (7.6 m) in height	20	6.1	20	6.1	Permitted as alternative to presumed clearance of 20 ft (6.1 m)
Rack storage over 25 ft (7.6 m) in height	10	3.0	10	3.0	Permitted as alternative to presumed clearance of 10 ft (3.0 m)

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

21.1.9.2

Protection of plastic and rubber commodities with CMDA criteria having clearance exceeding the allowable limits of Table 21.1.9 shall be in accordance with Table 21.1.9.2.

Table 21.1.9.2 Plastics and Rubber Commodities

	Where the clearance to ceiling exceeds		Protection is based upon the storage height that would result in a clearance to ceiling of…		
Storage Configuration	ft	m	ft	m	In-rack Sprinklers*
Palletized, solid-piled, bin box, shelf, or back-to-back shelf storage	20	6.1	20	6.1	N/A
Rack storage up to and including 25 ft (7.6 m) in height	10	3.0	10	3.0	Permitted as alternative to presumed clearance of 10 ft (3.0 m)
Rack storage over 25 ft (7.6 m) in height	10	3.0	N/A		Required

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

21.1.9.3

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

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

21.2.1

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

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

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

21.2.2.1 System Criteria.

21.2.2.1.1

Densities shall be selected from Table 21.2.2.1.1 with a design area of 2000 ft^2 (185 m^2).

Table 21.2.2.1.1 Sprinkler System Design Density, Storage 12 ft to 30 ft (3.7 m to 9.1 m) High [gpm/ft^2 (mm/min)]

Storage Height		Commodity Class	High-Temperature-Rated Sprinkler	Ordinary-Temperature-Rated Sprinkler
ft	m			
12 to 15	3.7 to 4.6	I	0.15 (6.1)	0.15 (6.1)
		II	0.15 (6.1)	0.16 (6.5)
		III	0.20 (8.2)	0.20 (8.2)
		IV	0.21 (8.6)	0.27 (11.0)
>15 to 18	>4.6 to 5.5	I	0.15 (6.1)	0.19 (7.7)
		II	0.15 (6.1)	0.21 (8.6)
		III	0.20 (8.2)	0.26 (10.6)
		IV	0.27 (11.0)	0.35 (14.3)
>18 to 20	>5.5 to 6.1	I	0.15 (6.1)	0.21 (8.6)
		II	0.17 (6.9)	0.23 (9.4)
		III	0.21 (8.6)	0.29 (11.8)
		IV	0.30 (12.2)	0.39 (15.9)
>20 to 22	>6.1 to 6.7	I	0.17 (6.9)	0.23 (9.4)
		II	0.19 (7.7)	0.25 (10.2)
		III	0.23 (9.4)	0.32 (13.0)
		IV	0.33 (13.4)	0.43 (17.5)

Storage Height		Commodity Class	High-Temperature-Rated Sprinkler	Ordinary-Temperature-Rated Sprinkler
ft	m			
>22 to 25	>6.7 to 7.6	I	0.20 (8.2)	0.28 (11.4)
		II	0.23 (9.4)	0.31 (12.6)
		III	0.28 (11.4)	0.39 (15.9)
		IV	0.41 (16.7)	0.53 (21.6)
>25 to 28	>7.6 to 8.5	I	0.25 (10.2)	0.35 (14.3)
		II	0.28 (11.4)	0.38 (15.5)
		III	0.35 (14.3)	0.48 (19.6)
		IV	0.50 (20.4)	0.64 (26.1)
>28 to 30	>8.5 to 9.1	I	0.29 (11.8)	0.40 (16.3)
		II	0.32 (13.0)	0.44 (17.9)
		III	0.40 (16.3)	0.55 (22.4)
		IV	0.57 (23.2)	0.74 (30.2)

21.2.2.1.2

For back-to-back shelf storage greater than 12 ft (3.7 m) and up to 15 ft (4.6 m), the design density shall be taken from Table 21.2.2.1.1 for storage greater than 18 ft (5.5 m) and up to 20 ft (6.1 m) using ordinary temperature sprinklers.

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

21.2.3.1

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

21.2.3.2

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

21.2.3.3

Encapsulated storage over 15 ft (4.6 m) in height up to and including 20 ft (6.1 m) in height of Class I commodity shall be protected with a density/area of at least 0.46 gpm/ft^2 over 2000 ft^2 (18.7 mm/min over 185 m^2).

21.2.3.4

Encapsulated storage over 15 ft (4.6 m) in height up to and including 20 ft (6.1 m) in height of Class II commodity shall be protected with a density/area of at least 0.53 gpm/ft^2 over 2000 ft^2 (21.6 mm/min over 185 m^2).

21.2.3.5

Encapsulated storage over 15 ft (4.6 m) in height up to and including 20 ft (6.1 m) in height of Class III and Class IV commodity shall be protected with a density/area of at least 0.6 gpm/ft^2 over 2000 ft^2 (24.5 mm/min over 185 m^2).

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

21.3.1

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

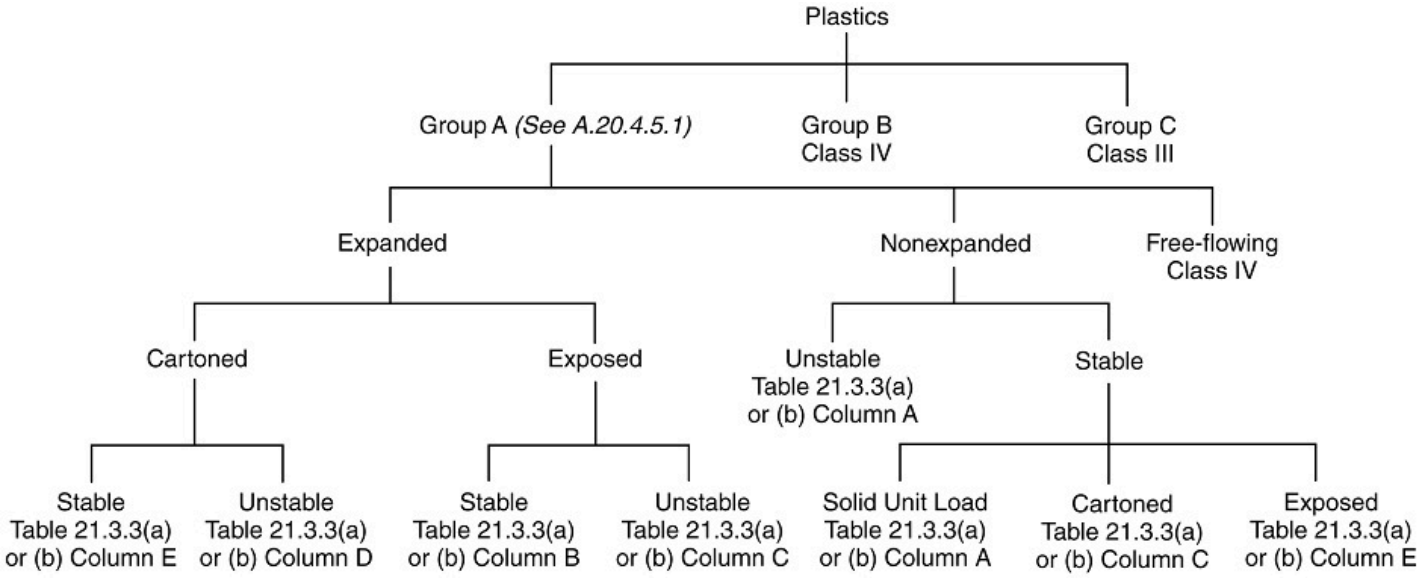
(1) Commodities that are stored palletized, solid piled, or in bin boxes up to 25 ft (7.6 m) in height.
(2) Commodities that are stored in shelf storage up to 15 ft (4.6 m) in height.

(3) Commodities that are stored using back-to-back shelf storage up to 15 ft (4.6 m) in height. The minimum aisle width shall be 5 ft (1.5 m). The design criteria shall be in accordance with Table 21.3.1. The back-to-back shelf shall have a full height solid vertical transverse barrier of $\frac{3}{8}$ in. (10 mm) plywood or particleboard, .78 mm sheet metal, or equivalent, from face of aisle to face of aisle, spaced at a maximum 45 ft (14 m) interval. The transverse barrier shall be permitted to terminate at the longitudinal barrier.

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

Storage Height		Ceiling Height		
ft	m	ft	m	Protection
Over 5 up to 8	1.5/2.4	Up to 14	4.3	Ordinary Hazard Group 2
Up to 12	3.7	Up to 15	4.6	0.45 gpm/ft^2 over 2500 ft^2 18.3 mm/min/230 m^2
Up to 12	3.7	Up to 30	9.1	0.6 gpm/ft^2 over 2500 ft^2 24.5 mm/min/232 m^2
Up to 15	4.6	Up to 30	9.1	0.7 gpm/ft^2 over 2500 ft^2 28.5 mm/min/230 m^2

Figure 21.3.1 Decision Tree.



21.3.2 *

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

21.3.3 *

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

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

Maximum Storage Height (ft)	Roof/Ceiling Height (ft)	Density (gpm/ft^2)				
		A	B	C	D	E
>5 to ≤12	Up to 15	0.2	EH2	0.3	EH1	EH2
	>15 to 20	0.3	0.6	0.5	EH2	EH2
	>20 to 32	0.4	0.8	0.6	0.45	0.7

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

Notes:

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

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

A: (1) Nonexpanded, unstable

(2) Nonexpanded, stable, solid unit load

B: Expanded, exposed, stable

C: (1) Expanded, exposed, unstable

(2) Nonexpanded, stable, cartoned

D: Expanded, cartoned, unstable

E: (1) Expanded, cartoned, stable

(2) Nonexpanded, stable, exposed

(3) EH1 = Density required by Extra Hazard Group 1 and 19.2.3.1.1

EH2 = Density required by Extra Hazard Group 2 and 19.2.3.1.1

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

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

Maximum Storage Height (m)	Roof/Ceiling Height (m)	Density (mm/min)				
		A	B	C	D	E
>1.5 to ≤3.6	Up to 4.6	8.2	EH2	12.2	EH1	EH2
	>4.6 to 6.1	12.2	24.5	20.4	EH2	EH2
	>6.1 to 9.7	16.3	32.6	24.5	18.3	28.5
4.6	Up to 6.1	12.2	24.5	20.4	16.3	18.3
	>6.1 to 7.6	16.3	32.6	24.5	18.3	28.5
	>7.6 to 10.7	18.3	36.7	28.5	22.4	34.6
6.1	Up to 7.6	16.3	32.6	24.5	18.3	28.5
	>7.6 to 9.1	18.3	36.7	28.5	22.4	34.6

Maximum Storage Height (m)	Roof/Ceiling Height (m)	Density (mm/min)				
		A	B	C	D	E
	>9.1 to 10.7	24.5	48.9	34.6	28.5	44.8
7.6	Up to 9.1	18.3	36.7	28.5	22.4	34.6
	>9.1 to 10.7	24.5	48.9	34.6	28.5	44.8

Notes:

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

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

A: (1) Nonexpanded, unstable

(2) Nonexpanded, stable, solid unit load

B: Expanded, exposed, stable

C: (1) Expanded, exposed, unstable

(2) Nonexpanded, stable, cartoned

D: Expanded, cartoned, unstable

E: (1) Expanded, cartoned, stable

(2) Nonexpanded, stable, exposed

(3) EH1 = Density required by Extra Hazard Group 1 and 19.2.3.1.1

EH2 = Density required by Extra Hazard Group 2 and 19.2.3.1.1

(4) Roof/ceiling height greater than 11 m is not permitted.

21.3.3.1 *

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

(1) The area shall be a minimum of 2500 ft^2 (230 m^2).
(2) Where Table 21.3.3(a) and Table 21.3.3(b) allow densities and areas to be selected in accordance with Extra Hazard Group 1 and Group 2, including 19.2.3.1.1, the following area reductions shall be permitted:
    (a) For K-8.0 (115) sprinklers used with Extra Hazard Group 1, the design area shall be permitted to be reduced by 25 percent, but not below 2000 ft^2 (185 m^2), where high temperature–sprinklers are used.
    (b) For K-11.2 (160) or larger sprinklers, the design area shall be permitted to be reduced by 25 percent, but not below 2000 ft^2 (185 m^2), regardless of sprinkler temperature rating.
(3) For closed arrays, the area shall be permitted to be reduced to 2000 ft^2 (185 m^2).

21.3.3.2 *

Interpolation of densities between storage heights shall be permitted.

21.3.3.2.1

Interpolation of ceiling/roof heights shall not be permitted.

21.3.4

The ceiling-only protection criteria specified in Chapter 21 for rack storage of Group A plastic commodities shall be permitted to be used for solid-piled and palletized storage of the same commodity at the same height and clearance to ceiling.

21.3.5

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

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

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

21.4.1.1 * General.

Ceiling sprinkler water demand shall be determined in accordance with 21.4.1.2 for single- and double-row racks or 21.4.1.5 and 21.4.1.3 for multiple-row racks. *(See Section C.14.)*

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

21.4.1.2.1

For single- or double-row racks for Class I, Class II, Class III, or Class IV commodities, encapsulated or nonencapsulated, the ceiling sprinkler water demand in terms of density [gpm/ft^2 (mm/min)] and area of sprinkler operation [ft^2 (m^2) of ceiling or roof] shall be selected from the criteria in Table 21.4.1.2.1(a) through Table 21.4.1.2.1(e) that are appropriate for each commodity and configuration and shall be modified as appropriate by 21.4.1.4.

Table 21.4.1.2.1(a) Single- or Double-Row Racks — Storage Height Up to and Including 15 ft (4.6 m) [gpm/ft^2 (mm/min)]

Commodity Class	Encapsulated	In-Rack Sprinklers Mandatory	Aisles ft (m)	High-Temperature-Rated Sprinkler	Ordinary-Temperature-Rated Sprinkler
I	No	No	4 (1.2)	0.19 (7.7)	0.22 (9.0)
			8 (2.4)	0.17 (6.9)	0.20 (8.1)
	Yes	No	4 (1.2)	0.33 (13.4)[a]	0.33 (13.4)[b]
			8 (2.4)	0.28 (11.4)	0.32 (13.0)
II	No	No	4 (1.2)	0.23 (9.4)	0.26 (10.6)
			8 (2.4)	0.20 (8.2)	0.22 (9.0)
	Yes	No	4 (1.2)	0.33 (13.4)[a]	0.33 (13.4)[b]
			8 (2.4)	0.28 (11.4)	0.32 (13.0)
III	No	No	4 (1.2)	0.26 (10.6)	0.29 (11.8)
			8 (2.4)	0.22 (9.0)	0.25 (10.2)
	Yes	Yes	4 (1.2)	See Chapter 25.	
			8 (2.4)		
IV	No	No	4 (1.2)	0.35 (14.3)	0.36 (14.7)[c]
			8 (2.4)	0.30 (12.2)	0.34 (13.9)
	Yes	Yes	4 (1.2)	See Chapter 25.	
			8 (2.4)		

[a]Design area is 2400 ft^2 (220 m^2).

[b]Design area is 4000 ft^2 (370 m^2).

[c]Design area is 3000 ft^2 (280 m^2).

Table 21.4.1.2.1(b) Single- or Double-Row Racks —Storage Height Greater Than 15 ft (4.6 m) Up to and Including 18 ft (5.5 m) [gpm/ft^2 (mm/min)]

Commodity Class	Encapsulated	In-Rack Sprinklers Mandatory	Aisles ft (m)	High-Temperature-Rated Sprinkler	Ordinary-Temperature-Rated Sprinkler
I	No	No	4 (1.2)	0.27 (11.0)	0.31 (12.6)
			8 (2.4)	0.25 (10.2)	0.28 (11.4)
	Yes	No	4 (1.2)	0.47 (19.2)[a]	0.47 (19.2)[b]
			8 (2.4)	0.40 (16.3)	0.46 (18.7)
II	No	No	4 (1.2)	0.32 (13.0)	0.37 (15.1)
			8 (2.4)	0.28 (11.4)	0.31 (12.6)
	Yes	No	4 (1.2)	0.47 (19.2)[a]	0.47 (19.2)[b]
			8 (2.4)	0.40 (16.3)	0.46 (18.7)
III	No	No	4 (1.2)	0.37 (15.1)	0.42 (17.1)
			8 (2.4)	0.31 (12.6)	0.36 (14.7)
	Yes	Yes	4 (1.2)	See Chapter 25.	
			8 (2.4)		
IV	No	No	4 (1.2)	0.49 (20.0)	0.51 (20.8)[c]
			8 (2.4)	0.42 (17.1)	0.48 (19.6)
	Yes	Yes	4 (1.2)	See Chapter 25.	
			8 (2.4)		

[a]Design area is 2400 ft^2 (220 m^2).

[b]Design area is 4000 ft^2 (370 m^2).

[c]Design area is 3000 ft^2 (280 m^2).

Table 21.4.1.2.1(c) Single- or Double-Row Racks — Storage Height Greater Than 18 ft (5.5 m) Up to and Including 20 ft (6.1 m) [gpm/ft^2 (mm/min)]

Commodity Class	Encapsulated	In-Rack Sprinklers Mandatory	Aisles ft (m)	High-Temperature-Rated Sprinkler	Ordinary-Temperature-Rated Sprinkler
I	No	No	4 (1.2)	0.32 (13.0)	0.37 (15.1)
			8 (2.4)	0.29 (11.8)	0.33 (13.4)
	Yes	No	4 (1.2)	0.55 (22.4)[a]	0.55 (22.4)[b]
			8 (2.4)	0.47 (19.1)	0.54 (21.9)
II	No	No	4 (1.2)	0.38 (15.5)	0.44 (17.9)
			8 (2.4)	0.33 (13.5)	0.37 (15.1)
	Yes	No	4 (1.2)	0.55 (22.4)[a]	0.55 (22.4)[b]
			8 (2.4)	0.47 (19.1)	0.54 (21.9)
III	No	No	4 (1.2)	0.43 (17.5)	0.49 (19.9)
			8 (2.4)	0.37 (15.1)	0.42 (17.1)
	Yes	Yes	4 (1.2)	See Chapter 25.	
			8 (2.4)		
IV	No	No	4 (1.2)	0.58 (23.7)	0.60 (24.5)[c]
			8 (2.4)	0.50 (20.4)	0.57 (23.2)

Commodity Class	Encapsulated	In-Rack Sprinklers Mandatory	Aisles ft (m)	High-Temperature-Rated Sprinkler	Ordinary-Temperature-Rated Sprinkler
	Yes	Yes	4 (1.2)	See Chapter 25.	
			8 (2.4)		

[a]Design area is 2400 ft^2 (220 m^2).

[b]Design area is 4000 ft^2 (370 m^2).

[c]Design area is 3000 ft^2 (280 m^2).

Table 21.4.1.2.1(d) Single- or Double-Row Racks — Storage Height Greater Than 20 ft (6.1 m) Up to and Including 22 ft (6.7 m) [gpm/ft^2 (mm/min)]

Commodity Class	Encapsulated	In-Rack Sprinklers Mandatory	Aisles ft (m)	High-Temperature-Rated Sprinkler	Ordinary-Temperature-Rated Sprinkler
I	No	No	4 (1.2)	0.42 (17.1)	0.48 (19.6)
			8 (2.4)	0.38 (15.5)	0.43 (17.5)
	Yes	Yes	4 (1.2)	See Chapter 25.	
			8 (2.4)		
II	No	No	4 (1.2)	0.49 (20.0)	0.57 (23.2)
			8 (2.4)	0.43 (17.5)	0.48 (19.6)
	Yes	Yes	4 (1.2)	See Chapter 25.	
			8 (2.4)		
III	No	No	4 (1.2)	0.56 (22.8)	0.64 (26.1)
			8 (2.4)	0.48 (19.6)	0.55 (22.4)
	Yes	Yes	4 (1.2)	See Chapter 25.	
			8 (2.4)		
IV	No	No	4 (1.2)	0.75 (30.5)	0.78 (31.7)*
			8 (2.4)	0.65 (26.5)	0.74 (30.1)
	Yes	Yes	4 (1.2)	See Chapter 25.	
			8 (2.4)		

*Design area is 3000 ft^2 (280 m^2).

Table 21.4.1.2.1(e) Single- or Double-Row Racks — Storage Height Greater Than 22 ft (6.7 m) Up to and Including 25 ft (7.6 m) [gpm/ft^2 (mm/min)]

Commodity Class	Encapsulated	In-Rack Sprinklers Mandatory	Aisles ft (m)	High-Temperature-Rated Sprinkler	Ordinary-Temperature-Rated Sprinkler
I	No	No	4 (1.2)	0.56 (22.8)	0.65 (26.9)
			8 (2.4)	0.51 (20.8)	0.58 (23.6)
	Yes	Yes	4 (1.2)	See Chapter 25.	
			8 (2.4)		
II	No	No	4 (1.2)	0.67 (27.3)	0.77 (31.3)

Commodity Class	Encapsulated	In-Rack Sprinklers Mandatory	Aisles ft (m)	High-Temperature-Rated Sprinkler	Ordinary-Temperature-Rated Sprinkler
	Yes	Yes	8 (2.4)	0.58 (23.7)	0.65 (26.5)
			4 (1.2)	See Chapter 25.	
			8 (2.4)		
III	No	No	4 (1.2)	0.75 (30.5)	0.86 (34.9)
			8 (2.4)	0.65 (26.5)	0.74 (30.1)
	Yes	Yes	4 (1.2)	See Chapter 25.	
			8 (2.4)		
IV	No	Yes	4 (1.2)	See Chapter 25.	
			8 (2.4)		
	Yes	Yes	4 (1.2)		
			8 (2.4)		

21.4.1.2.2

The requirements in 21.4.1.2.1 shall apply to portable racks arranged in the same manner as single- or double-row racks.

21.4.1.2.3

Unless otherwise indicated in Table 21.4.1.2.1(a) through Table 21.4.1.2.1(e), the minimum design area shall be 2000 ft^2 (185 m^2).

21.4.1.2.4 *

Design densities for single- and double-row racks shall be selected to correspond to aisle width in 21.4.1.2. *(See Section C.15.)*

21.4.1.2.4.1

For aisle widths between 4 ft (1.2 m) and 8 ft (2.4 m), the rules for 4 ft (1.2 m) aisle width shall be used or direct linear interpolation between the densities shall be permitted.

21.4.1.2.4.2

The density given for 8 ft (2.4 m) wide aisles shall be applied to aisles wider than 8 ft (2.4 m).

21.4.1.2.4.3

The density given for 4 ft (1.2 m) wide aisles shall be applied to aisles more narrow than 4 ft (1.2 m) down to $3\frac{1}{2}$ ft (1.1 m).

21.4.1.2.4.4

Where aisles are more narrow than $3\frac{1}{2}$ ft (1.1 m), racks shall be considered to be multiple-row racks.

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

21.4.1.3.1

For Class I, Class II, Class III, or Class IV commodities, encapsulated or nonencapsulated, ceiling sprinkler water demand in terms of density [gpm/ft^2 (mm/min)] and area of sprinkler operation [ft^2 (m^2) of ceiling or roof] shall be selected from the criteria in Table 21.4.1.3.1(a) through Table 21.4.1.3.1(e) that are appropriate for each commodity and configuration and shall be modified as appropriate by 21.4.1.4.

Table 21.4.1.3.1(a) Multiple-Row Racks — Rack Depth Up to and Including 16 ft (4.9 m), Aisles 8 ft (2.4 m) or Wider, Storage Height Up to and Including 15 ft (4.6 m) [gpm/ft^2 (mm/min)]

Commodity Class	Encapsulated	In-Rack Sprinklers Mandatory	High-Temperature-Rated Sprinkler	Ordinary-Temperature-Rated Sprinkler
I	No	No	0.22 (9.0)	0.25 (10.2)

Commodity Class	Encapsulated	In-Rack Sprinklers Mandatory	High-Temperature-Rated Sprinkler	Ordinary-Temperature-Rated Sprinkler
	Yes	No	0.28 (11.4)	0.31 (12.6)
II	No	No	0.25 (10.2)	0.28 (11.4)
	Yes	No	0.32 (13.0)	0.35 (14.3)
III	No	No	0.28 (11.4)	0.31 (12.6)
	Yes	Yes	See Chapter 25.	
IV	No	Yes	See Chapter 25.	
	Yes	Yes	See Chapter 25.	

Table 21.4.1.3.1(b) Multiple-Row Racks — Rack Depth Up to and Including 16 ft (4.9 m), Aisles 8 ft (2.4 m) or Wider, Storage Height Above 15 ft (4.6 m) Up to and Including 18 ft (5.5 m) [gpm/ft^2 (mm/min)]

Commodity Class	Encapsulated	In-Rack Sprinklers Mandatory	High-Temperature-Rated Sprinkler	Ordinary-Temperature-Rated Sprinkler
I	No	No	0.31 (12.6)	0.35 (14.3)
	Yes	No	0.39 (15.9)	0.44 (17.9)
II	No	No	0.36 (14.7)	0.40 (16.3)
	Yes	No	0.45 (18.3)	0.50 (20.4)
III	No	No	0.40 (16.3)	0.44 (17.9)
	Yes	Yes	See Chapter 25.	
IV	No	Yes	See Chapter 25.	
	Yes	Yes	See Chapter 25.	

Table 21.4.1.3.1(c) Multiple-Row Racks — Rack Depth Up to and Including 16 ft (4.9 m), Aisles 8 ft (2.4 m) or Wider, Storage Height Above 18 ft (5.5 m) Up to and Including 20 ft (6.1 m) [gpm/ft^2 (mm/min)]

Commodity Class	Encapsulated	In-Rack Sprinklers Mandatory	High-Temperature-Rated Sprinkler	Ordinary-Temperature-Rated Sprinkler
I	No	No	0.37 (15.1)	0.41 (16.7)
	Yes	No	0.46 (18.7)	0.51 (20.8)
II	No	No	0.42 (17.1)	0.47 (19.2)
	Yes	No	0.53 (21.6)	0.59 (24.0)
III	No	No	0.47 (19.1)	0.52 (21.2)
	Yes	Yes	See Chapter 25.	
IV	No	Yes	See Chapter 25.	
	Yes	Yes	See Chapter 25.	

Table 21.4.1.3.1(d) Multiple-Row Racks — Rack Depth Up to and Including 16 ft (4.9 m), Aisles 8 ft (2.4 m) or Wider, Storage Height Above 20 ft (6.1 m) Up to and Including 22 ft (6.7 m) [gpm/ft^2 (mm/min)]

Commodity Class	Encapsulated	In-Rack Sprinklers Mandatory	High-Temperature-Rated Sprinkler	Ordinary-Temperature-Rated Sprinkler
I	No	No	0.48 (19.6)	0.53 (21.6)
	Yes	Yes	See Chapter 25.	

Commodity Class	Encapsulated	In-Rack Sprinklers Mandatory	High-Temperature-Rated Sprinkler	Ordinary-Temperature-Rated Sprinkler
II	No	Yes	See Chapter 25.	
	Yes	Yes	See Chapter 25.	
III	No	Yes	See Chapter 25.	
	Yes	Yes	See Chapter 25.	
IV	No	Yes	See Chapter 25.	
	Yes	Yes	See Chapter 25.	

Table 21.4.1.3.1(e) Multiple-Row Racks — Rack Depth Up to and Including 16 ft (4.9 m), Aisles 8 ft (2.4 m) or Wider, Storage Height Above 22 ft (6.7 m) Up to and Including 25 ft (7.6 m) [gpm/ft^2 (mm/min)]

Commodity Class	Encapsulated	In-Rack Sprinklers Mandatory	High-Temperature-Rated Sprinkler	Ordinary-Temperature-Rated Sprinkler
I	No	No	0.65 (26.5)	0.72 (29.3)
	Yes	Yes	See Chapter 25.	
II	No	Yes	See Chapter 25.	
	Yes	Yes	See Chapter 25.	
III	No	Yes	See Chapter 25.	
	Yes	Yes	See Chapter 25.	
IV	No	Yes	See Chapter 25.	
	Yes	Yes	See Chapter 25.	

21.4.1.3.2

The protection criteria in accordance with 21.4.1.3.1 shall apply to portable racks arranged in the same manner as multiple-row racks.

21.4.1.3.3

Unless otherwise indicated in Table 21.4.1.3.1(a) through Table 21.4.1.3.1(e), the minimum design area shall be 2000 ft^2 (185 m^2).

21.4.1.4 Protection for 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).

21.4.1.4.1

For Class I, Class II, Class III, or Class IV commodities, encapsulated or nonencapsulated, storage height up to and including 15 ft. (4.6 m), the ceiling sprinkler water demand in terms of density [gpm/ft^2 (mm/min)] and area of sprinkler operation [ft^2 (m^2) of ceiling or roof] appropriate for each commodity and configuration shall be selected from Table 21.4.1.4.1 and shall be modified as appropriate by 21.4.1.4.

Table 21.4.1.4.1 Multiple-Row Racks — Rack Depth Over 16 ft (4.9 m) or Aisles Narrower Than 8 ft (2.4 m), Storage Height Up to and Including 15 ft (4.6 m)

Commodity Class	Encapsulated	In-Rack Sprinklers Mandatory	High-Temperature-Rated Sprinkler	Ordinary-Temperature-Rated Sprinkler
I	No	No	0.22 (9.0)	0.25 (10.2)
	Yes	No	0.28 (11.4)	0.31 (12.6)
II	No	No	0.25 (10.2)	0.28 (11.4)
	Yes	No	0.32 (13.0)	0.35 (14.3)
III	No	No	0.28 (11.4)	0.31 (12.6)
	Yes	Yes	See Chapter 25.	

Commodity Class	Encapsulated	In-Rack Sprinklers Mandatory	High-Temperature-Rated Sprinkler	Ordinary-Temperature-Rated Sprinkler
IV	No	Yes	See Chapter 25.	
	Yes	Yes	See Chapter 25.	

21.4.1.4.2

Encapsulated or nonencasulated Class I through Class IV commodities stored over 15 ft (4.6 m) shall be in accordance with Chapter 25.

21.4.1.4.3

The protection criteria in accordance with 21.4.1.4.1 shall apply to portable racks arranged in the same manner as multiple-row racks.

21.4.1.5 Multiple-Row Racks — Storage Height Over 12 ft (3.7 m) Up to and Including 25 ft (7.6 m).

21.4.1.5.1

Where Class I, Class II, and Class III commodities are encapsulated, ceiling sprinkler density shall be 25 percent greater than for nonencapsulated.

21.4.1.5.2

Where Class IV commodities are encapsulated, ceiling sprinkler density shall be 50 percent greater than for nonencapsulated.

21.4.1.6 Ceiling Sprinkler Density Adjustments.

21.4.1.6.1

Where solid, flat-bottom, combustible pallets (slave pallets) are used with storage height up to and including 25 ft (7.6 m), the densities that are indicated based on conventional pallets shall be increased 20 percent for the given area.

21.4.1.6.1.1

The percentage shall be applied to the density determined in accordance with 21.4.1.6.

21.4.1.6.1.2

The increase in density shall not apply where in-rack sprinklers are utilized in the design.

21.4.2 Control Mode Density/Area Sprinkler Protection Criteria for Rack Storage of Class I Through Class IV Commodities Stored Over 25 ft (7.6 m) in Height.

21.4.2.1 *

The protection criteria requirements for rack storage of Class I through Class IV commodities stored over 25 ft (7.6 m) in height protected by CMDA sprinklers shall be in accordance with Chapter 25.

21.4.2.2

Where such storage is encapsulated, ceiling sprinkler density shall be 25 percent greater than for nonencapsulated storage.

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

21.5.1

Plastic commodities shall be protected in accordance with this section. *(See Section C.21.)*

21.5.1.1

For Group A plastic commodities in cartons, encapsulated or nonencapsulated in single-, double-, and multiple-row racks and with a clearance to ceiling up to and including 10 ft (3.1 m), ceiling sprinkler water demand in terms of density [gpm/ft^2 (mm/min)] and area of operation [ft^2 (m^2)] shall be selected from Table 21.5.1.1. *(See Section C.22.)*

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 (3.0 m) gpm/ft^2 (mm/min)	Ceiling Sprinkler Operating Area ft^2 (m^2)
Group A plastic commodities in cartons, encapsulated or nonencapsulated	5 to 10 (1.5 to 3.0)	<5 (<1.5)	<15 (<4.6)	0.30 (12.2)	2000 (185)
		5 to 10 (1.5 to 3.0)	20 (6.1)	0.45 (18.3)	
	15 (4.6)	5 to 10 (1.5 to 3.0)	22 (6.7)	0.45 (18.3)	
		≤10 (≤3.0)	25 (7.7)	0.60 (24.5)	
	20 (6.1)	<5 (<1.5)	<25 (<7.7)	0.60 (24.5)[a]	
		5 to 10 (1.5 to 3.0)	27 (8.2)	0.60 (24.5)	
	25 (7.7)	≤10 (≤3.0)	30 (9.1)	0.8 (32.6)[b,c]	
		5 to 10 (1.5 to 3.0)	35 (11)	See Chapter 25.	

[a]For the protection of single- and double-row racks only.

[b]Ceiling-only protection is not permitted for this storage configuration except where K-16.8 (K-240) spray sprinklers listed for storage use are installed.

[c]For dry systems, the operating area is increased to 4500 ft^2 (420 m^2).

21.5.1.2

Linear interpolation of design densities and areas of application shall be permitted between storage heights with the same clearance to ceiling.

21.5.1.3

No interpolation between clearance to ceiling shall be permitted.

21.5.1.4

An option shall be selected from Table 21.5.1.1 given the storage height and clearance being protected.

21.5.2

Exposed nonexpanded Group A plastics protected with control mode density/area sprinklers shall be protected in accordance with Table 21.5.2.

Table 21.5.2 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^2 (mm/min)	Ceiling Sprinkler Operating Area ft^2 (m^2)
Exposed nonexpanded Group A plastic	10 ft (3.1 m)	20 ft (6.1 m)	0.80 gpm/ft^2 (32.6 mm/min)	2500 ft^2 (230 m^2)

21.6 Control Mode Density/Area Sprinkler Protection Criteria for Rack Storage of Group A Plastic Commodities Stored Over 25 ft (7.6 m) in Height for Single-, Double-, and Multiple-Row Racks.

The protection criteria requirements for rack storage of Group A plastic commodities stored over 25 ft (7.6 m) in height protected by CMDA sprinklers shall be in accordance with Chapter 25.

21.7 * Control Mode Density/Area Sprinkler Protection Criteria for Storage of Rubber Tires.

21.7.1 Ceiling Systems.

Protection of rubber tire storage by ceiling-only sprinkler arrangements shall be selected from Table 21.7.1(a) or Table 21.7.1(b) or in accordance with Chapter 25 using ceiling and in-rack sprinkler arrangements.

Table 21.7.1(a) Protection Criteria for Rubber Tire Storage Using Control Mode Density/Area Sprinklers

Piling Method	Pile Height [ft (m)]	Sprinkler Discharge Density[a] [gpm/ft^2 (mm/min)]	Areas of Application[a] [ft^2 (m^2)]	
			Ordinary Temperature	High Temperature
(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[b]	Over 12 (3.7) to 18 (5.5)	0.60 (24.5)	Not allowed	2500 (230)
(2) On-floor storage	Up to 5 (1.5)	0.19 (7.7)	2000 (185)	2000 (185)
Tires, on-tread	Over 5 (1.5) to 12 (3.7)	0.30 (12.2)	2500 (230)	2500 (230)
(3) Palletized portable rack storage	Up to 5 (1.5)	0.19 (7.7)	2000 (185)	2000 (185)
On-side or on-tread	Over 5 (1.5) to 20 (6.1)	See Table 21.7.1(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 21.7.1(b).	—	—
	Over 20 (6.1) to 25 (7.6)	0.60 (24.5) and	Not allowed	5000 (465)
		0.90 (36.7)[c] or	Not allowed	3000 (280)
		0.75 (2.8) with 1-hour fire-resistive rating of roof and ceiling assembly	Not allowed	4000 (370)
(5) Open portable rack storage, on-side or on-tread	Up to 5 (1.5)	0.19 (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	Not allowed	5000 (465)
		0.90 (36.7)[c] or	Not allowed	3000 (280)
		0.30 (12.2) plus high-expansion foam	3000 (280)	3000 (280)
(6) Open portable rack storage, laced	Over 12 (3.7) to 20 (6.1)	0.60 (24.5) and	Not allowed	5000 (465)
		0.90 (36.7)[c,d]	Not allowed	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 21.7.1(b) or	3000 (280)	3000 (280)
		0.30 (12.2) plus high-expansion foam	—	—
	Over 20 (6.1) to 30 (9.1)	0.30 (12.2) plus high-expansion foam	Not allowed	3000 (280)

Piling Method	Pile Height [ft (m)]	Sprinkler Discharge Density[a] [gpm/ft^2 (mm/min)]	Areas of Application[a] [ft^2 (m^2)]	
			Ordinary Temperature	High Temperature
(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	Not allowed	5000 (465)
		0.90 (36.7)[c] or	Not allowed	3000 (280)
		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)

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

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

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

[c]Water supply fulfills both requirements.

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

Table 21.7.1(b) Control Mode Density/Area Sprinklers System Density [gpm/ft^2 (mm/min)] 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)

21.8 Control Mode Density/Area Sprinkler Protection Criteria for Roll Paper Storage.

21.8.1

Storage of heavyweight or mediumweight classes of rolled paper up to 10 ft (3.0 m) in height shall be protected by sprinklers designed for ordinary hazard Group 2 densities.

21.8.2

Storage of tissue and lightweight classes of paper up to 10 ft (3.0 m) in height shall be protected by sprinklers in accordance with extra hazard Group 1 densities.

21.8.3

Sprinkler design criteria for storage of roll paper 10 ft (3.0 m) high and higher in buildings or structures with roof or ceilings up to 30 ft (9.1 m) shall be in accordance with Table 21.8.3(a) and Table 21.8.3(b).

Table 21.8.3(a) Control Mode Density/Area Sprinkler Protection Criteria for Roll Paper Storage for Buildir with Roof or Ceilings Up to 30 ft (Discharge Densities are gpm/ft^2 over ft^2)

Storage Height (ft)	Ceiling (ft)	Heavyweight					Mediumweight			
		Closed Array Banded or Unbanded	Standard Array		Open Array		Closed Array Banded or Unbanded	Standard Array		
			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	
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	
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	
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	
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	
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	
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	

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 21.8.3(b) Control Mode Density/Area Sprinkler Protection Criteria for the Protection of Roll Paper S Buildings or Structures with Roof or Ceilings Up to 9.1 m (Discharge Densities are mm/min over m^2)

Storage Height (m)	Ceiling (m)	Heavyweight					Mediumweight			
		Closed Array Banded or Unbanded	Standard Array		Open Array		Closed Array Banded or Unbanded	Standard Array		
			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	
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	
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	
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	
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	
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	
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	

Notes:

(1) Sprinkler protection requirements for tissue stored above 6.1 m have not been determined.

(2) Densities or areas, or both, shall be permitted to be interpolated between any 1.5 m storage height increment.

21.8.4 *

High-temperature sprinklers shall be used for installations protecting roll paper stored 15 ft (4.6 m) or higher.

21.8.5

The protection area per sprinkler shall not exceed 100 ft^2 (9.3 m^2) or be less than 70 ft^2 (6.5 m^2).

21.8.6

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^2 (9.8 mm/min) with a minimum operating area of 2000 ft^2 (185 m^2).

21.8.7

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 21.8.3(a) and Table 21.8.3(b).