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

21.1 General

21.1.1

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

21.1.2\*

For storage applications with densities of 0.2 gpm/ft2 (8.2 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/ft2 to 0.34 gpm/ft2 (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/ft2 (13.9 mm/min), standard-response spray sprinklers with a K-factor of K-11.2 (161) or larger that are listed for storage applications shall be used.

21.1.5\*

Unless the requirements of 21.1.6 are met, the requirements of Table 21.5.1.1 shall not apply to modifications to existing storage application systems, using sprinklers with K-factors of K-8.0 (115) or less.

21.1.6

Where applying the requirements of Table 21.5.1.1 utilizing the design criteria of 0.6 gpm/ft2 per 2000 ft2 (24.5 mm/min per 185 m2) to existing storage applications, the requirements of 21.1.4 shall apply.

21.1.7

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

21.1.8

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

21.1.8.1

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

21.1.8.2

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

21.1.9

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

21.1.10 Discharge Considerations

21.1.10.1

The water supply for sprinklers only shall be determined either from the density/area requirements of Chapter 20 through Chapter 25 or shall be based upon the room design method in accordance with Section 20.8, at the discretion of the designer.

21.1.10.2

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

21.1.10.3

When using the density/area method, the design area shall meet the requirements of 27.2.4.2.1.

21.1.10.4

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

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:

Nonencapsulated commodities that are solid-piled, palletized, or bin box storage up to 30 ft (9.1 m) in height

Nonencapsulated commodities on shelf storage up to 15 ft (4.6 m) in height

\* Encapsulated commodities that are solid-piled, palletized, bin box, or shelf storage up to 15 ft (4.6 m) in height

Back-to-back shelf storage up to 15 ft (4.6 m) in height

Encapsulated storage of solid-piled and palletized Class I through IV commodities permitted in accordance with 21.2.3 for storage heights over 15 ft (4.6 m) up to and including 20 ft (6.1 m)

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

21.2.2.1

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

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

21.2.2.2

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

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

21.2.2.3

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

FIGURE 21.2.2.3 Ceiling Sprinkler Density vs. Storage Height.

21.2.2.4

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

21.2.2.5

For storage greater than 12 ft (3.7 m), the design density shall not be less than 0.15 gpm/ft2 (6.1 mm/min), and the design area shall not be less than 2000 ft2 (185 m2) for wet systems or 2600 ft2 (240 m2) for dry systems for any commodity, class, or group.

21.2.2.6

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

21.2.2.7

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

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

21.2.3.1

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

21.2.3.2

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

21.2.3.3

Encapsulated storage over 15 ft (4.6 m) in height up to and including 20 ft (6.1 m) in height of Class I commodity shall be protected with a density/area of at least 0.46 gpm/ft2 over 2000 ft2 (18.7 mm/min over 185 m2).

21.2.3.4

Encapsulated storage over 15 ft (4.6 m) in height up to and including 20 ft (6.1 m) in height of Class II commodity shall be protected with a density/area of at least 0.53 gpm/ft2 over 2000 ft2 (21.6 mm/min over 185 m2).

21.2.3.5

Encapsulated storage over 15 ft (4.6 m) in height up to and including 20 ft (6.1 m) in height of Class III and Class IV commodity shall be protected with a density/area of at least 0.6 gpm/ft2 over 2000 ft2 (24.5 mm/min over 185 m2).

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

21.2.4.1 Bin Box and Shelf Storage

21.2.4.1.1

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

21.2.4.1.2

Protection shall be as follows:

Ceiling design density shall be based on the total height of storage within the building.

Automatic sprinklers under walkways shall be designed to maintain a minimum discharge pressure of 15 psi (1.0 bar) for the most hydraulically demanding six sprinklers on each level. Walkway sprinkler demand shall not be required to be added to the ceiling sprinkler demand. Sprinklers under walkways shall not be spaced more than 8 ft (2.4 m) apart horizontally.

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

21.3.1

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

Commodities that are stored palletized, solid piled, or in bin boxes up to 25 ft (7.6 m) in height.

Commodities that are stored in shelf storage up to 15 ft (4.6 m) in height.

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 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 Protection

ft m ft m

Over 5 up to 8 1.5/2.4 Up to 14 4.3 Ordinary Hazard Group 2

Up to 12 3.7 Up to 15 4.6 0.45 gpm/ft2 over 2500 ft2 18.3 mm/min/230 m2

Up to 12 3.7 Up to 30 9.1 0.6 gpm/ft2 over 2500 ft2 24.5 mm/min/232 m2

Up to 15 4.6 Up to 30 9.1 0.7 gpm/ft2 over 2500 ft2 28.5 mm/min/230 m2

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

There are multiple layers of corrugation or equivalent outer material that would significantly delay fire involvement of the Group A plastic.

The amount and arrangement of Group A plastic material within a carton with a single layer of corrugation would not be expected to significantly increase the fire hazard.

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 (U.S. Customary Units)

Maximum Storage Height (ft) Roof/Ceiling Height (ft) Density (gpm/ft2)

A B C D E

>5 to ≤12 Up to 15 0.2 EH2 0.3 EH1 EH2

>15 to 20 0.3 0.6 0.5 EH2 EH2

>20 to 32 0.4 0.8 0.6 0.45 0.7

15 Up to 20 0.3 0.6 0.5 0.4 0.45

>20 to 25 0.4 0.8 0.6 0.45 0.7

>25 to 35 0.45 0.9 0.7 0.55 0.85

20 Up to 25 0.4 0.8 0.6 0.45 0.7

>25 to 30 0.45 0.9 0.7 0.55 0.85

>30 to 35 0.6 1.2 0.85 0.7 1.1

25 Up to 30 0.45 0.9 0.7 0.55 0.85

>30 to 35 0.6 1.2 0.85 0.7 1.1

Notes:

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

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

A: (1) Nonexpanded, unstable

(2) Nonexpanded, stable, solid unit load

B: Expanded, exposed, stable

C: (1) Expanded, exposed, unstable

(2) Nonexpanded, stable, cartoned

D: Expanded, cartoned, unstable

E: (1) Expanded, cartoned, stable

(2) Nonexpanded, stable, exposed

(3) EH1 = Density required by Extra Hazard Group 1 design curve and 19.3.3.1.1

EH2 = Density required by Extra Hazard Group 2 design curve and 19.3.3.1.1

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

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

Maximum Storage Height (m) Roof/Ceiling Height (m) Density (mm/min)

A B C D E

>1.5 to ≤3.6 Up to 4.6 8.2 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 11 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

>9.1 to 11 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 11 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 design curve and 19.3.3.1.1

EH2 = Density required by Extra Hazard Group 2 design curve and 19.3.3.1.1

(4) Roof/ceiling height 35 ft (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:

The area shall be a minimum of 2500 ft2 (230 m2).

Where Table 21.3.3(a) and Table 21.3.3(b) allow densities and areas to be selected in accordance with curve Extra Hazard Group 1 and Group 2, including 19.3.3.1.1, the following area reductions shall be permitted:

For K-8.0 (115) sprinklers used with curve Extra Hazard Group 1, the design area shall be permitted to be reduced by 25 percent, but not below 2000 ft2 (185 m2), where high temperature sprinklers are used.

For K-11.2 (160) or larger sprinklers, the design area shall be permitted to be reduced by 25 percent, but not below 2000 ft2 (185 m2), regardless of temperature rating.

For closed arrays, the area shall be permitted to be reduced to 2000 ft2 (185 m2).

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\*

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

21.4.1.2\*

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

Table 21.4.1.2 Single- or Double-Row Racks — Storage Height Over 12 ft (3.7 m) Up to and Including 25 ft (7.6 m)

Height Commodity Class Encapsulated Aisles\* Ceiling Sprinkler Water Demand

ft m Figure Curves Apply Figure 21.4.1.4.1

Over 12 ft (3.7 m) up to and including 20 ft (6.1 m) I No 4 1.2 21.4.1.2(a) B and D Yes

8 2.4 A and C

Yes 4 1.2 21.4.1.2(e) C and D Yes

8 2.4 A and B

II No 4 1.2 21.4.1.2(b) C and D Yes

8 2.4 A and B

Yes 4 1.2 21.4.1.2(e) C and D Yes

8 2.4 A and B

III No 4 1.2 21.4.1.2(c) C and D Yes

8 2.4 A and B

Yes 4 1.2 In-rack sprinklers required. See Chapter 25. NA NA

8 2.4

IV No 4 1.2 21.4.1.2(d) C and D Yes

8 2.4 A and B

Yes 4 1.2 In-rack sprinklers required. See Chapter 25. NA NA

8 2.4

Over 20 ft (6.1 m) up to and including 22 ft (6.7 m) I No 4 1.2 21.4.1.2(a) A and C Yes

8 2.4 B and D

Yes 4 1.2 In-rack sprinklers required. See Chapter 25. NA NA

8 2.4

II No 4 1.2 21.4.1.2(b) C and D Yes

8 2.4 A and B

Yes 4 1.2 In-rack sprinklers required. See Chapter 25. NA NA

8 2.4

III No 4 1.2 21.4.1.2(c) C and D Yes

8 2.4 A and B

Yes 4 1.2 In-rack sprinklers required. See Chapter 25. NA NA

8 2.4

IV No 4 1.2 21.4.1.2(d) C and D Yes

8 2.4 A and B

Yes 4 1.2 In-rack sprinklers required. See Chapter 25. NA NA

8 2.4

Over 22 ft (6.7 m) up to and including 25 ft (7.6 m) I No 4 1.2 21.4.1.2(a) A and C Yes

8 2.4 B and D

Yes 4 1.2 In-rack sprinklers required. See Chapter 25. NA NA

8 2.4

II No 4 1.2 21.4.1.2(b) C and D Yes

8 2.4 A and B

Yes 4 1.2 In-rack sprinklers required. See Chapter 25. NA NA

8 2.4

III No 4 1.2 21.4.1.2(c) C and D Yes

8 2.4 A and B

Yes 4 1.2 In-rack sprinklers required. See Chapter 25. NA NA

8 2.4

IV No 4 1.2 In-rack sprinklers required. See Chapter 25. NA NA

8 2.4

Yes 4 1.2 In-rack sprinklers required. See Chapter 25. NA NA

8 2.4

\*See 21.4.1.2.1 for interpolation of aisle widths.

NA: Not applicable.

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

FIGURE 21.4.1.2(b) Sprinkler System Design Curves — 20 ft (6.1 m) High Rack Storage — Class II Nonencapsulated Commodities — Conventional Pallets.

FIGURE 21.4.1.2(c) Sprinkler System Design Curves — 20 ft (6.1 m) High Rack Storage — Class III Nonencapsulated Commodities — Conventional Pallets.

Note: Curves C and D also apply to ceiling sprinklers only for multiple-row rack storage up to and including 15 ft (4.6 m) high, and Figure 21.4.1.4.1 shall not be applied.

FIGURE 21.4.1.2(d) Sprinkler System Design Curves — 20 ft (6.1 m) High Rack Storage — Class IV Nonencapsulated Commodities — Conventional Pallets.

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

21.4.1.2.1\*

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

(A)

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

(B)

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

(C)

The density given for 4 ft (1.2 m) wide aisles shall be applied to aisles more narrow than 4 ft (1.2 m) down to 31/2 ft (1.1 m).

(D)

Where aisles are more narrow than 31/2 ft (1.1 m), racks shall be considered to be multiple-row racks.

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

21.4.1.3.1 Multiple-Row Racks — Rack Depth Up to and Including 16 ft (4.9 m) With Aisles 8 ft (2.4 m) or Wider

For Class I, Class II, Class III, or Class IV commodities, encapsulated or nonencapsulated, ceiling sprinkler water demand in terms of density [gpm/ft2 (mm/min)] and area of sprinkler operation [ft2 (m2) of ceiling or roof] shall be selected from the density/area curves of Figure 21.4.1.2(a) through Figure 21.4.1.2(e) that are appropriate for each commodity and configuration as shown in Table 21.4.1.3.1 and shall be modified as appropriate by 21.4.1.4. The protection criteria shall apply to portable racks arranged in the same manner as multiple-row racks.

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

Height Commodity Class Encapsulated 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.

21.4.1.3.2 Multiple-Row Racks — Rack Depth Over 16 ft (4.9 m) or Aisles More Narrow Than 8 ft (2.4 m)

For Class I, Class II, Class III, or Class IV commodities, encapsulated or nonencapsulated, ceiling sprinkler water demand in terms of density [gpm/ft2 (mm/min)] and area of sprinkler operation [ft2 (m2) of ceiling or roof] shall be selected from the density/area curves of Figure 21.4.1.2(a) through Figure 21.4.1.2(e) that are appropriate for each commodity and configuration as shown in Table 21.4.1.3.2 and shall be modified as appropriate by 21.4.1.4. The protection criteria shall apply to portable racks arranged in the same manner as multiple-row racks.

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

Height Commodity Class Encapsulated 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.

21.4.1.3.3

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

21.4.1.3.4

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

21.4.1.4 Ceiling Sprinkler Density Adjustments

21.4.1.4.1

For storage height over 12 ft (3.7 m) up to and including 25 ft (7.6 m) protected with ceiling sprinklers only, densities obtained from design curves shall be adjusted in accordance with Figure 21.4.1.4.1.

FIGURE 21.4.1.4.1 Ceiling Sprinkler Density vs. Storage Height.

21.4.1.4.2

Where solid, flat-bottom, combustible pallets (slave pallets) are used with storage height up to and including 25 ft (7.6 m), the densities that are indicated in the design curves shown in Figure 21.4.1.2(a) through Figure 21.4.1.2(e), based on conventional pallets, shall be increased 20 percent for the given area.

(A)

The percentage shall be applied to the density determined in accordance with 21.4.1.4.

(B)

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

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

21.4.2.1\*

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.

21.4.2.1.1

Where storage as described in 21.4.2.2 is encapsulated, ceiling sprinkler density shall be 25 percent greater than for nonencapsulated storage.

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/ft2 (mm/min)] and area of operation [ft2 (m2)] shall be selected from Table 21.5.1.1.

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

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/ft2 (mm/min) Ceiling Sprinkler Operating Area ft2 (m2)

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/ft2 (12.2 mm/min) 2000 ft2

(185 m2)

5 ft to 10 ft (1.5 m to 3.1 m) 20 ft (6.1 m) 0.45 gpm/ft2 (18.3 mm/min)

15 ft (4.6 m) ≥5 ft (1.5 m) 22 ft (6.7 m) 0.45 gpm/ft2 (18.3 mm/min)

≤10 ft (3.1 m) 25 ft (7.6 m) 0.60 gpm/ft2 (24.5 mm/min)

20 ft (6.1 m) <5 ft (1.5 m) <25 ft (7.6 m) 0.60 gpm/ft2 (24.5 mm/min)a,b

5 ft to 10 ft (1.5 m to 3.1 m) 27 ft (8.2 m) 0.60 gpm/ft2 (24.5 mm/min)a

30 ft (9.1 m)

25 ft (7.6 m) <5 ft (1.5 m) 30 ft (9.1 m) 0.8 gpm/ft2 (32.6 mm/min)c

5 ft to 10 ft (1.5 m to 3.1 m) 35 ft (11 m)

aCeiling-only protection is not permitted for this storage configuration except where K-11.2 or larger spray sprinklers listed for storage use are installed.

bFor the protection of single- and double-row rack only.

cCeiling-only protection shall not be permitted for this storage configuration except where K-16.8 spray sprinklers listed for storage use are installed.

21.5.1.2

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

21.5.1.3

No interpolation between clearance to ceiling shall be permitted.

21.5.1.4

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

21.5.2

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

21.5.3

Exposed nonexpanded Group A plastics protected with control mode density/area sprinklers shall be protected in accordance with Table 21.5.3.

Table 21.5.3 Control Mode Density/Area Sprinkler Protection Criteria for Exposed 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/ft2 (mm/min) Ceiling Sprinkler Operating Area ft2 (m2)

Exposed nonexpanded Group A plastic 10 ft (3.1 m) 20 ft (6.1 m) 0.80 gpm/ft2 (32.6 mm/min) 2500 ft2 (230 m2)

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

21.5.4.1

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.

21.6\* Control Mode Density/Area Sprinkler Protection Criteria for Rack Storage Rubber Tires

21.6.1 Ceiling Systems

Protection of rubber tire storage by ceiling-only sprinkler arrangements shall be selected from Table 21.6.1(a) or Table 21.6.1(b) or per Chapter 25 using ceiling and in-rack sprinkler arrangements.

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

Piling Methodd Pile Height [ft (m)] Sprinkler Discharge Densitya [gpm/ft2 (mm/min)] Areas of Applicationa [ft2 (m2)]

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 formedb 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 21.6.1(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 21.6.1(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,e 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 21.6.1(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)

(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 shall be protected as solid rack shelving.

aSprinkler 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.

bLaced 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).

cWater supply shall fulfill both requirements.

dShelf storage of rubber tires shall be protected as solid rack shelving.

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

Table 21.6.1(b) Control Mode Density/Area Sprinklers System Density (gpm/ft2) 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)

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

21.7.1

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

21.7.2

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

21.7.3

Sprinkler design criteria for storage of roll paper 10 ft (3.0 m) high and higher in buildings or structures with roof or ceilings up to 30 ft (9.1 m) shall be in accordance with Table 21.7.3(a) and Table 21.7.3(b).

Table 21.7.3(a) Control Mode Density/Area Sprinkler Protection Criteria for Roll Paper Storage for Buildings or Structures with Roof or Ceilings Up to 30 ft (Discharge Densities are gpm/ft2 over ft2)

Storage Height (ft) Ceiling (ft) Heavyweight Mediumweight Tissue All Storage Arrays

Closed Array Banded or Unbanded Standard Array Open Array Closed Array Banded or Unbanded Standard Array Open Array Banded or Unbanded

Banded Unbanded Banded Unbanded Banded Unbanded

10 ≤5 0.3/2000 0.3/2000 0.3/2000 0.3/2000 0.3/2000 0.3/2000 0.3/2000 0.3/2000 0.3/2000 0.45/2000

10 >5 0.3/2000 0.3/2000 0.3/2000 0.3/2000 0.3/2000 0.3/2000 0.3/2000 0.3/2000 0.3/2000 0.45/2500

15 ≤5 0.3/2000 0.3/2000 0.3/2000 0.3/2500 0.3/3000 0.3/2000 0.3/2000 0.45/2500 0.45/2500 0.60/2000

15 >5 0.3/2000 0.3/2000 0.3/2000 0.3/3000 0.3/3500 0.3/2000 0.3/2500 0.45/3000 0.45/3000 0.60/3000

20 ≤5 0.3/2000 0.3/2000 0.3/2500 0.45/3000 0.45/3500 0.3/2000 0.45/2500 0.6/2500 0.6/2500 0.75/2500

20 >5 0.3/2000 0.3/2500 0.3/3000 0.45/3500 0.45/4000 0.3/2500 0.45/3000 0.6/3000 0.6/3000 0.75/3000

25 ≤5 0.45/2500 0.45/3000 0.45/3500 0.6/2500 0.6/3000 0.45/3000 0.6/3000 0.75/2500 0.75/2500 see Note 1

Notes:

(1) Sprinkler protection requirements for tissue stored above 20 ft have not been determined.

(2) Densities or areas, or both, shall be permitted to be interpolated between any 5 ft storage height increment.

Table 21.7.3(b) Control Mode Density/Area Sprinkler Protection Criteria for the Protection of Roll Paper Storage for Buildings or Structures with Roof or Ceilings Up to 9.1 m (Discharge Densities are mm/min over m2)

Storage Height (m) Ceiling (m) Heavyweight Mediumweight Tissue All Storage Arrays

Closed Array Banded or Unbanded Standard Array Open Array Closed Array Banded or Unhanded Standard Array Open Array Banded or Unhanded

Banded Unhanded Banded Unhanded Banded Unhanded

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 see Note 1

Notes:

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

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

21.7.4\*

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

21.7.5

The protection area per sprinkler shall not exceed 100 ft2 (9.3 m2) or be less than 70 ft2 (6.5 m2).

21.7.6

Where high-expansion foam systems are installed in heavyweight class and mediumweight class storage areas, sprinkler discharge design densities shall be permitted to be reduced to not less than 0.24 gpm/ft2 (9.8 mm/min) with a minimum operating area of 2000 ft2 (185 m2).

21.7.7

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

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

21.8.1 Slatted Shelves

21.8.1.1\*

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

21.8.1.2

A wet pipe system that is designed to provide a minimum of 0.6 gpm/ft2 (24.5 mm/min) density over a minimum area of 2000 ft2 (185 m2) shall be permitted to protect single-row and double-row racks with slatted rack shelving where all of the following conditions are met:

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.

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.

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.

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).

Transverse flue spaces at least 3 in. (75 mm) wide shall be provided at least every 10 ft (3.0 m) horizontally.

Longitudinal flue spaces at least 6 in. (150 mm) wide shall be provided for double-row racks.

The aisle widths shall be at least 71/2 ft (2.3 m).

The maximum roof height shall be 27 ft (8.2 m).

The maximum storage height shall be 20 ft (6.1 m).

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/ft2 (24.5 mm/min) density over 2000 ft2 (185 m2) and 0.7 gpm/ft2 (28.5 mm/min) density for the four hydraulically most demanding sprinklers with 500 gpm (1900 L/min) hose stream allowance for a 2-hour duration — shall be permitted to protect single- and double-row slatted shelf racks when the following conditions are met:

An extended coverage sprinkler with a nominal K-factor of K-25.2 (360) listed for storage occupancies shall be provided.

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.

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).

A single level of solid shelving 31/2 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).

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.

Other than what is allowed in this section, solid plywood or similar materials shall not be placed on the slatted shelves.

Solid displays shall be permissible, provided that all flues are maintained and only one display is installed per bay.

Maximum roof height shall be 30 ft (9.1 m) in the protected area.

Maximum storage height shall be 22 ft (6.7 m).

Aisle widths shall be a minimum of 8 ft (2.4 m).

Minimum transverse flue spaces of 3 in. every 10 ft (75 mm every 3.0 m) horizontally shall be provided.

Minimum longitudinal flue spaces of 6 in. (150 mm) shall be provided for double-row racks.

Storage in the aisle shall be permissible, provided the aisle storage is no more than 4 ft (1.2 m) high and a minimum clear aisle of 4 ft (1.2 m) is maintained.

21.9.2

A wet pipe system designed to meet two separate design points — 0.425 gpm/ft2 (17.3 mm/min) density over 2000 ft2 (185 m2) and 0.50 gpm/ft2 (20.4 mm/min) density for the four hydraulically most demanding sprinklers with 500 gpm (1900 L/min) hose stream allowance for a 2-hour duration — shall be permitted in solid steel cantilever-style retail shelving racks (gondola racks) when the following conditions are met:

An extended coverage sprinkler with a nominal K-factor of K-25.2 (360) listed for storage occupancies shall be provided.

The storage height shall not exceed 12 ft (3.7 m).

The ceiling height shall not exceed 22 ft (6.7 m) in the protected area.

Gondola rack structure shall not exceed 48 in. (1200 mm) in aggregate depth or 78 in. (1950 mm) in height.

A minimum aisle of 5 ft (1.5 m) between storage shall be maintained.

Rack lengths shall be no more than 70 ft (21 m).

21.9.3

A wet system designed to meet two separate design points — 0.425 gpm/ft2 (17.3 mm/min) density over 2000 ft2 (185 m2) and 0.50 gpm/ft2 (20.4 mm/min) density for the four hydraulically most demanding sprinklers with 500 gpm (1900 L/min) hose stream allowance for a 2-hour duration — shall be permitted in solid steel cantilever-style retail shelving racks (gondola racks) when the following conditions are met:

An extended coverage sprinkler with a nominal K-factor of K-25.2 (360) listed for storage occupancies shall be provided.

Storage height shall not exceed 15 ft (4.6 m).

Ceiling height shall not exceed 25 ft (7.6 m) in the protected area.

Gondola rack structure shall not exceed 60 in. (1500 mm) in aggregate depth or 8 ft (2.4 m) in height.

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).

Rack lengths shall not exceed 70 ft (21 m).

A minimum aisle space of 6 ft (1.8 m) shall be provided.

21.9.4

A wet pipe system designed to meet two separate design points — 0.45 gpm/ft2 (18.3 mm/min) density over 2000 ft2 (185 m2) and 0.55 gpm/ft2 (22.4 mm/min) density for the four hydraulically most demanding sprinklers with 500 gpm (1900 L/min) hose stream allowance for a 2-hour duration — shall be permitted without the use of in-rack sprinklers when the following conditions are met:

An extended coverage sprinkler with a nominal K-factor of K-25.2 (360) listed for storage occupancies shall be provided.

Storage height shall not exceed 15 ft (4.6 m).

Ceiling height shall not exceed 25 ft (7.6 m).

Shelving structure shall not exceed 48 in. (1200 mm) aggregate depth or 12 ft (3.7 m) in height.

Shelving shall be permitted to be made of solid particle-board.

A minimum aisle space of 3 ft (900 mm) shall be maintained.

Shelving length shall be a maximum of 70 ft (21 m).

21.9.5

A wet pipe system designed to meet two separate design points — 0.38 gpm/ft2 (15.5 mm/min) density over 2000 ft2 (185 m2) and 0.45 gpm/ft2 (18.3 mm/min) density for the four hydraulically most demanding sprinklers with 500 gpm (1900 L/min) hose stream allowance for a 2-hour duration — shall be permitted without the use of in-rack sprinklers in steel retail sales floor shelving racks where the following conditions are met:

An extended coverage sprinkler with a nominal K-factor of K-25.2 (360) listed for storage occupancies shall be provided.

Storage height shall not exceed 14 ft (4.3 m).

Ceiling height shall not exceed 20 ft (6.1 m).

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.

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.

A minimum aisle space of 5 ft (1.5 m) shall be maintained.

A minimum longitudinal flue of 6 in. (150 mm) shall be maintained.

Rack length shall be a maximum of 70 ft (21 m).

21.9.6

A wet pipe system designed to meet two separate design points — 0.49 gpm/ft2 (20 mm/min) density over 2000 ft2 (185 m2) and 0.55 gpm/ft2 (22.4 mm/min) density for the four hydraulically most demanding sprinklers with 500 gpm (1900 L/min) hose stream allowance for a 2-hour duration — shall be permitted without the use of in-rack sprinklers in retail solid shelved steel rack structure when the following conditions are met:

An extended coverage sprinkler with a nominal K-factor of K-25.2 (360) listed for storage occupancies shall be provided.

Storage height shall not exceed 16.5 ft (5 m).

Ceiling height shall not exceed 22 ft (6.7 m).

Shelving structure shall not exceed 51 in. (1275 mm) aggregate depth or 148 in. (3700 mm) in 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.

A minimum aisle width of 4 ft (1.2 m) shall be maintained between shelf units and other displays.

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

21.10.1

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

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

System Type Discharge Density per Area [gpm/ft2 over ft2 (mm/min over m2)]

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)

21.10.2

Where roof or ceiling heights would prohibit storage above a nominal 10 ft (3 m), the sprinkler discharge density shall be permitted to be reduced by 20 percent of that indicated in Table 21.10.1 but shall not be reduced to less than 0.15 gpm/ft2 (6.1 mm/min).

21.11 Control Mode Density/Area Sprinkler Protection Criteria for Carton Records Storage With Catwalk Access

21.11.1

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

21.11.2

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

21.11.2.1

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

21.11.2.2

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

21.11.2.3

Longitudinal flues shall not be required.

21.11.3

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

A single-row rack not greater than 72 in. (1800 mm) deep

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.

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/ft2

0.33 0.29 0.3 0.4

mm/min

13.4 11.8 12.2 16.3

Area

ft2

2000 2000 2000 2000

m2

185 185 185 185

Hose Allowance

gpm

500 500 500 500

L/m

1900 1900 1900 1900

Duration

hours

2 2 2 2

21.11.6.2.1

Ceiling sprinklers spaced to cover a maximum of 100 ft2 (9 m2) 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.

FIGURE 21.11.6.4 Sprinkler Location and Spacing in Transverse Flues.

21.11.6.4.1

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

21.11.6.4.2

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

21.11.6.4.3

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

21.11.6.4.3.1

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

21.11.6.4.4

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

21.11.6.4.5

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

21.11.6.5

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

21.11.6.5.1

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

21.11.6.5.2

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

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

21.12.1\*

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

21.12.2

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

21.12.3

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

21.12.4

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

21.12.5\*

Solid 24 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 ft2 (23 m2).

21.12.6.1

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

21.12.6.2

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