23.1 General.

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

23.1.1

ESFR sprinklers designed to meet any criteria in this chapter shall be permitted to protect any of the following:

(1) Light hazard occupancies
(2) Ordinary hazard occupancies
(3) Any storage arrangement with OH1, OH2, EH1, and EH2 design criteria

23.1.2 Draft Curtains.

23.1.2.1

Where ESFR sprinkler systems are installed adjacent to sprinkler systems with standard-response sprinklers, a draft curtain of noncombustible construction and at least 2 ft (600 mm) in depth shall be required to separate the two areas.

23.1.2.2

A clear aisle of at least 4 ft (1.2 m) centered below the draft curtain shall be maintained for separation.

23.1.3

The ceiling design criteria for single-, double-, and multiple-row racks in this chapter shall be based on open-rack configurations as defined in 3.3.154.

23.1.3.1

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

23.1.3.2

ESFR sprinklers shall not be permitted to protect storage with open-top containers.

23.1.3.3

ESFR sprinkler systems shall be designed such that the minimum operating pressure is not less than that indicated in this chapter for type of storage, commodity, storage height, and building height involved.

23.2 ESFR Design Criteria.

23.2.1

ESFR design criteria shall be selected from Section 23.3 through Section 23.6.

23.2.2

All design areas shall consist of the most hydraulically demanding 12 sprinklers, with four sprinklers on each of three branch lines, unless otherwise specified.

23.2.3

Where ESFR sprinklers are spaced less than the minimum distances permitted and nonstructural baffles are installed in accordance with 14.2.8.4.2(1) to compensate, the design area shall cover a minimum of 768 ft^2 (71 m^2).

23.3 ESFR Sprinklers for Palletized, Solid-Piled, or Rack Storage of Class I Through Class IV and Group A Plastic Commodities.

23.3.1

Protection of palletized, solid-piled, or rack storage of Class I through Class IV and Group A commodities shall be in accordance with Table 23.3.1.

Table 23.3.1 ESFR Sprinkler Ceiling-Only Options for Solid Pile; Palletized; and Single-, Double-, and Multiple-Row Rack Storage

	Maximum Ceiling/Roof Height		Maximum Storage Height		ESFR Sprinklers — Pendent Orientation Minimum Operating Pressure psi (bar)				ESFR Sprinklers — Upright Orientation Minimum Operating Pressure psi (bar)	
					Nominal K-Factors				Nominal K-Factors	
Commodity[a]	ft	m	ft	m	14 (200)	16.8 (240)	22.4 (320)	25.2 (360)	14 (200)	16.8 (240)
Class I through Class IV and cartoned nonexpanded Group A plastics	25	7.6	20	6.1	50 (3.4)[b]	35 (2.4)[b]	25 (1.7)[b]	15 (1.0)[b]	50 (3.4)[b]	35 (2.4)[b]
	30	9.1	25	7.6	50 (3.4)	35 (2.4)	25 (1.7)	15 (1.0)	50 (3.4)	35 (2.4)
	35	10.7	30	9.1	75 (5.2)[b]	52 (3.6)[b]	35 (2.4)	20 (1.4)	75 (5.2)	52 (3.6)
	40	12.2	35	10.7	—	52 (3.6)	40 (2.8)[b]	25 (1.7)	—	—
	45	13.7	40	12.2	—	—	40 (2.8)	40 (2.8)	—	—
Cartoned expanded Group A plastics	25	7.6	20	6.1	50 (3.4)[b]	35 (2.4)[b]	35 (2.4)[b]	35 (2.4)[b]	50 (3.4)[b]	35 (2.4)[b]
	30	9.1	25	7.6	50 (3.4)[b]	35 (2.4)[b]	35 (2.4)	35 (2.4)	50 (3.4)	35 (2.4)
	35	10.7	30	9.1	—	—	75 (5.2)[b]	60 (4.1)[b]	—	—
	40	12.2	35	10.7	—	—	75 (5.2)[b]	60 (4.1)[b]	—	—
	45	13.7	40	12.2	—	—	—	—	—	—
Exposed nonexpanded, Group A plastics	25	7.6	20	6.1	50 (3.4)[b]	35 (2.4)[b]	35 (2.4)[b]	35 (2.4)[b]	—	—
	30	9.1	25	7.6	50 (3.4)	35 (2.4)	35 (2.4)	35 (2.4)	—	—
	35	10.7	30	9.1	—	—	75 (5.2)	60 (4.1)[b]	—	—
	40	12.2	35	10.7	—	—	75 (5.2)	60 (4.1)	—	—
	45	13.7	40	12.2	In-rack sprinklers required. See Chapter 25.	In-rack sprinklers required. See Chapter 25.	—	—	—	—

Commodity[a]	Maximum Ceiling/Roof Height ft	Maximum Ceiling/Roof Height m	Maximum Storage Height ft	Maximum Storage Height m	ESFR Sprinklers — Pendent Orientation Minimum Operating Pressure psi (bar) Nominal K-Factors 14 (200)	16.8 (240)	22.4 (320)	25.2 (360)	ESFR Sprinklers — Upright Orientation Minimum Operating Pressure psi (bar) Nominal K-Factors 14 (200)	16.8 (240)
Exposed expanded Group A plastics	25	7.6	20	6.1	—	—	—	30 (2.0)[b,c] or 60 (4.1)[d]	—	—
	30	9.1	25	7.6	—	—	—	30 (2.0)[c] or 60 (4.1)[d]	—	—
	—	—	—	—	—	—	—	—	—	—
	35	10.7	30	9.1	—	—	—	60 (4.1)[b,c]	—	—
	40	12.2	25	7.6	—	—	—	60 (4.1)[d]	—	—
	40	12.2	35	10.7	—	—	—	60 (4.1)[c]	—	—

[a]See 20.3.2 for information regarding protection of lower hazard commodities with higher hazard criteria.

[b]These options are based on the testing criteria of the higher hazard and have not been specifically tested.

[c]These options apply to in-rack storage when all requirements in Section 23.4 are applied including vertical barriers.

[d]This option applies to palletized and solid pile storage in a closed array.

23.4 * Protection of Exposed Expanded Group A Plastics.

23.4.1

Protection of single-, double-, and multiple-row rack storage of exposed expanded Group A plastics shall be permitted to be in accordance with 23.4.2 through 23.4.7.

23.4.2

The maximum storage height shall be 35 ft (10.7 m).

23.4.3

The maximum ceiling height shall be 40 ft (12.2 m).

23.4.4

Sprinklers shall be intermediate temperature–rated ESFR pendent sprinklers with a nominal K-factor of K-25.2 (360).

23.4.4.1

The maximum sprinkler deflector distance below the ceiling shall be 14 in. (350 mm).

23.4.5

The minimum operating pressure shall be as follows, based upon the applicable storage and ceiling height for the installation:

(1) 30 psi (2.0 bar) for storage heights up to 25 ft (7.6 m) with a maximum ceiling height of 30 ft (9.1 m)

(2) 60 psi (4.1 bar) for storage heights up to 35 ft (10.7 m) with a maximum ceiling height of 40 ft (12.2 m)

23.4.6

The minimum aisle width shall be 8 ft (2.4 m).

23.4.7

The rack shall have a solid vertical barrier of $^{3}/_{8}$ in. (10 mm) plywood or particleboard, 0.013 in. (0.78 mm) sheet metal, or equivalent, from face of rack to face of rack, spaced at a maximum of 16.5 ft (5.0 m) intervals.

23.4.7.1

The vertical barrier shall extend from a maximum of 4 in. (100 mm) above the floor to the maximum storage height.

23.4.7.2

The plan area of storage between vertical barriers and aisles shall not exceed 124 ft^2 (12 m^2).

23.4.7.3

The vertical barrier shall extend across the longitudinal flue.

23.4.7.4

The commodity shall be permitted to extend a nominal 4 in. (100 mm) beyond the vertical barrier at the aisle.

23.5 ESFR Protection of Rack Storage of Rubber Tires.

The sprinkler discharge and area of application shall be in accordance with Table 23.5.

Table 23.5 ESFR Sprinklers for Protection of Rubber Tires

Piling Method	Pile Height	Maximum Building Height		Nominal K-factor	Orientation	Number of Sprinklers	Minimum Operating Pressure	
		ft	m				psi	bar
Rubber tire storage, on-side or on-tread, in palletized portable racks, open portable racks, or fixed racks without solid shelves	Up to 25 ft (7.6 m)	30	9.1	14.0 (200)	Upright/pendent	12[a]	50	3.4
				16.8 (240)	Upright/pendent	12[a]	35	2.4
				22.4 (320)	Pendent	12[a]	25	1.7
				25.2 (360)	Pendent	12[a]	15	1.0
Rubber tire storage, on-side, in palletized portable racks, open portable racks, or fixed racks without solid shelves	Up to 25 ft (7.6 m)	35	10.7	14.0 (200)	Upright/pendent	12[a]	75	5.2
				16.8 (240)	Pendent	12[a]	52	3.6
				22.4 (320)	Pendent	12[a]	35	2.4
				25.2 (360)	Pendent	12[a]	25	1.7
On-tread, on-side, and laced tires in open portable steel racks or palletized portable racks	Up to 25 ft (7.6 m)	30	9.1	14.0 (200)	Pendent	20[b,c]	75	5.2
				16.8 (240)	Pendent	20[b,c]	52	3.6
Rubber tire storage, on-side, in palletized portable racks	Up to 25 ft (7.6 m)	40	12.2	16.8 (240)	Pendent	12[a]	52	3.6
Rubber tire storage, on-tread or laced in open portable steel racks	Up to 25 ft (7.6 m)	40	12.2	25.2 (360)	Pendent	12[a]	40	2.8
On-tread, on-side, and laced tires in open portable steel racks or palletized portable racks	Up to 30 ft (9.1 m)	40	12.2	25.2 (360)	Pendent	12[a]	75	5.2

Note: This table is applicable to wet systems only.

[a]The shape of the design area is in accordance with 23.2.2.

[b]Where used in this application, ESFR protection is expected to control rather than suppress the fire.

[c]The design area consists of the most hydraulically demanding 20 sprinklers, with five sprinklers on each of four branch lines. The design includes a minimum operating area of 1600 ft^2 (150 m^2).

23.6 ESFR Sprinklers for Protection of Roll Paper Storage.

Where automatic sprinkler system protection utilizes ESFR sprinklers, hydraulic design criteria shall be as specified in Table 23.6.

Table 23.6 ESFR Sprinklers for Protection of Roll Paper Storage (Maximum Height of Storage Permitted)

ESFR K-Factor	Orientation	System Type	Pressure		Building Height		Heavyweight						Mediumweight						T
							Closed		Standard		Open		Closed		Standard		Open		
			psi	bar	ft	m	ft	m	ft	m	ft	m	ft	m	ft	m	ft	m	A
14.0 (200)	Upright/pendent	Wet	50	3.4	30	9.1	25	7.6	25	7.6	25	7.6	25	7.6	25	7.6	25	7.6	
16.8 (240)	Upright/pendent	Wet	35	2.4															
22.4 (320)	Pendent	Wet	25	1.7															
25.2 (360)	Pendent	Wet	15	1.0															
14.0 (200)	Upright/pendent	Wet	75	5.2	35	10.7	30	9.1	30	9.1	30	9.1	NA		NA		NA		
16.8 (240)	Upright/pendent	Wet	52	3.6															
16.8 (240)	Pendent	Wet	52	3.6	40	12.2	30	9.1	30	9.1	30	9.1	NA		NA		NA		
22.4 (320)	Pendent	Wet	40	2.7															
25.2 (360)	Pendent	Wet	25	1.7															
22.4 (320)	Pendent	Wet	50	3.4	45	13.7	30	9.1	30	9.1	30	9.1	NA		NA		NA		
25.2 (360)	Pendent	Wet	50	3.4															

NA: Not applicable.