STORAGE OF AEROSOL PRODUCTS

Table of Contents

Page

1.0 SCOPE 4
1.1 Hazard 4
1.2 Changes 4
2.0 LOSS PREVENTION RECOMMENDATIONS 4
2.1 Aerosol Product Classification 4
2.1.1 Aerosol Products in Metal Containers of 33.8 oz (1000 ml) or Less 4
2.1.2 Aerosol Cooking Spray Products in Metal Containers of 33.8 oz (1000 ml) or Less 6
2.1.3 Aerosol Products in Plastic Containers of 33.8 oz (1000 ml) or Less 6
2.1.4 Aerosol Cooking Spray Products in Plastic Containers or 33.8 oz (1000 ml) or Less 7
2.2 Construction and Location 7
2.3 Occupancy 14
2.4 Protection 15
2.4.1 General 15
2.4.2 Warehouse Storage of Aerosol Products in Metal Containers 17
2.4.3 Warehouse Storage of Aerosol Products in Plastic Containers 25
2.4.4 Mercantile Locations 26
2.4.5 Automatic Storage and Retrieval Systems (ASRS) 26
2.4.6 Manual Picking Stations 30
2.5 Training 33
2.6 Human Factor 33
2.7 Ignition Source Control 33
3.0 SUPPORT FOR RECOMMENDATIONS 33
3.1 General 33
3.2 Aerosol Products in Metal Containers: Classification by Chemical Heat of Combustion 34
3.3 Fire Hazard 34
3.3.1 Fire Protection 34
3.3.2 Segregation 36
4.0 REFERENCES 36
4.1 FM 36
4.2 Others 36
APPENDIX A GLOSSARY OF TERMS 37
APPENDIX B DOCUMENT REVISION HISTORY 37
APPENDIX C NFPA STANDARD 39
APPENDIX D AEROSOL PRODUCTS CLASSIFICATION 40
D.1 Chemical Heat of Combustion Data 40
APPENDIX E IN-RACK SPRINKLER LAYOUTS AND FIRE PROTECTION SCHEMES 43
E.1 In-Rack Sprinkler Layouts 43
E.2 Fire Protection Scheme A 61
E.3 Aerosol Product Flow-Through Rack Protection Scheme 66
E.4 Mercantile Fire Protection Schemes 68

List of Figures

Fig. 2.1.1.1. Aerosol product classification 5
Fig. 2.2.5-1. Design of fencing where adjacent storage is protected with Scheme A 11
Fig. 2.2.5-2. Design of fencing where adjacent storage is not protected with Scheme A 12

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Fig. 2.2.6.2. Example of a labyrinth opening arrangement for a cutoff room opening. 13
Fig. 2.3.3.B. Separation of aerosol product storage from non-aerosol storage using a chain link fence .. 15
Fig. 2.3.3.C. Separation of aerosol product storage from non-aerosol storage using a solid vertical barrier . 16
Fig. 2.4.6.6.5 Gaps at rack uprights below walkway level 31
Fig. 2.4.6.6-1 Manual picking station arrangement: elevation view 31
Fig. 2.4.6.6-2 Manual picking station arrangement: plan view 32
Fig. 2.4.6.7-1 Sprinkler locations for manual picking station: one line of sprinklers 32
Fig. 2.4.6.7-2 Sprinkler locations for manual picking station: two lines of sprinklers 32
Fig. E.1-1a. Cartoned Level 2 Aerosol products and Level 3 Aerosol products – single row racks 44
Fig. E.1-1b. Cartoned Level 2 Aerosol products and Level 3 Aerosol products – double row racks 45
Fig. E.1-1c. Cartoned Level 2 Aerosol products and Level 3 Aerosol products – multiple row racks 46
Fig. E.1-2a. Cartoned Level 3 Aerosol products — single row racks up to 25 ft (7.6 m) high storage in quick-response sprinkler protected building 47
Fig. E.1-2b. Cartoned Level 3 Aerosol products — double row racks up to 25 ft (7.6 m) high storage in quick-response sprinkler protected building 48
Fig. E.1-3a. Cartoned Level 3 Aerosol products – single row racks 49
Fig. E.1-3b. Cartoned Level 3 Aerosol products – double row racks 50
Fig. E.1-3c. Cartoned Level 3 Aerosol products – multiple row racks 51
Fig. E.1-4a. Cartoned Level 2 Aerosol products and Level 3 Aerosol products, clearance more than 15 ft (4.6m) – single row racks 52
Fig. E.1-4b. Cartoned Level 2 Aerosol products and Level 3 Aerosol products, clearance more than 15 ft (4.6m) – double row racks 53
Fig. E.1-4c. Cartoned Level 2 Aerosol products and Level 3 Aerosol products, clearance more than 15 ft (4.6m) – multiple row racks 54
Fig. E.1-5a. Uncartoned Level 2 Aerosol products and Level 3 Aerosol products – single row racks up to 20 ft (6.1 m) high storage 55
Fig. E.1-5b. Uncartoned Level 2 Aerosol products and Level 3 Aerosol products – double row racks up to 20 ft (6.1 m) high storage 56
Fig. E.1-5c. Uncartoned Level 2 Aerosol products and Level 3 Aerosol products – multiple row racks up to 20 ft (6.1 m) high storage 57
Fig. E.1-6a. Uncartoned Level 2 Aerosol products and Level 3 Aerosol products – single row racks up to 25 ft (7.6 m) high storage 58
Fig. E.1-6b. Uncartoned Level 2 Aerosol products and Level 3 Aerosol products – double row racks up to 25 ft (7.6 m) high storage 59
Fig. E.1-6c. Uncartoned Level 2 Aerosol products and Level 3 Aerosol products – multiple row racks up to 25 ft (7.6 m) high storage 60
Fig. E.2-1. Single row rack in-rack sprinkler layout — Fire Protection Scheme A 62
Fig. E.2-2. Single row rack in-rack sprinkler layout — Fire Protection Scheme A 63
Fig. E.2-3. Double row rack in-rack sprinkler layout — Fire Protection Scheme A 64
Fig. E.2-4. Multiple row rack in-rack sprinkler layout — Fire Protection Scheme A 65
Fig. E.3-1. Aerosol product picking area elevation view 67
Fig. E.3-2. Aerosol product picking area plan view 67
Fig. E.4-1. Mercantile storage, Option 1 69
Fig. E.4-2. Mercantile storage, Option 2 70
Fig. E.4-3. Mercantile storage, Option 3 71

List of Tables

Table 2.1.1.1. Aerosol Product Classification 4
Table 2.1.1.2. Chemical Heat of Combustion for Various Materials 5
Table 2.2.1. Aerosol Product Storage Location Options 8
Table 2.2.1. Aerosol Product Storage Location Options (continued) 9
Table 2.4.1.5. Hose Demand and Water Supply Duration Design Guidelines 17
Table 2.4.2.2. Palletized and Solid Pile Storage of Cartoned or Uncartoned Level 2 Aerosol Products .. 18
Table 2.4.2.3. Palletized and Solid Pile Storage of Cartoned Level 3 Aerosol Products 19
Table 2.4.2.4. Rack Storage of Cartoned Level 2 Aerosol Products 20
Table 2.4.2.5. Rack Storage of Cartoned Level 3 Aerosol Products 21

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Table 2.4.2.5. Rack Storage of Cartoned Level 3 Aerosol Products (continued) 22
Table 2.4.2.6. Rack Storage of Uncartoned Level 2 Aerosol Products 23
Table 2.4.2.7. Rack Storage of Uncartoned Level 3 Aerosol Products 24
Table 2.4.2.8. Rack, Palletized, and Solid-Pile Storage of Cartoned Aerosol Cooking Spray Products 25
Table 2.4.3.3. Rack Storage of Cartoned Plastic Aerosol 3 Products 25
Table 2.4.5.1.1. Allowable Aerosol Products Stored in ASRS 27
Table 2.4.5.2.2. Protection for Aerosol Products Stored in Top-Loading and Horizontal-Loading Mini-Load Systems 27
Table 2.4.5.3.3. Protection for Aerosol Products Stored in Horizontal-Loading Shuttle Systems 29
Table D.1. Chemical Heat of Combustion Data 41
Table D.1. Chemical Heat of Combustion Data (continued) 42

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1.0 SCOPE

This data sheet provides protection recommendations on the storage of aerosol products in metal containers; aerosol cooking spray products; and aerosol products in plastic containers. The maximum container size addressed in this data sheet is 33.8 oz (1000 ml).

This data sheet does not apply to other products consisting of ignitable liquids and flammable or nonflammable gas propellants stored in larger containers. That guidance is provided in other FM property loss prevention data sheets, including the following:

- Data Sheet 7-29, *Ignitable Liquid Storage in Portable Containers*
- Data Sheet 7-32, *Ignitable Liquid Operations*
- Data Sheet 7-32A, *Evaluation and Classification of Ignitable Liquids*
- Data Sheet 7-50, *Compressed Gases in Portable Cylinders and Bulk Storage*
- Data Sheet 7-55, *Liquefied Petroleum Gas (LPG) in Stationary Installations*
- Data Sheet 7-88, *Outdoor Ignitable Liquid Storage Tanks*

1.1 Hazard

When exposed to fire, aerosol cans may violently rupture or produce jets of flame. Both conditions expose adjacent aerosols and can result in more container failures. The only effective method of controlling this type of fire is the delivery of large quantities of water by sprinklers. If adequate protection is not provided, an aerosol product fire may grow quickly and produce high temperatures, thick smoke and rocketing containers that can trail burning liquid to areas well away from the fire's origin.

1.2 Changes

October 2026. Interim revision. Changes include the following:

A. Added guidance for storage of aerosol products in manual picking stations. This guidance is limited to specific aerosol products that are stored in metal bins on solid shelves.

B. Updated Figure E.2-4 to include a gap in the barrier. This was omitted in the previous figure. There are no changes to the protection guidance.

2.0 LOSS PREVENTION RECOMMENDATIONS

2.1 Aerosol Product Classification

2.1.1 Aerosol Products in Metal Containers of 33.8 oz (1000 ml) or Less

2.1.1.1 Classify aerosol products in metal containers using one of the following methods:

A. Sum the chemical heat of combustion for the constituent components of the aerosol product (e.g., propellant, liquid products) multiplied by their weight fraction. This is represented in mathematical notation by the following formula:

$$\Delta H_{cht} = \Sigma\, x_i \Delta H_{chi}$$

Where ΔH_{cht} = total chemical heat of combustion of the product, Btu/lb [kJ/g]
x_i = weight fraction of component i
ΔH_{chi} = chemical heat of combustion of component i

Based on the calculated chemical heat of combustion, use Table 2.1.1.1 to classify the aerosol product.

Table 2.1.1.1. Aerosol Product Classification

Chemical Heat of Combustion (ΔH_{ch})	*Aerosol Product Level*
$0 < \Delta H_{ch} \leq 8600$ ($0 < \Delta H_{ch} \leq 20$)	1
$8600 < \Delta H_{ch} \leq 12{,}900$ ($20 < \Delta H_{ch} \leq 30$)	2
$\Delta H_{ch} > 12{,}900$ ($\Delta H_{ch} > 30$)	3

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B. Use Figure 2.1.1.1 if the aerosol product's constituent materials are known and consist of saturated hydrocarbons, such as propane and isobutane, alcohols such as ethanol or methanol, and inert materials.

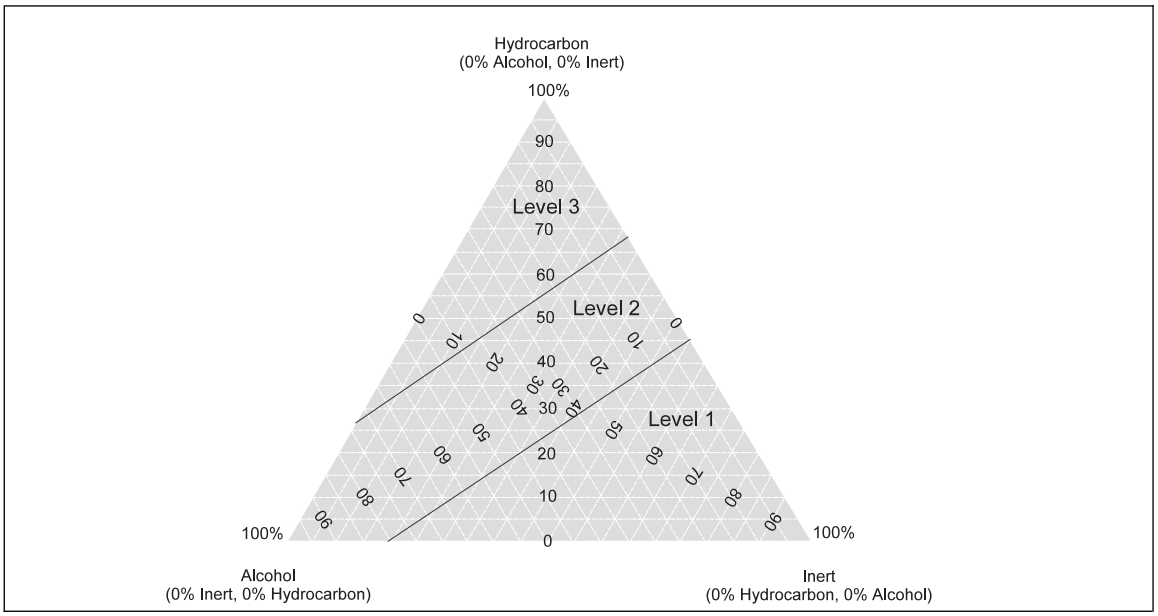


Fig. 2.1.1.1. Aerosol product classification

C. Classify the aerosol product as a Level 3 Aerosol if its composition is not known and test results are not available.

2.1.1.2 Determine the chemical heat of combustion for the component materials of an aerosol product using **one** of the following means:

A. If the exact aerosol product components and their weight fraction are known, use the chemical heat of combustion data in Table D.1.

B. If the exact aerosol product components and their weight fraction are known but the chemical heat of combustion is not available, use the total heat of combustion as determined by oxygen bomb calorimeter measurements.

C. If the exact components of the aerosol product are not known but the product can be broken down by weight fraction into the generic groups of hydrocarbon (e.g., propellant, non-water-miscible ignitable liquids), alcohol (e.g., ethanol, isopropanol), and inert (e.g., solids, nonignitable liquids), use the values shown in Table 2.1.1.2.

D. Conduct an oxygen bomb calorimeter test on the aerosol product mixture, including the propellant.

Note: Consider materials inert if they are nonignitable liquids (e.g., water, liquids without a fire point), solids (e.g., powders), or nonflammable gases (e.g., carbon dioxide).

Table 2.1.1.2. Chemical Heat of Combustion for Various Materials

Material	ΔH_{ch} *(Btu/lb)*	ΔH_{ch} *(kJ/g)*
Hydrocarbon	19,000	44
Alcohol	11,000	25
Inert	0	0

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2.1.2 Aerosol Cooking Spray Products in Metal Containers of 33.8 oz (1000 ml) or Less

2.1.2.1 Classify a cooking spray product in a metal container as an Aerosol Cooking Spray product if the product has a chemical heat of combustion that is higher than 20 KJ/g (8600 Btu/lb), and no more than 18% of its contents is a hydrocarbon propellant. (See Glossary for definition of cooking spray product.)

2.1.2.1.1 If the Aerosol Cooking Spray product has a chemical heat of combustion that is 20 KJ/g (8600 Btu/lb) or lower, consider it a Level 1 Aerosol product.

2.1.2.1.2 If the Aerosol Cooking Spray product has more than 18% hydrocarbon propellant, classify it in accordance with the product's chemical heat of combustion as a Level 1 Aerosol product, Level 2 Aerosol product, or Level 3 Aerosol product.

2.1.3 Aerosol Products in Plastic Containers of 33.8 oz (1000 ml) or Less

2.1.3.1 Plastic Aerosol 1 Products

Plastic Aerosol 1 products are those that meet **one** of the following criteria:

A. The base liquid product has no fire point when tested in accordance with ASTM D 92, *Standard Test Method for Flash and Fire Points by Cleveland Open Cup Tester,* and the propellant is nonflammable.

B. The base product does not exhibit sustained combustion when tested in accordance with (1) Method of Testing for Sustained Combustibility, Title 49, Code of Federal Regulations, Part 173, Appendix H, or (2) the UN Recommendations on the Transport of Dangerous Goods; and the propellant is nonflammable. For purposes of this definition the test shall be conducted at 36°F (20°C) above the flash point of the highest flash point component when the base product is a mixture of multiple liquids.

C. The base liquid product contains up to 20% by volume (15.8% by weight) of ethanol, propanol, other water miscible alcohols, or mixtures thereof in an aqueous mix, and the propellant is nonflammable.

D. The base liquid product contains 4% by weight or less of an emulsified flammable liquefied gas propellant within an aqueous base (i.e., the aqueous base is a nonignitable liquid), and the propellant remains emulsified for the life of the product or is nonflammable.

2.1.3.2 Plastic Aerosol 2 Products

Plastic Aerosol 2 products are those that meet one of the following criteria:

A. The base product contains greater than 20% by volume (15.8% by weight) up to 50% by volume (39.5% by weight) of ethanol, propanol, other water miscible alcohols, or mixtures thereof in an aqueous mix, and the propellant is nonflammable compressed gas.

B. The base product contains greater than 20% by volume (15.8% by weight) up to 50% by volume (39.5% by weight) of ethanol, propanol, other water miscible alcohols, or mixtures thereof in an aqueous mix; is packaged in a compartmented container that separates the product from the propellant as typified by a bag-on-valve (BOV) package, bag-in-container package, or piston-in-container package; and the propellant is nonflammable compressed gas, nonflammable liquified gas, or mixtures thereof.

2.1.3.3 **Plastic Aerosol 3 Products**

Plastic Aerosol 3 products are those that meet **one** of the following criteria:

A. The base liquid product has no fire point when tested in accordance with ASTM D 92, *Standard Test Method for Flash and Fire Points by Cleveland Open Cup Tester*, and there is not more than 10% flammable propellant.

B. The base product does not exhibit sustained combustion when tested in accordance with (1) Method of Testing for Sustained Combustibility, Title 49, Code of Federal Regulations, Part 173, Appendix H, or (2) the UN Recommendations on the Transport of Dangerous Goods; and there is not more than 10% flammable propellant. For purposes of this definition, the test shall be conducted at 36°F (20°C) above the flash point of the highest flash point component when the base product is a mixture of multiple liquids.

C. The base liquid product contains not more than 50% by volume of flammable, water-miscible alcohol in an aqueous mix, and there is not more than 10% flammable propellant.

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D. The base product contains greater than 50% by volume (39.5% by weight) up to 100% of ethanol, propanol, other water miscible alcohols, or mixtures thereof in an aqueous mix; is packaged in a compartmented container that separates the product from the propellant as typified by a bag-on-valve (BOV) package, bag-in-container package, or piston-in-container package; and the propellant is nonflammable compressed gas, nonflammable liquefied gas, or mixture thereof.

E. The base product contains no greater than 10% by weight of an emulsified, liquified flammable gas propellant with an aqueous base (i.e., the aqueous base is a nonignitable liquid), and the propellant remains emulsified for the life of the product or is nonflammable.

F. The base product contains 100% hydrocarbon (combination of ignitable content and flammable propellant) and a maximum liquid volume of 0.3 oz (9 ml).

2.1.3.4 Plastic Aerosol X Products

Plastic Aerosol X products are those that do not meet the criteria in Section 2.1.3.1, 2.1.3.2, or 2.1.3.3.

2.1.4 Aerosol Cooking Spray Products in Plastic Containers or 33.8 oz (1000 ml) or Less

2.1.4.1 Classify a cooking spray product in a plastic container as a Plastic Aerosol Cooking Spray product if one of the following is true: (See Glossary for definition of cooking spray product)

A. The base liquid product is a cooking spray with a closed cup flash point of greater than 414°F (212°C) and the propellant is nonflammable compressed gas. Up to 10% ethyl alcohol is permitted to be mixed with the base liquid product.

B. The base liquid product is a cooking spray with a closed cup flash point of greater than 414°F (212°C); is packaged in a compartmented container that separates the product from the propellant as typified by a bag-on-valve (BOV) package, bag-in-container package, or piston-in-container package; and the propellant is nonflammable compressed gas, nonflammable liquefied gas, or mix thereof. Up to 10% ethyl alcohol is permitted to be mixed with the base liquid product.

2.2 Construction and Location

2.2.1 Segregate aerosol product storage in accordance with Table 2.2.1.

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Table 2.2.1. Aerosol Product Storage Location Options

Aerosol Classification	*Storage Arrangement*	*Packaging*	*Provided Sprinkler Response*	*Storage Location Options*
Level 1 Aerosol product	Palletized/Rack	Cartoned/ Uncartoned	Any	Any location is acceptable
Level 2 Aerosol product	Palletized/Rack	Cartoned/ Uncartoned	Any	Dedicated building, cutoff room, or dedicated area defined by a chain link fence / barrier in a general-purpose warehouse
Level 3 Aerosol product	Palletized	Cartoned	Quick Response	Dedicated building, cutoff room, or dedicated area defined by a chain link fence / barrier in a general-purpose warehouse
			Standard Response	Dedicated building or cutoff room
		Uncartoned	Any	Dedicated building or cutoff room; refer to Section 2.2.3.
	Rack	Cartoned/ Uncartoned	Any	Dedicated building, cutoff room, or dedicated area defined by a chain link fence / barrier in a general-purpose warehouse
Plastic Aerosol 1 product	Palletized/Rack	Cartoned/ Uncartoned	Any	Any location is acceptable
Plastic Aerosol 2 product	Palletized	Cartoned/ Uncartoned	Any	Dedicated building or cutoff room; refer to Section 2.2.3.
	Rack	Cartoned	Any	Dedicated building, cutoff room, or dedicated area defined by a chain link fence / barrier in a general-purpose warehouse
		Uncartoned	Any	Dedicated building or cutoff room; refer to Section 2.2.3.
Plastic Aerosol 3 product (> 0.3 oz [9 ml])	Palletized	Cartoned/ Uncartoned	Any	Dedicated building or cutoff room; refer to Section 2.2.3.
	Rack	Cartoned	Any	Dedicated building, cutoff room, or dedicated area defined by a chain link fence / barrier in a general-purpose warehouse
		Uncartoned	Any	Dedicated building or cutoff room; refer to Section 2.2.3.
Plastic Aerosol 3 product (≤ 0.3 oz [9 ml])	Palletized	Cartoned/ Uncartoned	Any	Dedicated building or cutoff room; refer to Section 2.2.3.
	Rack	Cartoned	Any	Any location is acceptable
		Uncartoned	Any	Dedicated building or cutoff room; refer to Section 2.2.3.
Plastic Aerosol X product	Palletized/Rack	Cartoned/ Uncartoned	Any	Dedicated building or cutoff room; refer to Section 2.2.3.

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Table 2.2.1. Aerosol Product Storage Location Options (continued)

Aerosol Classification	*Storage Arrangement*	*Packaging*	*Provided Sprinkler Response*	*Storage Location Options*
Aerosol Cooking Spray product	Palletized	Cartoned	Quick Response	Any location is acceptable
			Standard Response	Dedicated building, cutoff room, or dedicated area defined by a chain link fence / barrier in a general-purpose warehouse
		Uncartoned	Quick Response	Dedicated building, cutoff room, or dedicated area defined by a chain link fence / barrier in a general-purpose warehouse
			Standard Response	Dedicated building or cutoff room; refer to Section 2.2.3.
	Rack	Cartoned	Quick Response	Any location is acceptable
			Standard Response	Dedicated building, cutoff room, or dedicated area defined by a chain link fence / barrier in a general-purpose warehouse
		Uncartoned	Any	Dedicated building, cutoff room, or dedicated area defined by a chain link fence / barrier in a general-purpose warehouse
Plastic Aerosol Cooking Spray product	Palletized	Cartoned	Quick Response	Any location is acceptable
			Standard Response	Dedicated building or cutoff room; refer to Section 2.2.3.
		Uncartoned	Any	Dedicated building or cutoff room; refer to Section 2.2.3.
	Rack	Cartoned	Any	Any location is acceptable
		Uncartoned	Any	Dedicated building or cutoff room; refer to Section 2.2.3.

2.2.2 Design cutoff rooms in accordance with the following recommendations:

A. Locate the room outside the building on an exterior wall. A less-desirable alternative is to locate the room inside the building on an exterior wall with access from the outside.

B. Provide noncombustible partitions, including gypsum wallboard, with a minimum 1-hour fire resistance as described in Data Sheet 1-21, *Fire Resistance of Building Assemblies.*

C. Provide impact protection for fire-rated walls constructed of low-impact strength materials. If gypsum wallboard is used, provide a minimum 22 gauge (0.7 mm) metal facing on the wallboard to provide some protection against aerosol product can impact. Provide the impact protection for the full height of the walls.

D. Protect necessary interior openings with a normally closed fire door. Locate the fire door on the storage side of the wall. Arrange doors to automatically close in the event of a fire. The use of a fusible link at ceiling level, sprinkler water flow alarm, heat detector, or a flame detector are acceptable means of releasing the door.

2.2.3 For products in Table 2.2.1 with storage locations that refer to Section 2.2.3, it is expected that all the aerosol containers within a room will release their contents, producing a hybrid ignitable liquid and flammable gas fire.

2.2.3.1 Store these products in one of the following areas:

A. A detached, low-value building.

B. An FM Approved prefabricated ignitable liquids storage buildings (PILSB), designed in accordance with Section 2.2.8. Locate the PILSB outside the main building.

C. A cutoff room including an emergency drainage system for the room, designed in accordance with Data Sheet 7-29, *Ignitable Liquid Storage in Portable Containers*.

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2.2.4 Provide separation around dedicated storage areas within general purpose warehouses using one of the following options:

A. Floor-to-ceiling chain link fence, minimum 9-gauge (3.8 mm) steel wire woven into a maximum 2 in. (50 mm) diamond mesh, that completely surrounds the designated aerosol product storage area. Fencing can use the rack structure for support.

B. Noncombustible impact-resistant barriers (e.g., minimum 22-gauge [0.7 mm] sheet metal) within the racks.

2.2.5 Where Scheme A is used to protect the rack storage of Level 2 Aerosol products and Level 3 Aerosol products located within a general purpose warehouse, the fencing specified in Section 2.2.4 does not need to be included in the aisles if adjacent racks are also protected with Scheme A. Fencing is only necessary at the outermost rack bays. Where adjacent racks are not protected with Scheme A, fencing is necessary around the entire perimeter of aerosol products storage. See Figures 2.2.5-1 and 2.2.5-2.

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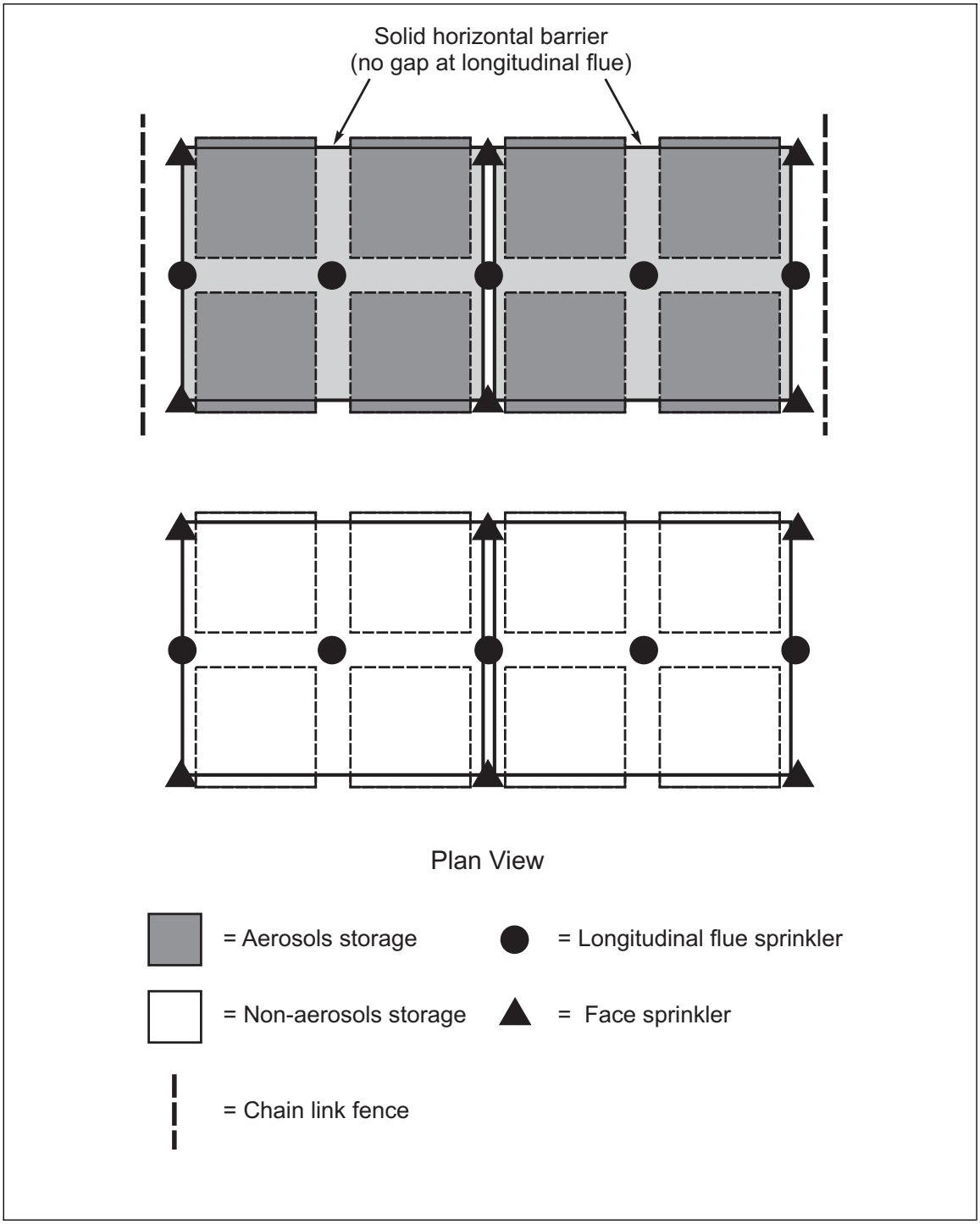


Fig. 2.2.5-1. Design of fencing where adjacent storage is protected with Scheme A

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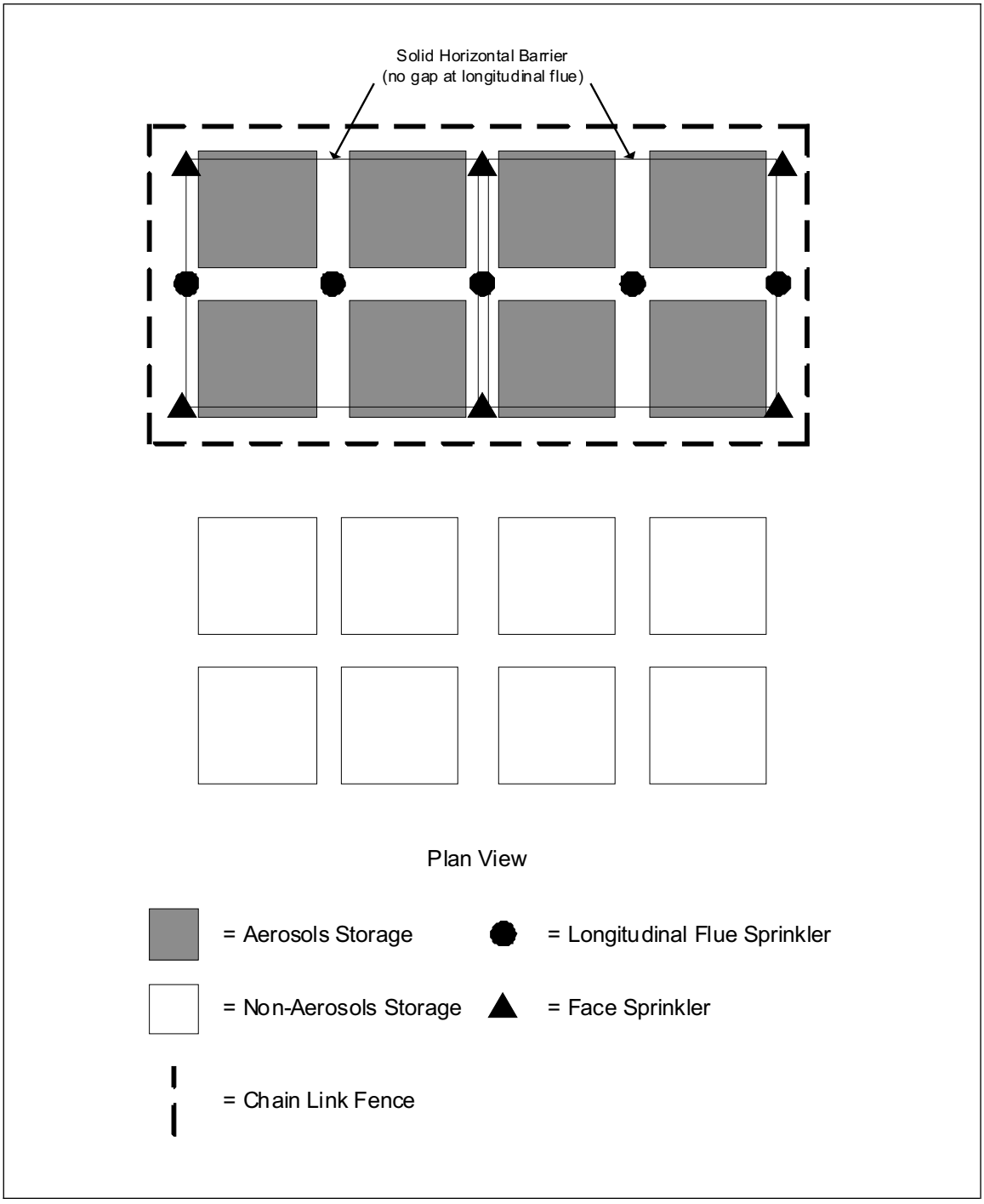


Fig. 2.2.5-2. Design of fencing where adjacent storage is not protected with Scheme A

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2.2.6 For cutoff rooms and dedicated areas in general purpose warehouses, protect openings with normally closed, automatically closing doors.

2.2.6.1 Arrange doors to automatically close in the event of a fire.

A.The use of a fusible link at ceiling level, sprinkler water flow alarm, heat detector, or a flame detector are acceptable means of releasing the door.

B.A less-desirable approach is to arrange a normally open door to automatically close when actuated by a fire inside or directly outside the room or area.

2.2.6.2 An alternative for openings in chain link fence-enclosed areas is to design a doorless opening (e.g., a labyrinth or tunnel approach) that does not provide a direct line of sight for a rocketing can to the area outside the enclosure (see Figure 2.2.6.2).

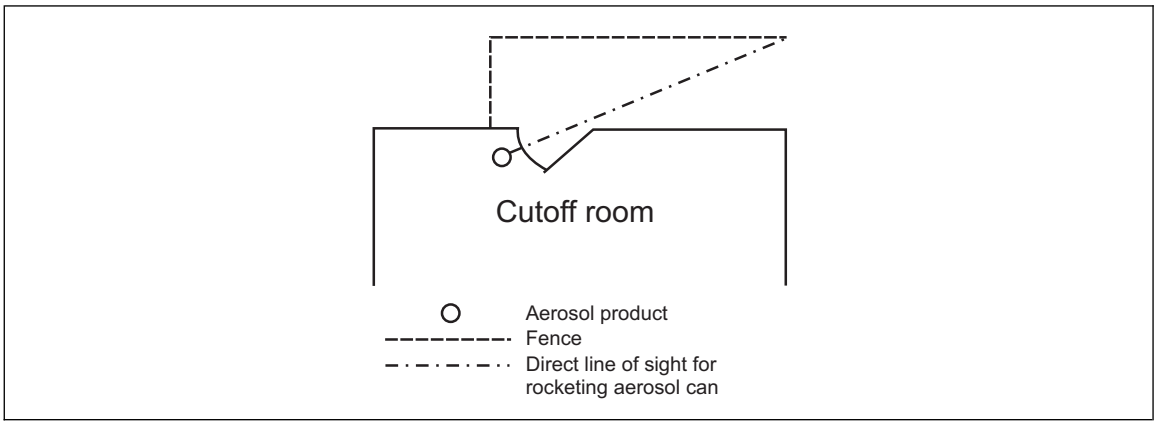


Fig. 2.2.6.2. Example of a labyrinth opening arrangement for a cutoff room opening.

2.2.7 In cases where aerosol storage directly exposes doors in MFL walls, provide a labyrinth style barrier (See Figure 2.2.6.2) at the opening in addition to the normally provided fire doors.

2.2.7.1 An acceptable alternative is to arrange the fire doors to automatically close by activation of a flame detector.

A. Arrange one flame detector to provide complete line-of-sight coverage across the front of the opening (near field).

B. Arrange a second flame detector to provide far field coverage over the top of storage.

C. Arrange doors to automatically close in the event of power loss.

2.2.8 For all detached buildings or cutoff rooms, provide an FM Approved roof assembly that consists of a Class 1 or noncombustible internal fire resistance and an ASTM E108 Class A-rated external fire resistance. See Data Sheet 1-29, *Roof Deck Securement and Above-Deck Roof Components*.

2.2.8.1 For cutoff rooms that have ceilings below the main building's roof, provide a ceiling assembly that has the same fire resistance as the interior walls of the cutoff room.

2.2.8.2 For cutoff rooms that have wooden roof assemblies, isolate the wooden roof with the same fire resistance as that needed for the interior walls of the cutoff room.

2.2.8.2.1 Provide sprinklers in any resulting combustible spaces in accordance with Data Sheet 1-12, *Ceilings and Concealed Spaces.*

2.2.9 FM Approved prefabricated ignitable liquids storage buildings (PILSB) may be used as an alternative to a permanently constructed cutoff or detached aerosol products storage room. The PILSB must provide all the active and passive protection features recommended in this data sheet (fire rating, automatic fire protection, etc.).

2.2.10 Special storage arrangements or equipment may be used for small quantities of aerosol products, including the following:

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A. Store individual cartons or cans inside FM Approved ignitable liquid cabinets. Arrange the cabinets as follows:

1. If storing Plastic Aerosol X products, restrict quantities as necessary so the liquid contents of all stored aerosol containers does not exceed that specified in the cabinet's FM Approval listing.

2. Cutoff is not needed from storage or nonstorage occupancies.

3. Provide a minimum of 20 ft (6 m) separation between cabinets and storage areas.

4. Do not put cabinets within rack storage arrangements.

5. Provide adequate protection for the surrounding occupancy.

B. Use portable, noncombustible bins to store pallet-load quantities. Enclose the bins on all sides, including the tops and bottoms. Construct the bins of 18-gauge (1.2 mm) steel with a continuous weld at fixed seams. Provide access to the container using a hinged door, with only a friction latch arranged in such a way that the door has to be closed so as not to obstruct the aisle. Individual designs are likely to be needed for such bins.

2.2.10.1 The storage arrangements listed in Section 2.2.10 are alternatives to the location recommendations in this data sheet (i.e., cutoff room or dedicated area), but they do not alter the sprinkler protection recommendations.

2.2.10.2 If stored in racks, limit these containers to the first tier of the rack, with no combustibles located below except for the pallet.

2.2.10.2.1 Provide in-rack sprinklers over such storage in accordance with Section 2.4. Determine the need for additional in-rack sprinkler protection based on the other commodities in the racks.

2.2.11 Shipping/Receiving Areas

2.2.11.1 For loading docks where aerosol products are staged, provide construction and protection as recommended by this data sheet. The term ″staged″ in this context excludes continuous movement of containers from inside the shipping vehicle directly to the storage area.

2.2.11.2 Where small amounts of aerosol product outside of appropriately arranged storage areas cannot be avoided, such as in staging areas, provide racking in the staging area sufficient for the required amount of product protected with Scheme A protection.

2.2.11.3 Locate aerosol product storage areas next to shipping/receiving areas to prevent the creation of an aerosol product fire hazard along transportation routes that are not protected for that hazard.

2.2.11.3.1 Provide space in the cutoff rooms for staging products before they are placed in storage or while they are waiting to be shipped.

2.3 Occupancy

2.3.1 Maintain only aerosol product storage in designated aerosol product storage areas or cutoff rooms/buildings.

2.3.2 Any level of aerosol product in maximum 33.8 oz (1000 ml) metal containers may be stored with ignitable liquids in metal containers up to 33.8 oz (1000 ml), if the provided fire protection scheme, isolation, and construction features are fully adequate for both storage types. Refer to Data Sheet 7-29, *Ignitable Liquid Storage in Portable Containers.* Do not mix aerosol product storage with ignitable liquid storage beyond this limit. In all other cases, maintain only aerosol product storage in designated aerosol product storage areas or cutoff rooms or buildings.

2.3.2.1 Do not mix storage of plastic aerosols with ignitable liquids.

2.3.3 Where Scheme A is used to protect the rack storage of Level 2 Aerosol products and Level 3 Aerosol products, mixed storage within the rack is acceptable if the following criteria are met:

A. Provide minimum 8 ft (2.4 m) aisles for all rack storage of Level 2 Aerosol products and Level 3 Aerosol products.

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B. For double-row rack tiers fully protected with Scheme A, provide a vertical chain link fence in longitudinal and transverse flue spaces to separate aerosol storage from adjacent storage of other commodities as shown in Figure 2.3.3.B.

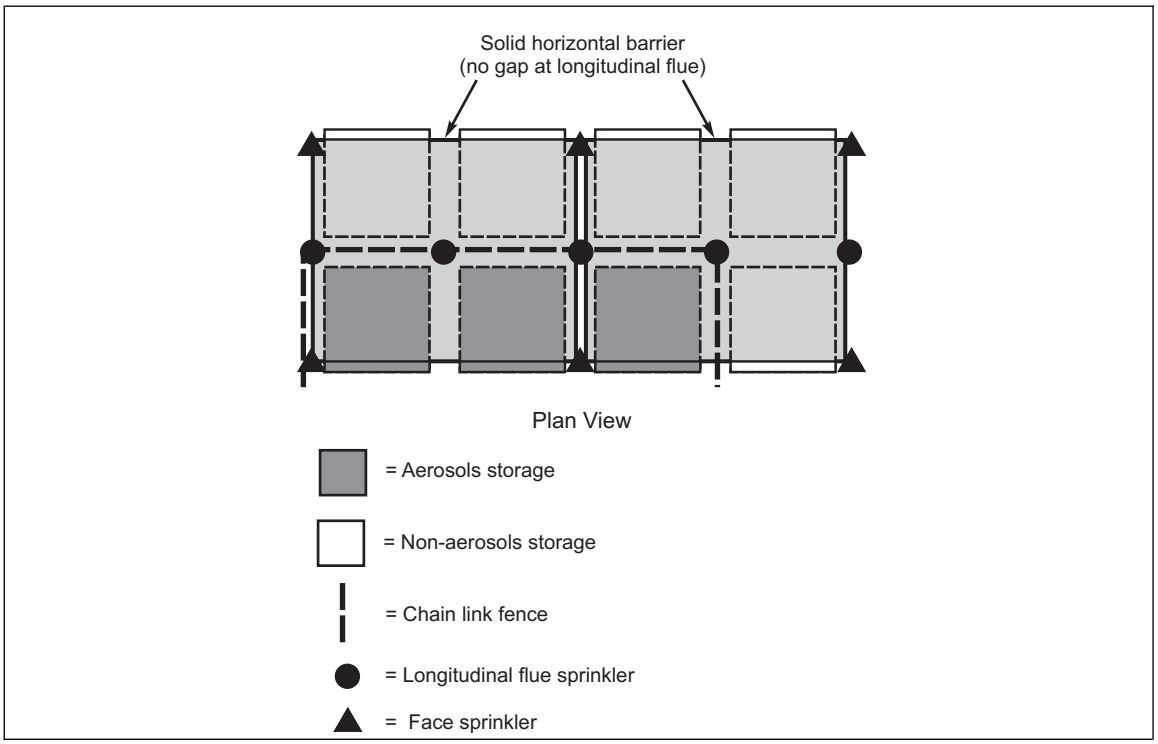


Fig. 2.3.3.B. Separation of aerosol product storage from non-aerosol storage using a chain link fence

C. For double-row rack tiers protected with Scheme A over aerosol product storage only (e.g., in one side of the rack), provide a solid vertical barrier in the longitudinal and transverse flue spaces to separate aerosol product storage from adjacent storage of other commodities as shown in Figure 2.3.3.C. Protect the adjacent storage based on the commodity stored in that area.

D. If aerosol products are stored at the outermost bay, provide a solid vertical barrier or chain link fence at the end of the bay, as shown in Figures 2.3.3.B and 2.3.3.C.

E. A chain link fence is not necessary within the aisles if adjacent racks are also protected with Scheme A (refer to Section 2.2.5).

2.4 Protection

2.4.1 General

2.4.1.1 Provide automatic fire protection using a wet, preaction, or deluge sprinkler system.

2.4.1.1.1 Install sprinklers in accordance with Data Sheet 2-0, *Installation Guidelines for Automatic Sprinklers*.

2.4.1.1.2 Arrange sprinklers on a maximum 100 ft^2 (9 m^2) spacing.

2.4.1.1.3 Arrange sprinklers with a maximum spacing of 10 ft (3.0 m). A variation of +1 ft (0.3 m) is permitted on either dimension to avoid obstructions by structural elements.

2.4.1.1.3.1 Where FM Approved K25EC (360EC) sprinklers (pendent or upright) are used, install on a minimum 13 ft (3.9 m) to a maximum 14 ft (4.2 m) linear spacing at a minimum pressure of 15 psi (1.0 bar).

2.4.1.1.4 Where a preaction system is installed, space detectors (pilot sprinkler, electric, or pneumatic) as follows:

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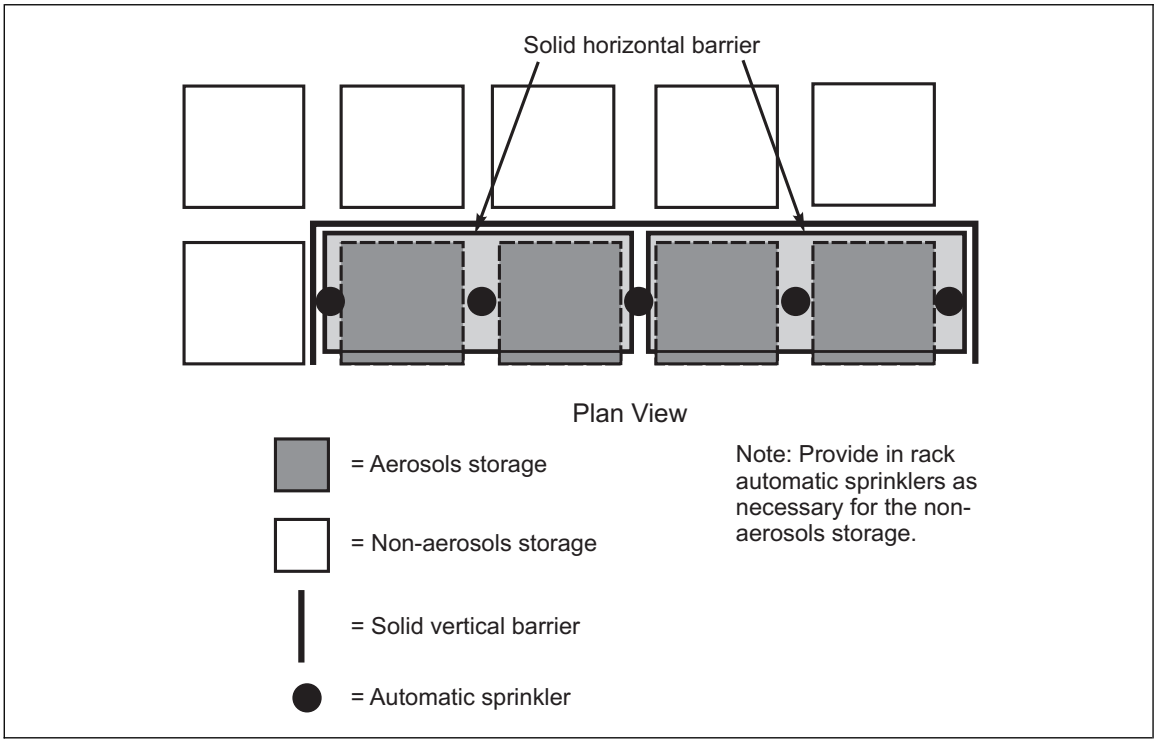


Fig. 2.3.3.C. Separation of aerosol product storage from non-aerosol storage using a solid vertical barrier

A. Install electric or pneumatic detectors at a spacing of one-half the listed linear detector spacing, or the full sprinkler spacing, whichever is greater. For design purposes, treat preaction systems with this detector spacing the same as wet systems (e.g., if a detector is FM Approved for 30 ft by 30 ft [9.1 m by 9.1 m] and allowable sprinkler spacing is 100 ft^2 [9 m^2], then maximum allowable linear detector spacing is 15 ft by 15 ft [4.6 m by 4.6 m]).

If a preaction system has a detector spacing greater than the above spacing, consider it a deluge system for design purposes. Refer to the *Approval Guide* for the maximum allowable spacing.

B. Install pilot sprinklers on the same spacing as the sprinklers. For design purposes, treat preaction sprinkler systems that use pilot sprinklers the same as dry systems, regardless of detector spacing.

2.4.1.1.5 Where a deluge system is installed, space detectors (pilot sprinkler, electric, or pneumatic) as follows:

A. Install pilot sprinklers on the same spacing as sprinklers.

B. Install electric or pneumatic devices under smooth ceilings in accordance with the manufacturer's specifications, the requirements listed in the *Approval Guide* for the device, and Data Sheet 5-48, *Automatic Fire Detection*.

2.4.1.2 A dry system is acceptable if the sprinkler operating area is equal to the room's footprint as defined by its walls, and water is delivered to the most remote sprinkler within 30 seconds of activation in a fire.

2.4.1.3 Where aerosol products are segregated by fencing in a general purpose warehouse, provide a consistent level of sprinkler protection throughout the dedicated area.

2.4.1.3.1 Provide protection for the most hazardous classification of products present.

2.4.1.3.2 Extend the recommended ceiling protection 20 ft (6.1 m) beyond the fence if it is more stringent than the ceiling sprinkler requirement for the adjacent occupancy.

2.4.1.4 When recommended per Tables 2.4.2.4 through 2.4.2.7, install in-rack sprinklers in accordance with Figures E.1-1 through E.1-6.

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2.4.1.4.1 Stagger in-rack sprinklers vertically where indicated in the figures.

2.4.1.4.2 In-rack design flows are provided in Tables 2.4.2.4 through 2.4.2.7.

2.4.1.4.3 Provide an end-sprinkler discharge pressure of at least 15 psi (1 bar) regardless of sprinkler type.

2.4.1.4.4 Base the in-rack sprinkler water demand on the simultaneous operation of the most hydraulically remote sprinklers as follows:

A. Eight (8) sprinklers where only one level of in-rack sprinklers is provided.

B. Twelve (12) sprinklers (six [6] sprinklers on two [2] levels) where only two (2) levels of in-rack sprinklers are provided.

C. Eighteen (18) sprinklers (six [6] sprinklers on the top three [3] levels) where more than two (2) levels of in-rack sprinkler are provided.

2.4.1.5 Ensure the water supply is capable of providing the combined sprinkler system (ceiling protection and, if provided, in-rack sprinklers) and hose stream demands at adequate pressure for the durations listed in Table 2.4.1.5.

Table 2.4.1.5. Hose Demand and Water Supply Duration Design Guidelines

Sprinkler Type by Spacing	*No. of Sprinklers in Ceiling Design*	*Hose Demand,*[Note 1] *gpm (L/min)*	*Duration, minutes*
Standard spacing	Up to 12	250 (950)	60
	13 to 19	500 (1900)	90
	20 or more	500 (1900)	120
Extended-coverage	Up to 6	250 (950)	60
	7 to 9	500 (1900)	90
	10 or more	500 (1900)	120

Note 1. Provide 250 gpm (950 L/min) for buildings or rooms with a floor area of 2000 ft^2 (185 m^2) or less, regardless of the ceiling protection.

2.4.2 Warehouse Storage of Aerosol Products in Metal Containers

2.4.2.1 Protect Level 1 Aerosol products in accordance with the recommendations for a Class 3 commodity in Data Sheet 8-9, *Storage of Class 1, 2, 3, 4 and Plastic Commodities*.

2.4.2.2 Protect palletized or solid-pile storage of cartoned or uncartoned Level 2 Aerosol products in accordance with Table 2.4.2.2.

2.4.2.3 Protect palletized or solid-pile storage of cartoned Level 3 Aerosol products in accordance with Table 2.4.2.3.

2.4.2.4 Protect rack storage of cartoned Level 2 Aerosol products in accordance with Table 2.4.2.4.

2.4.2.5 Protect rack storage of cartoned Level 3 Aerosol products in accordance with Table 2.4.2.5.

2.4.2.6 Protect rack storage of uncartoned Level 2 Aerosol products in accordance with Table 2.4.2.6.

2.4.2.7 Protect rack storage of uncartoned Level 3 Aerosol products in accordance with Table 2.4.2.7.

2.4.2.8 Protect rack, palletized, and solid-pile storage of cartoned Aerosol Cooking Spray products in accordance with Table 2.4.2.8.

2.4.2.8.1 Cartoned Aerosol Cooking Spray products can also be adequately protected using the protection criteria provided for Level 2 Aerosol and Level 3 Aerosol products.

2.4.2.9 Protect uncartoned Aerosol Cooking Spray products as uncartoned Level 2 Aerosol products or uncartoned Level 3 Aerosol products based on the product's chemical heat of combustion.

2.4.2.10 Protect small propane cylinders up to 17 oz (500 ml) [normal 1 lb (450 g) cylinders] with protection criteria suitable for Level 3 Aerosol products with all the following limitations:

A. Store containers with the relief vent in the vapor space.

B. For palletized storage use only quick response storage sprinkler protection criteria.

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C. For rack storage use either (1) quick response storage sprinkler protection criteria at the ceiling or (2) standard response storage sprinklers at the ceiling plus in-rack protection criteria.

Table 2.4.2.2. Palletized and Solid Pile Storage of Cartoned or Uncartoned Level 2 Aerosol Products

Packaging Type	*Maximum Ceiling Height ft (m)*	*Maximum Storage Height ft (m)*	*Ceiling Sprinkler Protection (Note 1)*		
			Response, Nominal Temperature Rating, and Sprinkler Orientation	K-Factor (Note 2) gpm/psi$^{1/2}$ (l/min/bar$^{1/2}$)	Design, # Sprinklers @ Pressure psi (bar)
Cartoned	25 (7.6)	18 (5.5)	SR, Ordinary, Upright	11.2 (161)	15 @ 50 (3.4)
			QR, Ordinary, Any	25.2EC (360EC)	8 @ 38 (2.6)
		20 (6.1)	QR, Ordinary, Pendent	14.0 (202)	12 @ 50 (3.4)
				16.8 (235)	12 @ 35 (2.4)
				22.4 (314)	12 @ 25 (1.7)
				25.2 (363)	12 @25 (1.7)
	30 (9.1)	5 (1.5)	SR, High, Any	≥11.2 (≥161)	25 @ 7 (0.5)
			QR, Ordinary, Any	25.2EC (360EC)	13 @ 15 (1.0)
		15 (4.6)	QR, Ordinary, Pendent	14.0 (202)	12 @ 50 (3.4)
				16.8 (235)	12 @ 35 (2.4)
				22.4 (314)	12 @ 25 (1.7)
				25.2 (363)	12 @ 25 (1.7)
Uncartoned	25 (7.6)	15 (4.6)	QR, Ordinary, Pendent	14.0 (202)	12 @ 50 (3.4)
				16.8 (235)	12 @ 35 (2.4)
				22.4 (314)	12 @ 25 (1.7)
				25.2 (363)	12 @ 25 (1.7)
	30 (9.1)	15 (4.6)	QR, Ordinary, Pendent	14.0 (202)	12 @ 75 (5.2)
				16.8 (235)	12 @ 52 (3.6)
				22.4 (314)	12 @ 45 (3.1)
				25.2 (363)	12 @ 25 (1.7)

Note 1. SR = Standard response; QR = quick response.
Note 2. The FM Approved K19.6 (282) sprinkler is not acceptable for the protection of palletized and solid pile storage of Level 2 Aerosol products.

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Table 2.4.2.3. Palletized and Solid Pile Storage of Cartoned Level 3 Aerosol Products

Packaging Type	*Maximum Ceiling Height ft (m)*	*Maximum Storage Height ft (m)*	*Ceiling Sprinkler Protection (Note 1)*		
			Response, Nominal Temperature Rating, and Sprinkler Orientation	K-Factor (Note 2) gpm/psi$^{1/2}$ (l/min/bar$^{1/2}$)	Design, # Sprinklers @ Pressurepsi (bar)
Cartoned	20 (6.1)	5 (1.5)	SR, High, Any	≥11.2 (≥161)	25 @ 7 (0.5)
			QR, Ordinary, Any	25.2EC (360EC)	13 @ 15 (1.0)
		10 (3)	SR, Ordinary, Upright	11.2 (161)	15 @ 75 (5.2)
			QR, Ordinary, Any	25.2EC (360EC)	8 @ 57 (3.9)
	25 (7.6)	15 (4.6)	QR, Ordinary, Pendent	14.0 (202)	12 @ 50 (3.4)
				16.8 (235)	12 @ 35 (2.4)
				22.4 (314)	12 @ 25 (1.7)
				25.2 (363)	12 @ 25 (1.7)
	30 (9.1)	5 (1.5)	SR, High, Any	11.2 (161)	25 @ 29 (2.0)
				14.0 (202)	25 @ 18 (1.2)
				16.8 (235)	25 @ 13 (0.9)
				25.2 (363)	25 @ 7 (0.5)
			QR, Ordinary, Any	25.2EC (360EC)	13 @ 15 (1.0)
		15 (4.6)	QR, Ordinary, Pendent	14.0 (202)	12 @ 75 (5.2)
				16.8 (235)	12 @ 52 (3.6)
				22.4 (314)	12 @ 45 (3.1)
				25.2 (363)	12 @ 25 (1.7)
Uncartoned	No Protection Criteria Available. See Section 2.4.3.5.				

Note 1. SR = Standard response; QR = quick response.
Note 2. The FM Approved K19.6 (282) sprinkler is not acceptable for the protection of palletized and solid pile storage of Level 3 Aerosol products.

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Table 2.4.2.4. Rack Storage of Cartoned Level 2 Aerosol Products

Maximum Ceiling Height, ft (m)	*Maximum Storage Height, ft (m)*	*Minimum Aisle Width, ft (m)*	*Ceiling Sprinkler Protection (Note 1)*			*In-Rack Sprinkler Protection (Note 1)*			
			Response, Nominal Temperature Rating, and Sprinkler Orientation	K-Factor (Note 2), gpm/psi$^{1/2}$ (L/min/bar$^{1/2}$)	Design, # Sprinklers @ Pressure psi (bar)	Layout, See Figure	Response, Nominal Temperature Rating	K-Factor, gpm/psi$^{1/2}$ (L/min/bar$^{1/2}$) (Note 3)	Discharge Flow, gpm (L/min)
25 (7.6)	20 (6.1)	4 (1.2)	QR, Ordinary, Pendent	14.0 (202)	12 @ 50 (3.4)	NA	NA	NA	NA
				16.8 (235)	12 @ 35 (2.4)				
				22.4 (314)	12 @ 25 (1.7)				
				25.2 (363)	12 @ 25 (1.7)				
30 (9.1)	15 (4.6)	4 (1.2)	QR, Ordinary, Pendent	14.0 (202)	12 @ 50 (3.4)	NA	NA	NA	NA
				16.8 (235)	12 @ 35 (2.4)				
				22.4 (314)	12 @ 25 (1.7)				
				25.2 (363)	12 @ 25 (1.7)				
	20 (6.1)	8 (2.4)	SR, High, Any	≥11.2 (≥161)	25 @ 7 (0.5)	E.1-1a, E.1-1b, or E.1-1c	QR, Ordinary	≥8.0 (≥115)	30 (114)
			QR, Ordinary, Any	25.2EC (360EC)	13 @ 15 (1.0)				
	25 (7.6)	8 (2.4)	QR, Ordinary, Pendent	14.0 (202)	12 @ 50 (3.4)	E.1-1a, E.1-1b, or E.1-1c	QR, Ordinary	≥8.0 (≥115)	30 (114)
				16.8 (235)	12 @ 35 (2.4)				
				22.4 (314)	12 @ 25 (1.7)				
				25.2 (363)	12 @ 25 (1.7)				
		8 (2.4)	SR, High, Any	11.2 (161)	25 @ 13 (0.9)	E.1-1a, E.1-1b, or E.1-1c	SR or QR, Ordinary	≥8.0 (≥115)	30 (114)
				14.0 (202)	25 @ 8 (0.6)				
				≥16.8 (≥235)	25 @ 7 (0.5)				
			QR, Ordinary, Any	25.2EC (360EC)	13 @ 15 (1.0)				
Unlimited	Unlimited	8 (2.4)	Any	Any	See Scheme A	See Scheme A			
For storage up to 25 ft and building heights greater than 30 ft, use the same level of protection as outlined in Table 2.4.2.5 for Level 3 Aerosol products or Scheme A.									

Note 1. SR = Standard response; QR = quick response. See Appendix E for an explanation of fire protection schemes.
Note 2. The FM Approved K19.6 (282) sprinkler is not acceptable for the protection of rack storage of cartoned Level 2 Aerosol products.
Note 3. Where IRAS with k-factors greater than those listed in the table are used, the end-sprinkler discharge pressure must be at least 15 psi (1 bar).

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Table 2.4.2.5. Rack Storage of Cartoned Level 3 Aerosol Products

Maximum Ceiling Height, ft (m)	*Maximum Storage Height, ft (m)*	*Minimum Aisle Width, ft (m)*	*Ceiling Sprinkler Protection (Note 1)*			*In-Rack Sprinkler Protection (Note 1)*			
			Response, Nominal Temperature Rating, and Sprinkler Orientation	K-Factor (Note 2) gpm/psi$^{1/2}$ (L/min/bar$^{1/2}$)	Design, # Sprinklers @ Pressure psi (bar)	Layout, See Figure	Response, Nominal Temperature Rating	K-Factor (Note 3), gpm/psi$^{1/2}$ (l/min/bar$^{1/2}$)	Discharge Flow, gpm (L/min)
25 (7.6)	15 (4.6)	4 (1.2)	QR, Ordinary, Pendent	14.0 (202)	12 @ 50 (3.4)	NA	NA	NA	NA
				16.8 (235)	12 @ 35 (2.4)				
				22.4 (314)	12 @ 25 (1.7)				
				25.2 (363)	12 @ 25 (1.7)				
30 (9.1)	15 (4.6)	8 (2.4)	QR, Ordinary, Pendent	14.0 (202)	12 @ 75 (5.2)	NA	NA	NA	NA
				16.8 (235)	12 @ 52 (3.6)				
				22.4 (314)	12 @ 45 (3.1)				
				25.2 (363)	12 @ 25 (1.7)				
	25 (7.6)	8 (2.4)	QR, Ordinary, Pendent	14.0 (202)	12 @ 50 (3.4)	E.1-2a or E.1-2b	QR, Ordinary	≥8.0 (≥115)	45 (170)
						E.1-3a, E.1-3b, or E.1-3c	SR or QR, Ordinary	≥8.0 (≥115)	30 (114)
				16.8 (235)	12 @ 35 (2.4)	E.1-2a or E.1-2b	QR, Ordinary	≥8.0 (≥115)	45 (170)
						E.1-3a, E.1-3b, or E.1-3c	SR or QR, Ordinary	≥8.0 (≥115)	30 (114)
				22.4 (314)	12 @ 25 (1.7)	E.1-2a or E.1-2b	QR, Ordinary	≥8.0 (≥115)	45 (170)
						E.1-3a, E.1-3b, or E.1-3c	SR or QR, Ordinary	≥8.0 (≥115)	30 (114)
				25.2 (363)	12 @ 25 (1.7)	E.1-2a or E.1-2b	QR, Ordinary	≥8.0 (≥115)	45 (170)
						E.1-3a, E.1-3b, or E.1-3c	SR or QR, Ordinary	≥8.0 (≥115)	30 (114)
		8 (2.4)	SR, High, Any	≥11.2 (≥161)	25 @ 7 (0.5)	E.1-3a, E.1-3b, or E.1-3c	SR or QR, Ordinary	≥8.0 (≥115)	30 (114)
			QR, Ordinary, Any	25.2EC (360EC)	13 @ 15 (1.0)				
		8 (2.4)	SR, High, Any	11.2 (161)	25 @ 29 (2.0)	E.1-1a, E.1-1b, or E.1-1c	SR or QR, Ordinary	≥8.0 (≥115)	30 (114)
				14.0 (202)	25 @ 18 (1.2)				
				16.8 (235)	25 @ 13 (0.9)				
				25.2 (363)	25 @ 7 (0.5)				
			QR, Ordinary, Any	25.2EC (360EC)	13 @ 22 (1.5)				

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Table 2.4.2.5. Rack Storage of Cartoned Level 3 Aerosol Products (continued)

Maximum Ceiling Height, ft (m)	*Maximum Storage Height, ft (m)*	*Minimum Aisle Width, ft (m)*	*Ceiling Sprinkler Protection (Note 1)*			*In-Rack Sprinkler Protection (Note 1)*			
			Response, Nominal Temperature Rating, and Sprinkler Orientation	K-Factor (Note 2) gpm/psi$^{1/2}$ (L/min/bar$^{1/2}$)	Design, # Sprinklers @ Pressure psi (bar)	Layout, See Figure	Response, Nominal Temperature Rating	K-Factor (Note 3), gpm/psi$^{1/2}$ (l/min/bar$^{1/2}$)	Discharge Flow, gpm (L/min)
40 (12.2)	25 (7.6)	8 (2.4)	SR, High, Any	11.2 (161)	25 @ 29 (2.0)	E.1-3a, E.1-3b, or E.1-3c	SR or QR, Ordinary	≥8.0 (≥115)	30 (114)
				14.0 (202)	25 @ 18 (1.2)				
				16.8 (235)	25 @ 13 (0.9)				
				25.2 (363)	25 @ 7 (0.5)				
			QR, Ordinary, Any	25.2EC (360EC)	13 @ 15 (1.0)				
>40 (>12.2)	25 (7.6)	8 (2.4)	SR, High, Any	≥11.2 (≥161) (Note 4)	25 @ 7 (0.5)	E.1-4a, E.1-4b, or E.1-4c	SR or QR, Ordinary	≥8.0 (≥115)	30 (114)
			QR, Ordinary, Any	25.2EC (360EC)	13 @ 15 (1.0)				
Unlimited	Unlimited	8 (2.4)	Any	Any	See Scheme A	See Scheme A			

Note 1. SR = Standard response; QR = quick response. See Appendix E for an explanation of fire protection schemes.
Note 2. The FM Approved K19.6 (282) sprinkler is not acceptable for the protection of rack storage of cartoned Level 3 Aerosol products.
Note 3. Where IRAS with k-factors greater than listed in the table are used, the end-sprinkler discharge pressure must be at least 15 psi (1 bar).

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Table 2.4.2.6. Rack Storage of Uncartoned Level 2 Aerosol Products

Maximum Ceiling Height ft (m)	*Maximum Storage Height ft (m)*	*Minimum Aisle Widthft (m)*	*Ceiling Sprinkler Protection (Note 1)*			*In-Rack Sprinkler Protection (Note 1)*			
			Response, Nominal Temperature Rating, and Sprinkler Orientation	K-Factor (Note 2) gpm/psi$^{1/2}$ (l/min/bar$^{1/2}$)	Design, # Sprinklers @ Pressure psi (bar)	Layout See Figure	Response, Nominal Temperature Rating	K-Factor gpm/psi$^{1/2}$ (l/min/bar$^{1/2}$) (Note 3)	Discharge Flow gpm (L/min)
30 (9.1)	15 (4.6)	4 (1.2)	QR, Ordinary, Pendent	14.0 (202)	12 @ 75 (5.2)	NA	NA	NA	NA
				16.8 (235)	12 @ 52 (3.6)				
				22.4 (314)	12 @ 45 (3.1)				
				25.2 (363)	12 @ 25 (1.7)				
	20 (6.1)	4 (1.2)	QR, Ordinary, Pendent	14.0 (202)	12 @ 50 (3.4)	c E.1-5a, E.1-5b, or E.1-5c	QR, Ordinary	≥8.0 (≥115)	45 (170)
				16.8 (235)	12 @ 35 (2.4)				
				22.4 (314)	12 @ 25 (1.7)				
				25.2 (363)	12 @ 25 (1.7)				
		8 (2.4)	SR, High, Any	≥11.2 (≥161)	25 @ 7 (0.5)	E.1-6a, E.1-6b, or E.1-6c	QR, Ordinary	≥8.0 (≥115)	45 (170)
			QR, Ordinary, Any	25.2EC (360EC)	13 @ 15 (1.0)				
		8 (2.4)	SR, High, Any	11.2 (161)	20 @ 29 (2.0)	E.1-5a, E.1-5b, or E.1-5c	QR, Ordinary	≥8.0 (≥115)	45 (170)
				14.0 (202)	20 @ 18 (1.2)				
				16.8 (235)	20 @ 13 (0.9)				
				25.2 (363)	20 @ 7 (0.5)				
			QR, Ordinary, Any	25.2EC (360EC)	10 @ 22 (0.7)				
	25 (7.6)	4 (1.2)	QR, Ordinary, Pendent	14.0 (202)	12 @ 50 (3.4)	E.1-6a, E.1-6b, or E.1-6c	QR, Ordinary	≥8.0 (≥115)	45 (170)
				16.8 (235)	12 @ 35 (2.4)				
				22.4 (314)	12 @ 25 (1.7)				
				25.2 (363)	12 @ 25 (1.7)				
		8 (2.4)	SR, High, Any	≥11.2 (≥161)	25 @ 7 (0.5)	E.1-6a, E.1-6b, or E.1-6c	QR, Ordinary	≥8.0 (≥115)	45 (170)
			QR, Ordinary, Any	25.2EC (360EC)	13 @ 15 (1.0)				
Unlimited	Unlimited	8 (2.4)	Any	Any	See Scheme A	See Scheme A			

Note 1. SR = Standard response; QR = quick response. See Appendix E for an explanation of fire protection schemes.
Note 2. The FM Approved K19.6 (K282) sprinkler is not acceptable for the protection of rack storage of uncartoned Level 2 Aerosol products.
Note 3. Where IRAS with k-factors greater than listed in the table are used, the end-sprinkler discharge pressure must be at least 15 psi (1 bar).

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Table 2.4.2.7. Rack Storage of Uncartoned Level 3 Aerosol Products

Maximum Ceiling Height, ft (m)	*Maximum Storage Height, ft (m)*	*Minimum Aisle Width, ft (m)*	*Ceiling Sprinkler Protection (Note 1)*			*In-Rack Sprinkler Protection (Note 1)*			
			Response, Nominal Temperature Rating, and Sprinkler Orientation	K-Factor, gpm/psi$^{1/2}$ (L/min/bar$^{1/2}$) (Note 2)	Design, # Sprinklers @ Pressure psi (bar)	Layout, See Figure	Response, Nominal Temperature Rating	K-Factor, gpm/psi$^{1/2}$ (L/min/bar$^{1/2}$) (Note 3)	Discharge Flow, gpm (L/min)
30 (9.1)	20 (6.1)	4 (1.2)	QR, Ordinary, Pendent	14.0 (202)	12 @ 75 (5.2)	E.1-5a, E.1-5b, or E.1-5c	QR, Ordinary	≥8.0 (≥115)	45 (170)
				16.8 (235)	12 @ 52 (3.6)				
				22.4 (314)	12 @ 25 (1.7)				
				25.2 (363)	12 @ 25 (1.7)				
		8 (2.4)	SR, High, Any	11.2 (161)	20 @ 29 (2.0)	E.1-5a, E.1-5b, or E.1-5c	QR, Ordinary	≥8.0 (≥115)	45 (170)
				14.0 (202)	20 @ 18 (1.2)				
				16.8 (235)	20 @ 13 (0.9)				
				25.2 (363)	20 @ 7 (0.5)				
			QR, Ordinary, Any	25.2EC (360EC)	10 @ 15 (1.0)				
		8 (2.4)	SR, High, Any	≥11.2 (≥161)	25 @ 7 (0.5)	E.1-6a, E.1-6b, or E.1-6c	QR, Ordinary	≥8.0 (≥115)	45 (170)
			QR, Ordinary, Any	25.2EC (360EC)	13 @ 15 (1.0)				
	25 (7.6)	4 (1.2)	QR, Ordinary, Pendent	14.0 (202)	12 @ 75 (5.2)	E.1-6a, E.1-6b, or E.1-6c	QR, Ordinary	≥8.0 (≥115)	45 (170)
				16.8 (235)	12 @ 52 (3.6)				
				22.4 (314)	12 @ 25 (1.7)				
				25.2 (363)	12 @ 25 (1.7)				
		8 (2.4)	SR, High, Any	≥11.2 (≥161)	25 @ 7 (0.5)	E.1-6a, E.1-6b, or E.1-6c	QR, Ordinary	≥8.0 (≥115)	45 (170)
			QR, Ordinary, Any	25.2EC (360EC)	13 @ 15 (1.0)				
Unlimited	Unlimited	8 (2.4)	Any	Any	See Scheme A	See Scheme A			

Note 1. SR = Standard response; QR = quick response. See Appendix E for an explanation of fire protection schemes.
Note 2. The FM Approved K19.6 (K282) sprinkler is not acceptable for the protection of rack storage of uncartoned Level 3 aerosol products.
Note 3. Where IRAS with k-factors greater than those listed in the table are used, the end-sprinkler discharge pressure must be at least 15 psi (1 bar).

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Table 2.4.2.8. Rack, Palletized, and Solid-Pile Storage of Cartoned Aerosol Cooking Spray Products

Maximum Ceiling Height, ft (m)	*Maximum Storage Height, ft (m)*	*Minimum Aisle Width, ft (m)*	*Ceiling Sprinkler Protection*		
			Response, Nominal Temperature Rating, and Sprinkler Orientation	K-Factor, gpm/psi$^{1/2}$ (L/min/bar$^{1/2}$)	Design,Number of Sprinklers @ Pressure psi (bar)
30 (9.1)	25 (7.6)	8 (2.4)	QR, Ordinary, Pendent	14.0 (202)	12 @ 75 (5.2)

2.4.2.11 Protect picking areas that contain Level 2 Aerosol products and Level 3 Aerosol products as follows:

A. For picking in standard configuration single-row and double-row racks, locate aerosol product storage on the first and second tiers of the rack. Install fire protection Scheme A over the picking area (see Section E.2). Provide a chain link fence or similar restraint at the edges of the aerosol product storage area. For example, if the aerosol product storage is located only on one side of a double-row rack, install vertical barriers down the longitudinal flue space and at each end of the storage rack (refer to Section 2.3.3).

B. For picking in ″flow-through″ racks (those with shelves consisting of slanted rollers spaced less than 1 ft (0.3 m) apart so product loaded on one side rolls to the other), store and protect the aerosol products in accordance with the aerosol product flow-through rack protection scheme described and illustrated in Section E.3.

2.4.2.12 Protect aerosol product storage in automated rack storage warehouses that are higher than 30 ft (9.1 m) with aisle widths of 4 ft (1.2 m) or more as follows:

A. Limit aerosol product storage to the bottom tiers of the racks.

B. Provide chain link fencing or noncombustible vertical barriers around the limits of the aerosol product storage. The rack face does not need to be enclosed (refer to Section 2.3.3).

C. Provide fire protection Scheme A over all aerosol product storage within the racks. If aerosol products are stored above the bottom two rack tiers, protect all tiers below the aerosol product storage using Scheme A as well.

2.4.3 Warehouse Storage of Aerosol Products in Plastic Containers

2.4.3.1 Protect cartoned or uncartoned Plastic Aerosol 1 products using the protection criteria provided for Class 3 commodities in Data Sheet 8-9, *Storage of Class 1, 2, 3, 4 and Plastic Commodities*.

2.4.3.2 Protect cartoned Plastic Aerosol 2 products using the protection criteria provided for cartoned Level 3 Aerosol products in Section 2.4.2.3 or 2.4.2.5.

2.4.3.3 Protect cartoned Plastic Aerosol 3 products in accordance with Table 2.4.3.3.

Table 2.4.3.3. Rack Storage of Cartoned Plastic Aerosol 3 Products

Maximum Ceiling Height, ft (m)	*Maximum Storage Height, ft (m)*	*Minimum Aisle Width, ft (m)*	*Ceiling Sprinkler Protection*			*In-Rack Sprinkler Protection*		
			Response, Nominal Temperature Rating, and Sprinkler Orientation	K-factor, gpm/psi$^{1/2}$ (L/min/bar$^{1/2)}$	Design, # Sprinklers @Pressure psi (bar)	Response, Nominal Temperature Rating	K-Factor, gpm/psi$^{1/2}$ (L/min/bar$^{1/2}$)	Discharge flow, gpm (L/min)
Unlimited	Unlimited	8 (2.4)	Any	Any	See Scheme A	See Scheme A		

2.4.3.4 Protect cartoned Plastic Aerosol Cooking Spray products using the protection criteria provided for cartoned Aerosol Cooking Spray products in accordance with Table 2.4.2.8.

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2.4.3.4.1 Rack storage of cartoned Plastic Aerosol Cooking Spray products can be protected using in-rack protection provided for Level 2 Aerosol products or Level 3 Aerosol products in accordance with Table 2.4.2.4, Table 2.4.2.5, Table 2.4.2.6, or Table 2.4.2.7.

2.4.3.5 Protect products in Table 2.2.1 with storage locations that refer to Section 2.2.3, located in a cutoff room, with a wet, dry, or deluge sprinkler systems designed to provide 75 psi (5.2 bar) discharge pressure for all the sprinklers in the cutoff room. Sprinklers should be at least K11.2 (K160).

2.4.3.5.1 Limit the quantity of these products stored in a single area and locate the area well away from important buildings.

2.4.4 Mercantile Locations

2.4.4.1 Shelf Storage

2.4.4.1.1 In retail locations that display and sell aerosol products on shelves, as defined in Data Sheet 8-9, *Storage of Class 1, 2, 3, 4, and Plastic Commodities*, with storage less than 8 ft (2.4 m) high, remove the aerosol products from their combustible packaging. Typically, this involves the removal of at least the tops and parts of the faces and sides of the combustible cartons.

2.4.4.1.2 Provide protection based on the surrounding occupancy.

2.4.4.2 Rack Storage

2.4.4.2.1 In retail occupancies that display aerosol products in picking shelves or racks, additional bulk storage of aerosol products is often located in racks above the display areas. Provide the following protection for these arrangements:

A. Limit the lower tiers [up to 8 ft (2.4 m) high] to the display of aerosol products that have been removed from their combustible packaging per Section 2.4.4.1.

B. Maintain storage of aerosol products located in upper tiers within cartons. Do not exceed a storage height of 18 ft (5.5 m).

C. Store and protect the aerosol products in accordance with Appendix E.4.

D. Limit uncartoned Plastic Aerosol X products on display shelves to a single case.

E. Do not store Plastic Aerosol 3 products in bulk storage area above display shelves.

2.4.4.3 Storage of aerosol products that are not on display as described in Sections 2.4.4.1 or 2.4.4.2 (i.e., back-stock storage areas) should be treated as warehouse storage of aerosol products.

2.4.4.3.1 Provide segregation and protection in accordance with this data sheet. Alternatively, relocate these aerosol products to one of the areas recommended in Sections 2.2.8 and 2.2.9.

2.4.4.3.2 Do not store Plastic Aerosol X products in back-stock areas. Provide segregation and protection in accordance with Sections 2.2.8. and 2.2.9.

2.4.5 Automatic Storage and Retrieval Systems (ASRS)

This section applies to ASRS as defined in the scope of Data Sheet 8-34, *Protection for Automatic Storage and Retrieval Systems (ASRS).*

2.4.5.1 General

2.4.5.1.1 Limit aerosol products stored in ASRS to those listed in Table 2.4.5.1.1.

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Table 2.4.5.1.1. Allowable Aerosol Products Stored in ASRS

Aerosol Product	*Product Container Type*	*Maximum Product Container Size*	*Maximum Total Volume per ASRS Container*
Level 1 Aerosol, Level 2 Aerosol, Level 3 Aerosol	Metal	33.8 oz (1000 mL)	No Limit
Plastic Aerosol 1 or Plastic Aerosol 2	Plastic	33.8 oz (1000 mL)	No Limit
Aerosol Cooking Spray	Metal or Plastic	33.8 oz (1000 mL)	No Limit
Plastic Aerosol 3 or Plastic Aerosol X	Plastic	None Allowed	None Allowed

2.4.5.1.2 Implement the guidelines in Data Sheet 8-34 applicable to top-loading ASRS, except as modified by Section 2.4.5.2.

2.4.5.1.3 Implement the guidelines in Data Sheet 8-34 applicable to horizontal-loading ASRS, except as modified by Sections 2.4.5.2 and 2.4.5.3.

2.4.5.1.4 Construct metal ASRS containers and metal liners for unexpanded plastic ASRS containers as follows:

A. Use a minimum of 18-gauge (0.04 in. [1.0 mm]) steel walls and bottom.

B. Fully weld all seams with no openings in the walls or bottom.

C. Size liners to occupy the full height of the ASRS container.

2.4.5.1.5 Where a combination of containers is used in the ASRS, base the protection on the container that requires the highest protection level.

2.4.5.1.6 Where aerosol products are permitted to be stored within the ASRS with other non-aerosol commodities, provide protection based on the highest hazard commodity.

2.4.5.1.7 Where aerosol products are stored in ASRS, isolation with fencing and/or walls is not required due to the tight spacing of these arrangements.

2.4.5.2 Top-Loading ASRS or Horizontal-Loading Mini-Load ASRS

2.4.5.2.1 Store aerosol products in top-loading ASRS or horizontal-loading mini-load ASRS in one of the following ASRS containers:

A. FM Approved, non-flame propagating

B. Solid-walled, solid-bottom metal (open-top or closed-top)

C. Unexpanded plastic (open-top or closed-top) equipped with solid-walled, solid-bottom metal liners

2.4.5.2.2 Protect aerosol-container combinations in top-loading ASRS or horizontal-loading mini-load ASRS in accordance with Table 2.4.5.2.2.

Table 2.4.5.2.2. Protection for Aerosol Products Stored in Top-Loading and Horizontal-Loading Mini-Load Systems

Type of ASRS	*Type of ASRS Container*	*Protection (Note 1)*
Top-Loading	FM Approved Non-Flame Propagating or Metal	Data Sheet 8-34, Top-Loading ASRS Storage Arrangements Using FM Approved Non-Flame Propagating Containers
	Metal-Lined Unexpanded Plastic	Data Sheet 8-34, Top-Loading ASRS Storage Arrangements Using Solid-Walled Containers
Horizontal-Loading Mini-Load	FM Approved Non-Flame Propagating Metal or Metal-Lined Unexpanded Plastic	Data Sheet 8-34, Protection of Horizontal-Loading Mini-Load ASRS Storage Arrangements Where Open-Top, Combustible Containers are Being Used

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2.4.5.3 Horizontal-Loading Shuttle ASRS

2.4.5.3.1 Store aerosol products in horizontal-loading shuttle ASRS in or on one of the following ASRS containers:

A. FM Approved, non-flame propagating

B. Solid-walled, solid-bottom metal (open-top or closed-top)

C. Unexpanded plastic (open-top or closed-top) equipped with solid-walled, solid-bottom metal liners

D. Solid-walled, solid-bottom unexpanded plastic (open-top or closed-top) without solid-walled, solid-bottom metal liners

E. Trays (metal or unexpanded plastic) without solid-walled, solid-bottom metal liners

2.4.5.3.2 Provide adequate flue spaces in accordance with Data Sheet 8-34.

2.4.5.3.3 Protect aerosol-container combinations in horizontal-loading shuttle ASRS in accordance with Table 2.4.5.3.3.

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Table 2.4.5.3.3. Protection for Aerosol Products Stored in Horizontal-Loading Shuttle Systems

Aerosol Product Type	*ASRS Container Type*	*Protection (Note 1)*
Level 2 Aerosol, Level 3 Aerosol, Aerosol Cooking Spray, Plastic Aerosol 2, Plastic Aerosol Cooking Spray	Closed-Top (Metal or Plastic)	Data Sheet 8-34, Horizontal-Loading Shuttle ASRS Using Closed-Top Combustible Containers In addition: 1. Limit the vertical spacing of the in-rack sprinkler and horizontal barrier levels to a maximum of 10 ft (3 m). 2. All aerosol storage must be maintained below the barrier. 3. Layout and design in-rack sprinklers using either Data Sheet 8-34 or Data Sheet 7-29 Scheme A, whichever is greater. 4. Design ceiling sprinklers per Data Sheet 8-34.
	Open-Top (Metal or Plastic)	Data Sheet 8-34, Horizontal-Loading Shuttle ASRS Using Open-Top Combustible Containers In addition: 1. Limit the vertical spacing of the in-rack sprinkler and horizontal barrier levels to a maximum of 10 ft (3 m) or per Data Sheet 8-34, whichever is less. 2. All aerosol storage must be maintained below the barrier. 3. Layout and design in-rack sprinklers using either Data Sheet 8-34 or Data Sheet 7-29 Scheme A, whichever is greater. 4. Design ceiling sprinklers per Data Sheet 8-34.
Level 1 Aerosol or Plastic Aerosol 1	Closed-Top (Metal or Plastic) or Trays	Data Sheet 8-34, Horizontal-Loading Shuttle ASRS Using Closed-Top Combustible Containers In addition: 1. Limit the vertical spacing of the in-rack sprinklers to a maximum of 20 ft (6.1 m). 2. All aerosol storage must be maintained below the in-rack sprinkler levels. 3. Layout and design in-rack sprinklers using either Data Sheet 8-34 or Data Sheet 7-29 Scheme E, whichever is greater. 4. Design ceiling sprinklers per Data Sheet 8-34.
	Open-Top (Metal or Plastic)	Data Sheet 8-34, Horizontal-Loading Shuttle ASRS Using Open-Top Combustible Containers In addition: 1. Limit the vertical spacing of the in-rack sprinklers to a maximum of 20 ft (6.1 m) or per Data Sheet 8-34, whichever is less. 2. All aerosol storage must be maintained below the in-rack sprinkler levels. 3. Layout and design in-rack sprinklers using either Data Sheet 8-34 or Data Sheet 7-29 Scheme E, whichever is greater. 4. Design ceiling sprinklers per Data Sheet 8-34.

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2.4.5.3.3.1 For storage arrangements that require protection in accordance with Data Sheet 8-34 and Data Sheet 7-29, use the highest level of protection when more than one protection option is listed.

2.4.6 Manual Picking Stations

This section applies to aerosol products stored in manual picking stations. These stations are fixed storage areas with multi-level shelving where individual items are manually selected from defined locations to fulfill customer orders.

2.4.6.1 Locate aerosol product storage on the bottom (floor) level.

2.4.6.2 Limit aerosol product storage to the following aerosol products:

- Level 1
- Level 2
- Level 3
- Aerosol Cooking Spray
- Plastic Aerosol 1
- Plastic Aerosol 2
- Plastic Aerosol Cooking Spray

2.4.6.3 Store aerosol products in metal storage bins, constructed as follows:

A. Minimum 20 ga. [0.03 in. (0.8 mm)] aluminum or steel walls and bottom.

B. Seal all seams with no openings in the walls and bottom.

2.4.6.4 For 33.8 oz (1000 mL) aerosol products, limit each metal bin to a maximum of twelve aerosol products.

2.4.6.4.1 For aerosol products less than 33.8 oz (1000 mL), limit the total number of products based on one of the following, whichever is less.

A. 25 aerosol products

B. Calculate the number of aerosol products based on a maximum volume per metal storage bin of 3.3 gal (12.5 L).

2.4.6.5 Storage of aerosol products in manual picking stations can be mixed with other storage if the arrangement and fire protection are fully adequate for both storage types. Ignitable liquids and aerosol products can be stored on the same shelf if they are stored in separate bins. Ignitable liquids may be stored in cardboard bins in accordance with Data Sheet 7-29.

2.4.6.6 Arrange the manual picking stations as follows and as shown in Figure 2.4.6.6-1 and Figure 2.4.6.6-2:

2.4.6.6.1 Provide solid, noncombustible walkways above aerosol storage with a maximum height of 10 ft (3 m).

2.4.6.6.2 Provide solid metal shelves within the storage tier, including directly above the top level of aerosol product storage.

2.4.6.6.3 Provide minimum 22 ga. [(0.03 in. (0.7 mm)] sheet metal horizontal barriers at the walkway height to eliminate all air gaps between tiers as follows:

A. Between walkway and shelf.

B. Flush with the rack uprights.

C. No gaps in the transverse or longitudinal flue spaces. This includes closing gaps on either side of the vertical barriers.

D. Mechanically fastened. Sealants / gaskets are not required.

2.4.6.6.4 Provide minimum 22 ga. [0.03 in. (0.7 mm)] sheet metal vertical barriers, with no air gaps, in transverse flue spaces at a maximum spacing of 30 ft (9.0 m).

2.4.6.6.4.1 Install barriers along the full shelf width (from aisle to aisle) when aerosol products are stored on either side.

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2.4.6.6.5 At rack uprights, where vertical barriers are not installed, provide a minimum 1 in. (25 mm) gap between shelves below walkway level as shown in Figure 2.4.6.6.5.

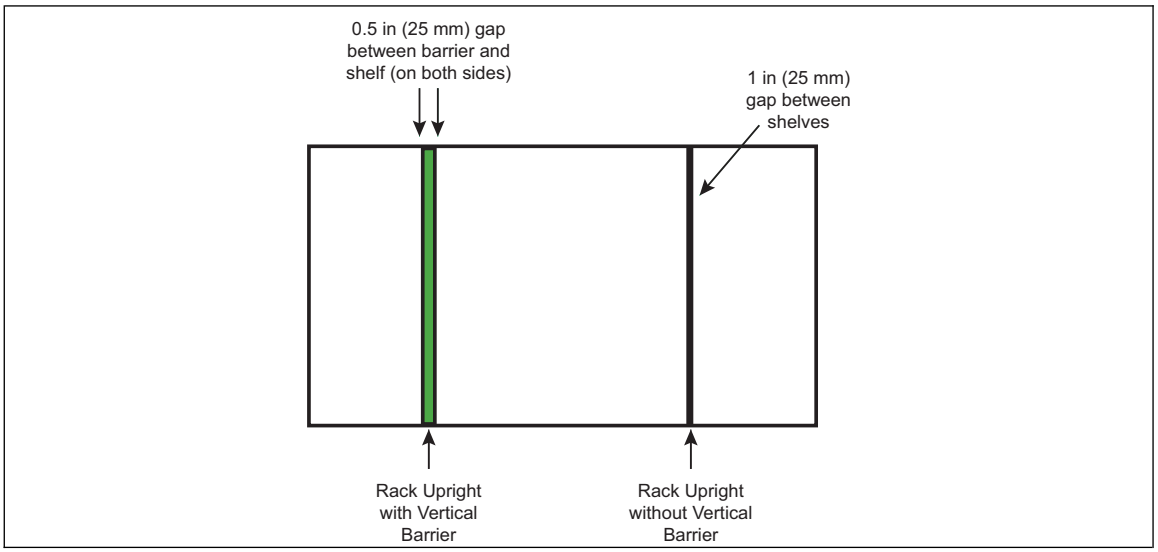


Fig. 2.4.6.6.5 Gaps at rack uprights below walkway level

2.4.6.6.6 At rack uprights where vertical barriers are installed, provide a minimum 0.5 in. (12 mm) gap between shelf and vertical barrier below walkway level as shown in Figure 2.4.6.6.5.

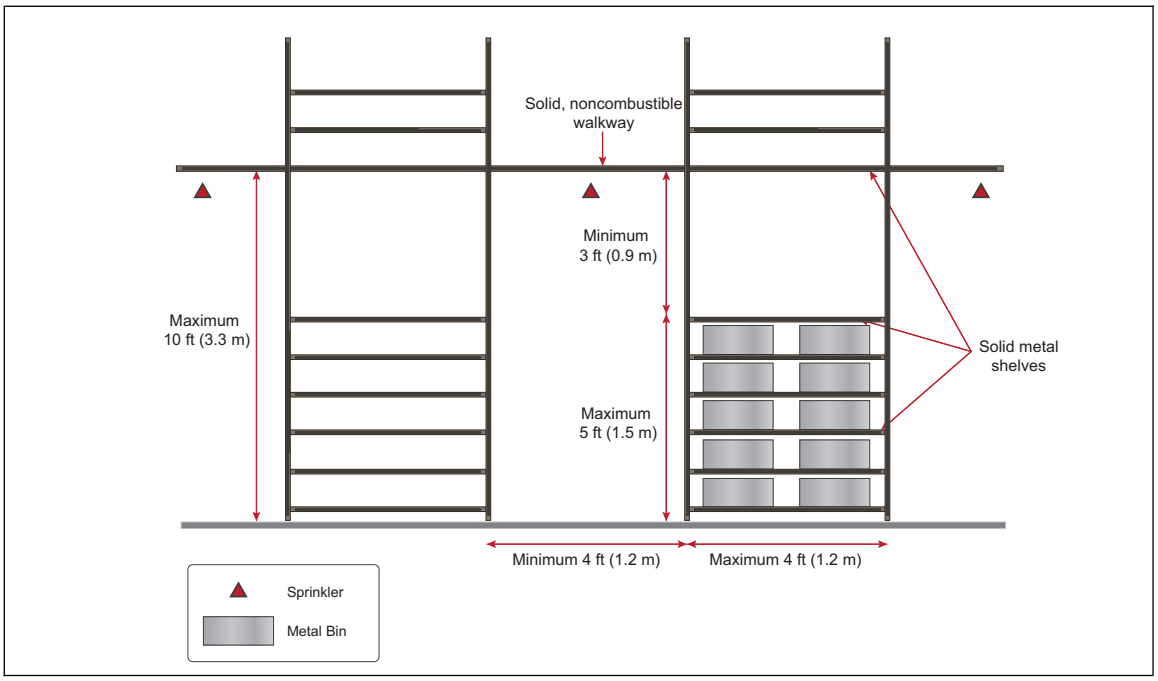


Fig. 2.4.6.6-1 Manual picking station arrangement: elevation view

2.4.6.6.7 Provide minimum 4 ft (1.2 m) wide aisles.

2.4.6.6.8 Limit rack depth to maximum 4 ft (1.2 m).

2.4.6.6.9 Limit the aerosol product storage to a maximum height of 5 ft (1.5 m).

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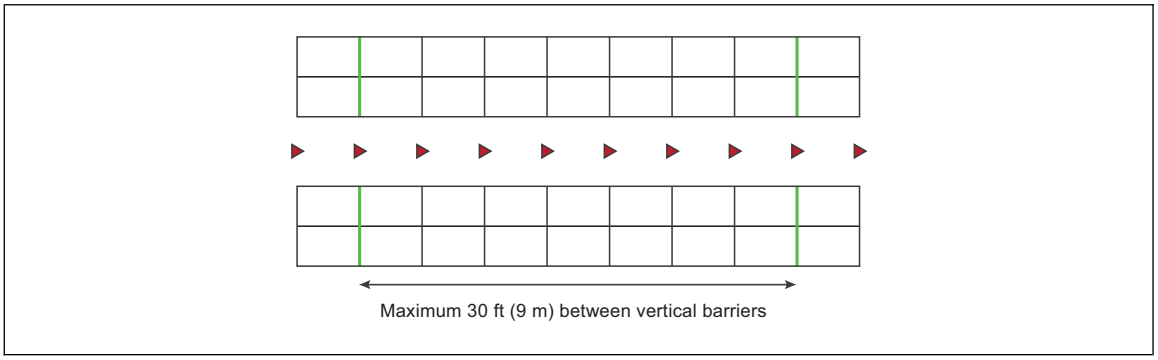


Fig. 2.4.6.6-2 Manual picking station arrangement: plan view

2.4.6.6.10 Provide a minimum clearance of 3 ft (0.9 m) between the top level of storage and the underside of the walkway.

2.4.6.7 Provide automatic sprinklers installed below each walkway where aerosol products are stored as follows and as shown in Figure 2.4.6.7-1 and Figure 2.4.6.7-2:

2.4.6.7.1 Install minimum K8 (K115), nominal 160°F (70°C) rated, quick response (QR) sprinklers.

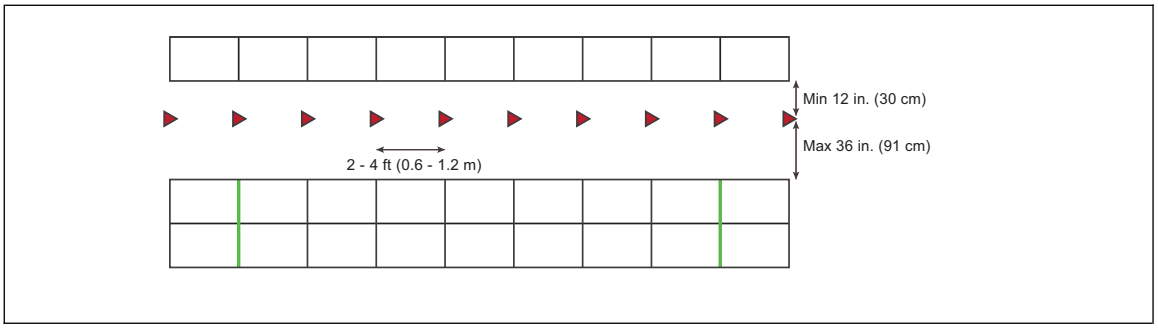


Fig. 2.4.6.7-1 Sprinkler locations for manual picking station: one line of sprinklers

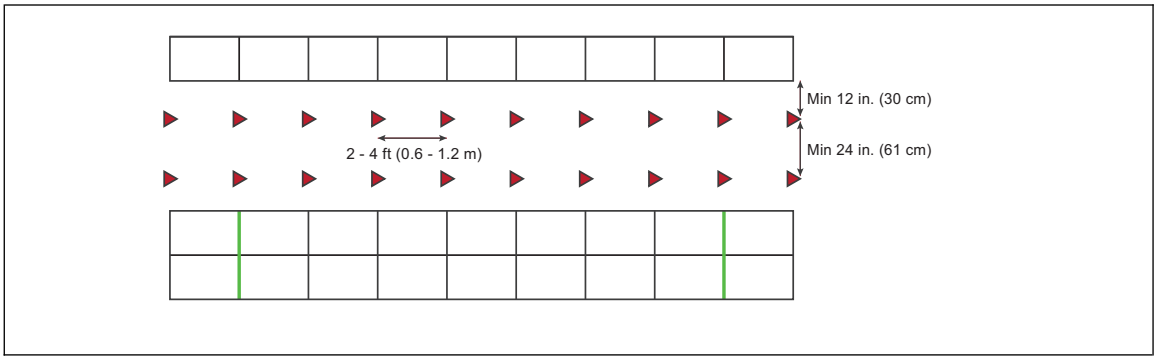


Fig. 2.4.6.7-2 Sprinkler locations for manual picking station: two lines of sprinklers

2.4.6.7.2 Design the sprinklers to provide a minimum flow of 30 gpm (114 L/min) out of the hydraulically most remote sixteen (16) sprinklers (eight sprinklers in two adjacent aisles).

2.4.6.7.3 The ceiling sprinkler demand and the in-rack sprinkler demand do not need to be balanced at the point of connection.

2.4.6.7.4 Determine the number of sprinklers lines based on the aisle width as follows:

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A. For aisles less than or equal to 6 ft (1.8 m) wide, install one line of sprinklers.

B. For aisles greater than 6 ft (1.8 m) wide, install two lines of sprinklers.

2.4.6.7.4.1 Locate sprinklers a minimum 12 in. (30 m) and maximum 36 in. (91 cm) from storage.

2.4.6.7.4.2 Where two lines of sprinklers are installed, provide a minimum 2 ft (61 cm) spacing between lines.

2.4.6.7.5 Install sprinklers at a minimum 2 ft (0.6 m) to maximum 4 ft (1.2 m) spacing.

2.4.6.7.6 Install sprinklers at maximum 13 in. (33 cm) below the walkway.

2.4.6.8 Where open-grids are required in the walkways for smoke ventilation, do the following:

A. Limit the size of the open-grid to 4 by 4 ft (1.2 by 1.2 m).

B. Remove storage within 2 ft (0.6 m) horizontally in all directions from the perimeter of the open-grid. Remove all storage within the footprint, regardless of vertical height.

2.4.6.9 Provide a 250 gpm (950 L/min) hose stream allowance.

2.4.6.10 Provide a water supply that can deliver the total sprinkler and hose stream demand for a duration of at least one hour.

2.5 Training

2.5.1 Train facility personnel in accordance with Data Sheet 7-29, *Ignitable Liquid Storage in Portable Containers*.

2.5.1.1 Instruct and train operating employees and members of the Emergency Response Team in the hazards of aerosol products and butane and propane containers, and in the emergency procedures to follow in the event of an accident.

2.5.1.2 Alert the public fire service to the hazards and to the fire protection provided.

2.6 Human Factor

2.6.1 Establish an emergency response plan in accordance with Data Sheet 7-29, *Ignitable Liquid Storage in Portable Containers.*

2.7 Ignition Source Control

2.7.1 Control ignition sources in accordance with Data Sheet 7-29, *Ignitable Liquid Storage in Portable Containers.*

3.0 SUPPORT FOR RECOMMENDATIONS

3.1 General

The typical aerosol container is a small, welded-joint, high-strength container (design pressures are as high as 240 to 400 psi [16.5 to 27.5 bar]) used to package a wide variety of consumer, industrial, and pharmaceutical products. A partial list of products includes air fresheners, starches, cleaners, shaving creams, furniture polishes, hair sprays, deodorants, spot removers, insecticides, lubricants, engine degreasers, and paints. Aerosol cans have capacities up to one (1) qt. (1 L), containing up to 16 oz (475 ml) of liquid.

Propellants include propane and butane, which are highly flammable, and other gases such as nitrogen, carbon dioxide, and nitrous oxide. Although nitrous oxide is a stable nonflammable gas, it is an oxidizer. Nonflammable chlorofluorocarbons have been eliminated in the United States for almost all uses in compliance with federal regulations and have been replaced with mixtures of propane and butane. Propellants in aerosol containers are 0.5% to more than 90% of the weight of the contents.

Aerosol products stored in metal containers have been grouped into Levels 1, 2, and 3. Level 1 Aerosol products represent the lowest fire hazard. Level 3 Aerosol products represents the highest fire hazard.

Level 1 Aerosol products include shaving cream, spray starch, window cleaner, alkaline oven cleaner, rug shampoo, some air fresheners, and some insecticides. The storage hazard of Level 1 Aerosol products is about the same as ordinary combustible goods in cartons. Storage should be arranged and protected accordingly.

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When a Level 1 Aerosol product can fails, the nonflammable product has a quenching effect on the flammable contents. Some products have very small quantities of flammable product. These products will have an overall chemical heat of combustion that is low.

Level 2 Aerosol products include many personal care products such as deodorant (except for oil-based antiperspirants), hair spray, antiseptic, and anesthetic. Other products include some furniture polishes and windshield deicers.

Level 3 Aerosol products include many automotive products (engine and carburetor cleaner, undercoat), home products (some wood polishes), paint and lacquer, lubricants, some insecticides, and oil-based antiperspirants.

A separate aerosol classification has been created for cooking sprays stored in metal containers. Historically, cooking sprays were classified as Level 1 Aerosols due to the use of high flash point vegetable oils in the products. However, based on full-scale fire testing, Aerosol Cooking Spray products have been shown to represent a fire hazard somewhere between a Level 1 Aerosol product and a Level 2 Aerosol product.

The use of plastic containers as a packaging method is a recent development in the aerosol industry. Recent testing has indicated that the fire hazard increases when the aerosols are stored in plastic containers. As such, aerosols in plastic containers cannot follow the same classification scheme (i.e., Levels 1, 2, and 3) as aerosols in metal containers.

3.2 Aerosol Products in Metal Containers: Classification by Chemical Heat of Combustion

The classification of aerosol products is critical to providing adequate protection. Test data indicates the overall fire hazard of an aerosol product in a metal container is a function of the chemical heat of combustion. The chemical heat of combustion is the product of the theoretical heat of combustion and a combustion efficiency. Typical chemical heats of combustion are provided in Table D.1. A typical combustion efficiency is 95%. Research conducted at FM correlated the chemical heat of combustion with results of various 12-pallet tests to provide a classification methodology based exclusively on chemical heat of combustion. Figure 2.1.1.1 in this data sheet is based on this methodology.

Some aerosol cans are labeled ″Flammable″ or ″Extremely Flammable″ in accordance with the Federal Hazardous Substances Act, but these designations have no relation to the classification of the aerosol product. The test for determining the label involves spraying an aerosol product can toward an ignition source and measuring the flame extension. This test will not predict the classification of the aerosol product.

Solids (e.g., powders), nonflammable gases (e.g., carbon dioxide), and nonignitable liquids (e.g., water, liquids without a fire point) are considered inert.

3.3 Fire Hazard

The initial aerosol product storage fire is driven by the packaging. However, once the aerosol products become involved, the fire severity increases significantly. As an aerosol can is heated, the interior pressure increases until the can ruptures. The rocketing can allows the fire to spread and impedes firefighting efforts. Alternatively, the aerosol product may fail at the valve, allowing the contents to leak and creating an equally challenging pool fire scenario. It is not possible to differentiate between aerosol products that vent and those that rupture. For this reason, this standard accounts for both failure modes, and the proper segregation and sprinkler protection of aerosol product storage is critical.

Plastic aerosol product storage fire hazards are also driven by the packaging. In this case, the plastic bottle will fail quickly when exposed to fire and release the liquid content plus the propellant. Unpressurized, the plastic bottle and ignitable liquid content produces a known severe fire hazard. The addition of a flammable propellant to the liquid-bottle combination produces a fire hazard that has not been fully quantified but will at least be as severe as the ignitable liquid-plastic bottle combination and likely more severe.

3.3.1 Fire Protection

3.3.1.1 Level 1 Aerosol Products

Fire testing on Level 1 Aerosol products indicated they could be adequately protected in accordance with the criteria in Data Sheet 8-9, *Storage of Class 1, 2, 3, 4 and Plastic Commodities.*

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3.3.1.2 Rack Storage vs. Palletized or Solid Pile Storage

Initial fire testing revealed that palletized storage of Level 2 Aerosol products and Level 3 Aerosol products in excess of one pallet high could not be protected using standard-response sprinklers, even with a 0.6 gpm/ft^2 (24 mm/min) density. Palletized storage of aerosol products protected in this manner should therefore be located in a cutoff room. The use of a chain link fence is not appropriate, as the level of fire control is marginal, resulting in an exposure to commodities stored beyond the chain link fence.

Subsequent testing demonstrated that palletized storage of aerosol products exceeding one pallet high could be protected using a K11.2 (K161), standard-response, ordinary temperature-rated, upright sprinkler. Similarly, adequate protection can be achieved for this storage configuration using quick-response sprinklers. These protection options are provided in Tables 2.4.2.2 and 2.4.2.3 of this data sheet.

These early fire test programs revealed that the key to providing adequate protection for aerosol products is to provide prompt cooling for aerosol products exposed to fire. Therefore, even though adequate fire protection was established for palletized and solid pile storage, the storage of aerosol products in racks is preferable, as in-rack sprinklers can provide water to quickly cool the aerosol products. Further, fire tests demonstrated that the used of face and flue in-rack sprinklers provided better protection than tests using in-rack sprinklers in the longitudinal flue space only. Fire protection options for the rack storage of Level 2 Aerosol products and Level 3 Aerosol products are provided in Tables 2.4.2.4 through 2.4.2.7 of this data sheet.

3.3.1.3 Cartoned vs. Uncartoned Storage

Cartoned storage of aerosol products includes cans that are packaged in at least a single layer of corrugated cardboard, where the cardboard covers at least the bottom, top, and two complete sides of the unit. The remaining two sides are at least 80% covered with corrugated cardboard. Uncartoned storage of aerosol products is any arrangement that does not meet the definition of cartoned storage, such as aerosol product arranged on slip sheets or trays, or stacked on a pallet and shrink wrapped.

Cartoned aerosol products promote initial fire growth and sprinkler operation, providing sprinklers an opportunity to control a fire prior to involvement of the aerosol containers. The corrugated cardboard segregates the aerosol cans, and provides good insulation against heat when wet. Conversely, uncartoned aerosol products have slow fire growth, allowing the aerosol cans to be heated and become involved in the fire before sprinkler operation. Uncartoned storage provides no segregation or insulation of cans.

For these reasons, when properly protected, cartoned aerosol products represent a less severe fire hazard than uncartoned aerosol products. It is important to note that completely removing aerosol products from their combustible packaging and displaying them in mercantile locations is different than uncartoned storage. Mercantile locations have a large variety of aerosol products in storage and on display. Products on display in selling areas do not present an unusual fire hazard in sprinklered buildings if they are removed from their combustible packaging.

3.3.1.4 Mixed Commodities

It is not recommended that aerosol products be mixed with other commodities, such as ignitable liquid storage or unexpanded plastics, in the same storage array. Previous experience with mixed commodities has shown that test results are worse than for each commodity by itself. In the early stages of a fire, before can ruptures begin to increase in frequency, the exposure fire of the bottom tier to the tiers above is intermittent and is essentially a cardboard fire. Replacing the bottom tier or tiers with plastics is expected to create a more intense and prolonged fire exposure to the tiers of aerosol products above, with unknown results.

Section 2.3 of this data sheet outlines specific instances of where the storage of mixed commodities is tolerable.

3.3.1.5 Aerosol Products in Plastic Containers

The use of plastic containers as a packaging method will increase the fire hazard associated with the aerosol product. The aerosol industry in the US worked with FM to determine what types of aerosol products in plastic containers can be protected. The first step was confirming that aerosol products with non-flammable propellants and non-ignitable liquid content did not create an unexpected fire hazard. Testing has shown that these products can be protected with protection criteria for Class 3 commodities and have been labeled “Plastic Aerosol 1 products.”

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3.3.1.6 Automatic Storage and Retrieval Systems (ASRS)

Storing aerosol products in ASRS can increase fire risk because large quantities of product are often concentrated in a compact, high-density storage arrangement. During a fire, the pressurized containers may rupture or violently discharge, allowing flames to spread rapidly to adjacent products and multiple storage levels. The enclosed nature of many ASRS installations can also hinder fire suppression efforts and emergency response activities, increasing the potential for significant property damage and business interruption.

3.3.1.7 Manual Picking Stations

Manual picking stations used for order fulfillment are frequently organized into multi-level pick towers and mezzanine-supported structures designed to concentrate high volumes of small, individual products into a compact footprint. These systems rely on vertical shelving, carton flow racks, and bin storage arranged across multiple levels, allowing workers to manually retrieve items. Each level can be accessed via stairs, platforms, or guarded walkways. Such pick stations are commonly used in e-commerce and retail distribution and routinely handle mixed consumer goods, including beauty and personal care products, many of which contain aerosol products.

3.3.2 Segregation

Even a single pallet load of a Level 3 Aerosol product in a general-purpose warehouse (as they are usually protected) constitutes a potentially serious loss. The rocketing cans, regardless of contents, could severely hamper manual firefighting efforts, and thick, black smoke will quickly obscure visibility.

This data sheet recommends storing Level 2 Aerosol products and Level 3 Aerosol products in cutoff rooms having one-hour fire resistance, which is in accordance with FM basic philosophies of confinement for low flash point ignitable liquids. In lieu of a cutoff room, FM has concluded the provision of a chain link fence enclosure can be accepted under certain conditions, provided the rack storage is protected with longitudinal flue and face sprinklers, and ceiling protection is provided.

As described in Section 3.3.1.2, the use of a chain link fence enclosure is not acceptable for palletized or solid pile Level 3 Aerosol products unless quick-response sprinklers are provided at the ceiling. With standard-response sprinklers, the degree of control is not as pronounced as it is with quick-response ceiling sprinklers or with in-rack sprinklers. If a chain link fence was used with standard-response ceiling sprinklers, there would be a greater exposure to the commodities stored beyond the chain link fence. Furthermore, the heat release from an aerosol product storage fire is significant. If a chain link fence was used with standard-response ceiling sprinklers, additional sprinklers would be expected to operate and potentially deplete the water supply. Fire testing demonstrated that an area protected with standard-response sprinklers produced enough heat to operate sprinklers installed in an area of the test building 50 ft (15 m) away.

4.0 REFERENCES

4.1 FM

Data Sheet 1-12, *Ceilings and Concealed Spaces*
Data Sheet 1-21, *Fire Resistance of Building Assemblies*
Data Sheet 1-29, *Roof Deck Securement and Above-Deck Roof Components*
Data Sheet 2-0, *Installation Guidelines for Automatic Sprinklers*
Data Sheet 5-48, *Automatic Fire Detection*
Data Sheet 7-29, *Ignitable Liquid Storage in Portable Containers*
Data Sheet 8-9, *Storage of Class 1, 2, 3, 4 and Plastic Commodities*
Data Sheet 8-34, *Protection for Automatic Storage and Retrieval Systems (ASRS)*

4.2 Others

Green, Don W. and Robert H. Perry, eds. *Perry's Chemical Engineering Handbook.* McGraw-Hill. 2008.

National Fire Protection Association (NFPA). *Code for Manufacture and Storage of Aerosol Products.* NFPA 30B.

Society of Fire Protection Engineers (SFPE). *SFPE Handbook of Fire Protection Engineering.* 4th edition. National Fire Protection Association (NFPA). 2008.

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APPENDIX A GLOSSARY OF TERMS

Aerosol product: A combination of a container, a propellant, and a material that is dispensed.

Aerosol container: A metal can or plastic container up to a maximum size of 33.8 oz (1000 ml).

Aerosol propellant: The liquefied or compressed gas that expels the content from and aerosol container with the valve is actuated. The propellant may be flammable for non-flammable gas.

Aerosol product packaging - cartoned: Aerosol cans packaged in at least a single layer of corrugated cardboard. The cardboard must cover at least the bottom, top, and two complete sides of the unit. The other two sides must be at least 80% covered.

Aerosol product packaging - uncartoned: Aerosol cans arranged on slip sheets or trays that are stacked on a pallet and shrink wrapped, and packaging that does not meet the definition of cartoned.

Base product (concentrate): The contents of an aerosol container, excluding the propellant.

Cooking spray product: A product designed to deliver a vegetable oil, solid, or nonignitable liquid to reduce sticking on cooking and baking surfaces, or to be applied to food, or both. These products may be in metal or plastic containers.

Emulsion: An emulsion is a stable mixture of two or more immiscible liquids held in suspension by small percentages of substances called emulsifiers.

FM Approved: Products and services that have satisfied the criteria for FM Approval. Refer to the *Approval Guide,* an online resource of FM Approvals, for a complete listing of products and services that are FM Approved.

Ignitable liquid: Any liquid or liquid mixture that is capable of fueling a fire, including flammable liquids, combustible liquids, inflammable liquids, or any other term for a liquid that will burn. An ignitable liquid is one that has a fire point.

Manual Picking Stations: Fixed storage areas where individual items are manually selected from defined locations to fulfill customer orders. They typically comprise multi-level racking or shelving on mezzanines or with walkways between storage structures.

Prefabricated ignitable liquid storage building (PILSB): A structure designed to provide a safe, secure storage area with secondary containment for chemicals and hazardous waste materials. They are designed for the indoor and outdoor storage of hazards such as aerosols and ignitable liquids. FM Approved buildings are normally of noncombustible construction, and some are of fire-rated construction. Additional details are provided in the *Approval Guide.*

Water-miscible liquid: A liquid that mixes in all proportions with water. When water-miscible ignitable liquids are mixed with water, a homogeneous solution is formed. The flash point, fire point, heat of combustion, and heat release rate of the solution will be different from the pure ignitable liquid. The flash point and fire point of the solution will increase as the water concentration increases. At a certain water concentration (which varies for different ignitable liquids), the fire point will no longer exist and the solution will no longer present a fire hazard (e.g., 15% ethyl alcohol in water, 15% acetone in water).

APPENDIX B DOCUMENT REVISION HISTORY

The purpose of this appendix is to capture the changes that were made to this document each time it was published. Please note that section numbers refer specifically to those in the version published on the date shown (i.e., the section numbers are not always the same from version to version).

October 2026. Interim revision. Changes include the following:

A. Added guidance for storage of aerosol products in manual picking stations. This guidance is limited to specific aerosol products that are stored in metal bins on solid shelves.

B. Updated Figure E.2-4 to include a gap in the barrier. This was omitted in the previous figure. There are no changes to the protection guidance.

July 2024. Interim revision. Added guidance on the storage of aerosol products in automatic storage and retrieval systems (ASRS).

July 2022. Interim Revision. The following major changes have been made:

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A. Provided additional criteria for classification of Plastic Aerosol 3 products, including those that contain 100% hydrocarbon and a maximum liquid volume of 0.3 oz (9 ml)

B. Provided criteria for classification of Plastic Aerosol 2 products and Plastic Aerosol Cooking Spray products

C. Provided protection guidance for Plastic Aerosol 2 products and Plastic Aerosol Cooking Spray products

D. Clarified the location of face sprinklers for Scheme A protection

E. Added extended coverage sprinklers as a protection option

F. Corrected protection criteria for rack storage of uncartoned Level 3 Aerosol Products in Table 2.4.2.7.

G. Added limitations on the use of the Method of Testing for Sustained Combustibility for determining combustibility of the base liquid for Plastic Aerosol 1 products and Plastic Aerosol 3 products

H. Renumbered tables and figures based on the section number

February 2020. Interim revision. A small modification was made to Section E.2.4 to include the recommended design flow of 57 gpm (220 L/min), which was incorrectly omitted from the January 2020 revision.

January 2020. Interim revision. Fire Protection Scheme A (Section E.2) was updated to cover both metal and plastic aerosol products.

January 2019. Interim revision. Incorporated guidance for plastic aerosol 3 products. The following changes were made:

A. Added a definition of plastic aerosol 3 products.

B. Added guidance on construction and location for plastic aerosol 3 products (Table 3).

C. Created a new table with protection guidance for plastic aerosol 3 products (Table 12).

D. Added guidance on mercantile storage of plastic aerosol 3 products.

April 2016. Interim revision. Editorial changes were made.

January 2016. The following major changes have been made:

A. Replaced references to “flammable” and “combustible” liquids with “ignitable” liquids throughout the document.

B. Reorganized the document to provide a consistent format with other data sheets.

C. Removed guidance on the storage of small liquefied petroleum gas (LPG) containers, such as butane cigarette lighters (0.2 oz [6 ml]).

D. Provided guidance for protecting propane cylinders up to 17 oz (500 ml) [nominal 1 lb (450 g) cylinders].

E. Deleted a recommendation to consider liquids with flash points higher than 500°F (260°C), such as some vegetable cooking oils, as inert materials when classifying aerosol products. New guidance has been provided for aerosol cooking spray products.

F. Added information on the storage and fire protection of aerosol products in plastic containers.

G. Updated Table 3, Aerosol Product Storage Location Options, to include new sprinkler terminology, aerosol cooking spray products and aerosol products in plastic containers.

H. Provided additional details on the proper storage of aerosol products protected using Scheme A.

I. Provided additional details on the appropriate design of cutoff rooms, including roof construction.

J. Added a figure to demonstrate the appropriate design of a “labyrinth” or “tunnel” approach to protect openings in fenced aerosol product areas.

K. Provided recommendations on the storage of small quantities of aerosol products in FM Approved ignitable liquid storage cabinets and buildings.

L. Clarified the recommendations related to shipping and receiving areas.

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M. Added guidance on the mixing of aerosol products and ignitable liquid storage.

N. Provided additional general information on the design of sprinkler systems, including guidance on spacing and sprinkler system types.

O. Changed all ceiling sprinkler recommendations to provide a K11.2 (K161) or larger sprinkler in accordance with the requirements of NFPA 13, *Standard for the Installation of Sprinkler Systems.*

P. Renumbered, edited, and reformatted all fire protection recommendations to improve consistency, clarity, and alignment with the pressure/number of sprinklers approach used in Data Sheet 8-9, *Storage of Class 1, 2, 3, 4, and Plastic Commodities.*

Q. Clarified fire protection recommendations for mercantile locations.

R. Reorganized Section 3, Support for Recommendations, for improved clarity.

S. The section on fire test data has been consolidated.

January 2012. Terminology related to ignitable liquids has been revised to provide increased clarity and consistency with regard to FM Global's loss prevention recommendations for ignitable liquid hazards.

May 2003. Minor editorial changes were made for this revision.

January 2003. The following changes were made for this revision:

1. Added new protection criteria for uncartoned aerosol storage.

2. Added new protection criteria for Suppression Mode sprinklers.

3. Revised all of the protection tables into a consistent format and provided figures for determining in-rack sprinkler layout.

4. Revised the text to be consistent with the new tables.

5. Eliminated allowance for unrestrained Level 2 aerosol storage to ensure a consistent application of aerosol protection.

6. Revised protection criteria for aerosol picking racks.

7. Revised protection criteria for aerosol storage in automatic storage and retrieval warehouses.

September 2000. This revision of the document has been modified to provide a consistent format.

January 1998. Minor technical revision (uncartoned aerosol information added).

May 1983. Full technical revision.

APPENDIX C NFPA STANDARD

The fire protection recommendations in this data sheet are nearly identical to those provided in NFPA 30B, *Code for the Manufacture and Storage of Aerosol Products,* 2019 Edition. The main differences are as follows:

A. NFPA 30B allows unlimited roof heights for the rack storage of cartoned Level 2 Aerosol products and Level 3 Aerosol products without the use of barriers (i.e., without the use of Scheme A protection).

B. NFPA 30B allows limited quantities of aerosol products to be stored in various locations without protecting them based on their classification as aerosol products. For example, up to 1000 lb (454kg) of Level 2 Aerosol products, 500 lb (227 kg) of Level 3 Aerosol products, and 500 lb (227 kg) of Plastic Aerosol 3 products are permitted in occupancies other than warehouses or mercantile locations without any special fireprotection. Also, up to 2500 lb (1135 kg) of Level 2 Aerosol products, 1000 lb (454 kg) of Level 3 Aerosol products, and 1000 lb (454 kg) of Plastic Aerosol 3 products are permitted in general purpose warehouses regardless of protection level provided.

C. Subject to the approval of the AHJ NFPA 30B allows up to 12,000 lb (5450 kg) of solid pile or palletized storage of Level 2 Aerosol products and/or Level 3 Aerosols products in a general purpose warehouse without any separation such as a chain link fence. Similarly, NFPA 30B allows up to 24,000 lb (10,900 kg) of rack storage of Level 2 Aerosol products, Level 3 Aerosol products, and/or Plastic Aerosol 3 products in a general purpose warehouse without any separation.

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D. Where aerosol storage is segregated from other commodities by fire walls or a chain link fence, NFPA 30B limits the floor area of the segregated aerosol storage to a percentage of the total floor area of the warehouse. Data Sheet 7-31 does not limit the floor area of aerosols in this manner.

E. NFPA 30B limits the density of aerosol storage in mercantile occupancies (i.e., product weight per unit area). Data Sheet 7-31 does not include this limitation.

F. NFPA 30B allows the storage of aerosols in plastic containers up to 4 oz (118 ml), regardless of the container contents. There is no such allowance in Data Sheet 7-31.

APPENDIX D AEROSOL PRODUCTS CLASSIFICATION

D.1 Chemical Heat of Combustion Data

The following table was generated by FM at the request of aerosol product manufacturers. It is not considered an all-inclusive table, but does contain many commonly used materials. The table will be updated as additional materials are tested. The table footnotes may be used as an additional source of information.

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Table D.1. Chemical Heat of Combustion Data

CAS#	*Material Name*	*Theoretical Heat of combustion (Note 1) ΔH_c (kJ/g)*	*Combustion Efficiency (Note 2) χ_{ch}^2*	*Chemical Heat of Combustion ΔH_{ch} (kJ/g)*
75-37-6	1,1-Diflouroethane (HFC 152a)	18.1	0.35 (Note 3)	6.3
95-63-6	1,1,1-Trimethylbenzene (Pseudocumene)	41.0	0.67 (Note 3)	27.5
1717-00-6	1,1-Dichloro-1-Fluoroethane	8.4	0.35 (Note 3)	2.9
110-71-4	1,2-Dimethoxyethane	26.7 (Note 2)	0.97	25.9
75-68-3	1-Chloro-1,1-Diflouroethane (HCFC 142b)	9.3	0.35 (Note 3)	3.3
108-65-6	1-Methoxy-2-Propanol Acetate	32.2 (Note 2)	0.96	30.9
111-76-2	2-Butoxyethanol	30.8 (Note 2)	0.96	29.6
110-80-5	2-Ethoxyethanol	26.7 (Note 2)	0.97	25.9
111-15-9	2-Ethoxyethyl Acetate	32.2 (Note 2)	0.96	30.9
75-28-5	2-Methylpropane (Isobutane)	45.5	0.94	42.8
67-64-1	Acetone	28.6	0.97 (Note 3)	27.7
8052-42-4	Asphalt	30.2 (Note 4)	0.75	22.7
7727-43-7	Barium Sulfate	0.0		0.0
106-97-8	Butane	45.6	0.95 (Note 3)	43.3
85-68-7	Butyl Benzl Phthalate	37.1 (Note 2)	0.85	3.15
1317-65-3	Calcium Carbonate	0.0		0.0
124-38-9	Carbon Dioxide	0.0		0.0
1308-14-1	Chrominum Hydroxide	0.0		0.0
8001-30-7	Corn Oil	36.8 (Note 4)	0.96	35.3
5989-27-5	d-Limonene	45.2	0.88	39.8
123-42-2	Diacetone Alcohol	37.3 (Note 2)	0.94	35.1
112-34-5	Diethylene Glycol Methyl Ether	34.4 (Note 2)	0.96	33.0
115-10-6	Dimethyl Ether	28.8	0.92	26.5
34590-94-8	Dipropylene Glycol Methyl Ether	33.5 (Note 2)	0.96	32.2
64-17-15	Ethanol (95.6 Azeotrope)	25.6	0.92	23.6
64-17-15	Ethanol	26.8	0.92	24.7
763-69-9	Ethyl 3-Ethoxypropionate	33.3 (Note 2)	0.96	32.0
100-41-4	Ethylbenzene	40.9	0.71	29.0
107-21-1	Ethylene Glycol	16.9	0.97	16.4
111-55-7	Ethylene Glycol Diacetate	33.3 (Note 2)	0.96	32.0
107-41-5	Hexylene Glycol	29.7	0.96	28.5
1309-37-1	Iron Oxide	0.0		0.0
78-83-1	Isobutyl Alcohol	32.7	0.91	29.8
108-21-4	Isopropyl Acetate	26.0	0.98	25.5
67-63-0	Isopropyl Alcohol	30.1	0.91	27.4
142-91-6	Isopropyl Palmitate	38.8 (Note 2)	0.96	37.2
110-27-0	Isopropyl Myristate	38.2 (Note 2)	0.95	36.2
1332-58-7	Kaolin Clay (Aluminum Silicate Hydroxide)	0.0		0.0

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Table D.1. Chemical Heat of Combustion Data (continued)

CAS#	*Material Name*	*Theoretical Heat of combustion (Note 1) ΔH_c (kJ/g)*	*Combustion Efficiency (Note 2) χ_{ch}^2*	*Chemical Heat of Combustion ΔH_{ch} (kJ/g)*
8008-20-6	Kerosene (Kerosine)	46.0 (Note 4)	0.90 (Note 5)	41.4
	Liquids, Non-Contributory			0.0
	Liquids, Nonignitable			0.0
14807-96-6	Magnesium Silicate (Talc)	0.0		0.0
67-56-1	Methanol	20.0	0.95 (Note 3)	19.0
78-93-3	Methyl Ethyl Ketone	31.5	0.97 (Note 3)	30.6
563-80-4	Methyl Isopropyl Ketone	33.1	0.94	31.1
110-43-0	Methyl n-Amyl Ketone	37.2 (Note 2)	0.94	35.0
75-09-2	Methylene Chloride	6.0	0.35 (Note 3)	2.1
12001-26-2	Mica (Mica Silicate)	0.0		0.0
64742-47-8	Mineral Spirits (Petroleum Distillate)	44.8	0.92	41.2
8012-95-1	Mineral Oil	41.5 (Note 4)	0.76 (Note 5)	31.5
64742-88-7	Mineral Spirits (Petroleum Distillate)	44.8	0.92	41.2
134-62-3	N,N-Diethyl-m-Toluamide (Deet)	38.1 (Note 2)	0.74	28.2
123-86-4	n-Butyl Acetate	28.2	0.98	27.6
142-82-5	n-Heptane	44.6	0.92 (Note 3)	41.0
110-54-3	n-Hexane	44.7	0.92 (Note 3)	41.1
113-48-4	n-Octyl Bicyclopheptane Dicarboximide	38.0 (Note 2)	0.79	30.0
64742-48-9	Naphtha, VM&P (Petroleum Distillate)	44.8	0.92	41.2
8030-30-6	Naphtha (Petroleum Distillate)	44.8	0.92	41.2
8052-41-3	Naphtha (High Flash Point)	44.8	0.92	41.2
64742-95-6	Naphtha, VM&P (Petroleum Distillate)	44.8	0.92	41.2
64742-94-5	Naphtha, VM&P (Petroleum Distillate)	44.8	0.92	41.2
7727-37-9	Nitrogen	0.0		0.0
109-66-0	Pentane	45.0	0.93 (Note 2)	41.9
64741-65-7	Petroleum Distillate	44.8	0.92	41.2
51-03-6	Piperonyl Butoxide	37.2 (Note 2)	0.86	32.0
74-68-6	Propane	46.3	0.95 (Note 3)	44.0
57-55-6	Propylene Glycol	21.4	0.96	20.5
78-92-2	sec-Butyl Alcohol	32.9	0.91	39.9
	Silica (Crystalline)	0.0		0.0
7631-86-9	Silica, Amorphous Hydrated	0.0		0.0
	Solids, Non-Contributory			0.0
	Solids, Noncombustible	0.0		0.0
1338-39-2	Sorbitan Monolaurate	39.5 (Note 2)	0.96	37.9
26266-57-9	Sorbitan Monopalmitate	39.5 (Note 2)	0.96	37.9
16252-10-5	Tin Oxide	0.0		0.0

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Table D.1. Chemical Heat of Combustion Data (continued)

CAS#	Material Name	Theoretical Heat of combustion (Note 1) ΔH_c (kJ/g)	Combustion Efficiency (Note 2) χ_{ch}^2	Chemical Heat of Combustion ΔH_{ch} (kJ/g)
13463-67-7	Titanium Dioxide	0.0		0.0
108-88-3	Toluene	40.5	0.70	28.4
102-76-1	Triacetin	36.9	0.96	35.4
7732-18-5	Water	0.0		0.0
1330-20-7	Xylene	40.9	0.67 (Note 3)	27.4
1314-13-2	Zinc Oxide	0.0		0.0

Note 1. Except as noted, theoretical heat of complete combustion (net) was determined from heat of formation or heat of combustion data assuming all products in the vapor phase per the *CRC Handbook of Chemistry and Physics,* 73th ed., David R. Lide, ed., CRC Press, Boca Raton, Florida, 1992.

Note 2. Except as noted, chemical combustion efficiency was determined by correlations based on chemical structure as given in *Smoke Point Height and Fire Properties of Materials,* Tewarson, A., NTIS P889-141089, May 1988.

Note 3. Chemical combustion efficiency reported in ″Generation of Heat and Chemical Compounds in Fires,″ Tewarson, A, Chapter 1-13 in *SFPE Handbook of Fire Protection Engineering,* P. J. DiNenno, ed., 1st ed., National Fire Protection Association, Quincy, Massachusetts, 1988.

Note 4. Heat of complete combustion (net) as measured by oxygen bomb calorimetry described in *Test Method for Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeter,* ASTM D240-92.

Note 5. Chemical combustion efficiency measured under simulated fire conditions using the method described in ″Generation of Heat and Chemical Compounds in Fires,″ Tewarson, A, Chapter 1-13 in *SFPE Handbook of Fire Protection Engineering,* P. J. DiNenno, ed., 1st ed., National Fire Protection Association, Quincy, Massachusetts, 1988.

APPENDIX E IN-RACK SPRINKLER LAYOUTS AND FIRE PROTECTION SCHEMES

E.1 In-Rack Sprinkler Layouts

Figures E.1-1 through E.1-6 show in-rack sprinkler layouts.

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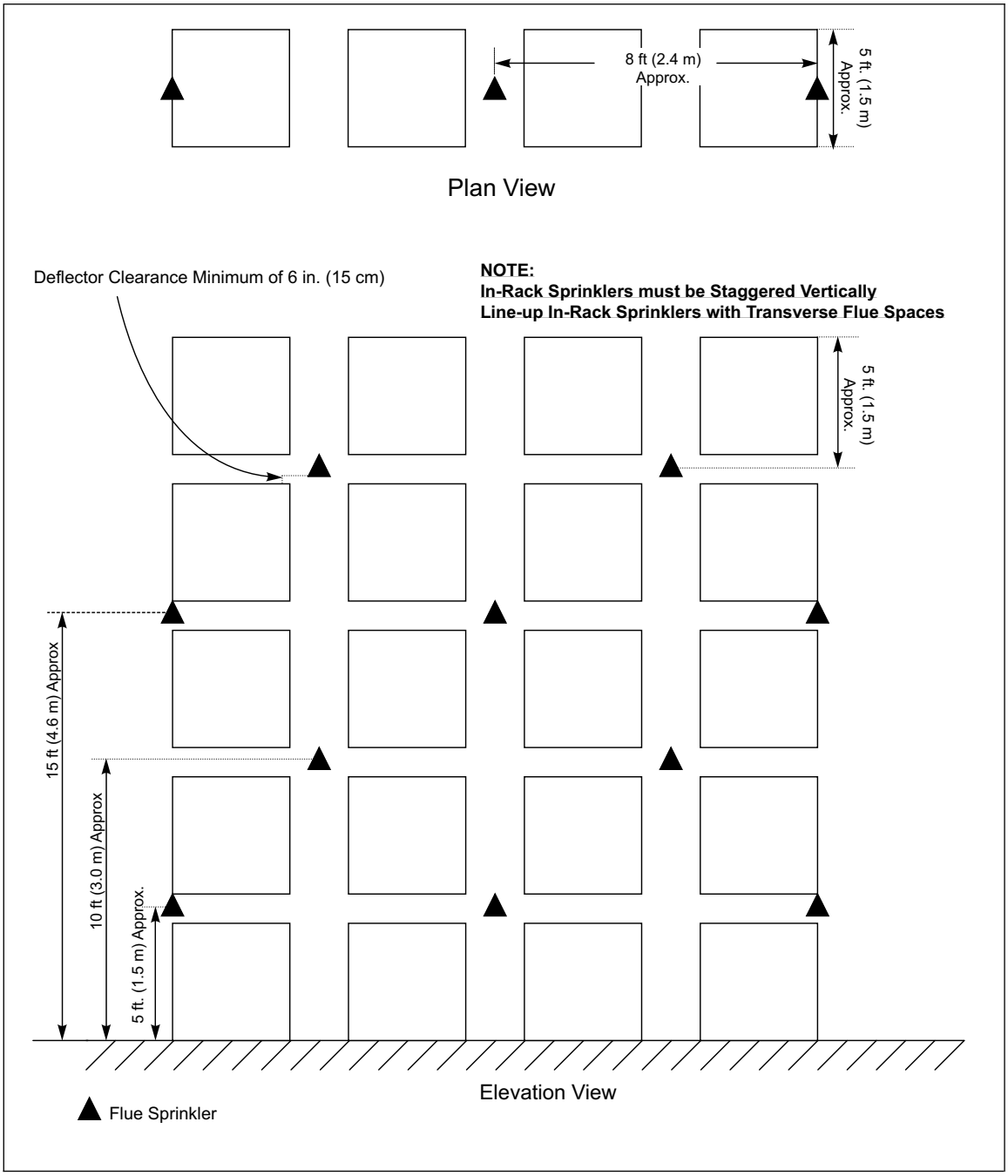


Fig. E.1-1a. Cartoned Level 2 Aerosol products and Level 3 Aerosol products – single row racks

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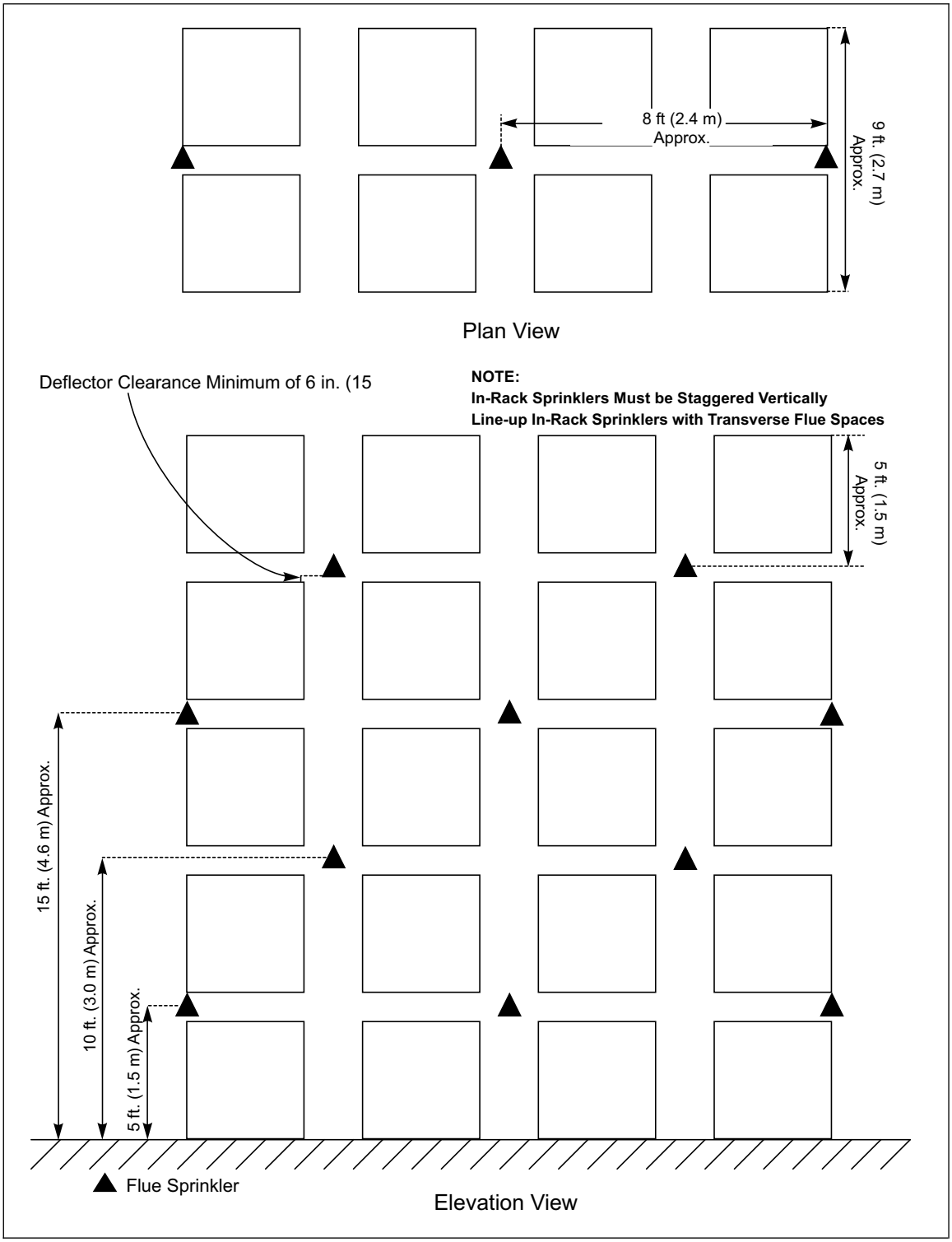


Fig. E.1-1b. Cartoned Level 2 Aerosol products and Level 3 Aerosol products – double row racks

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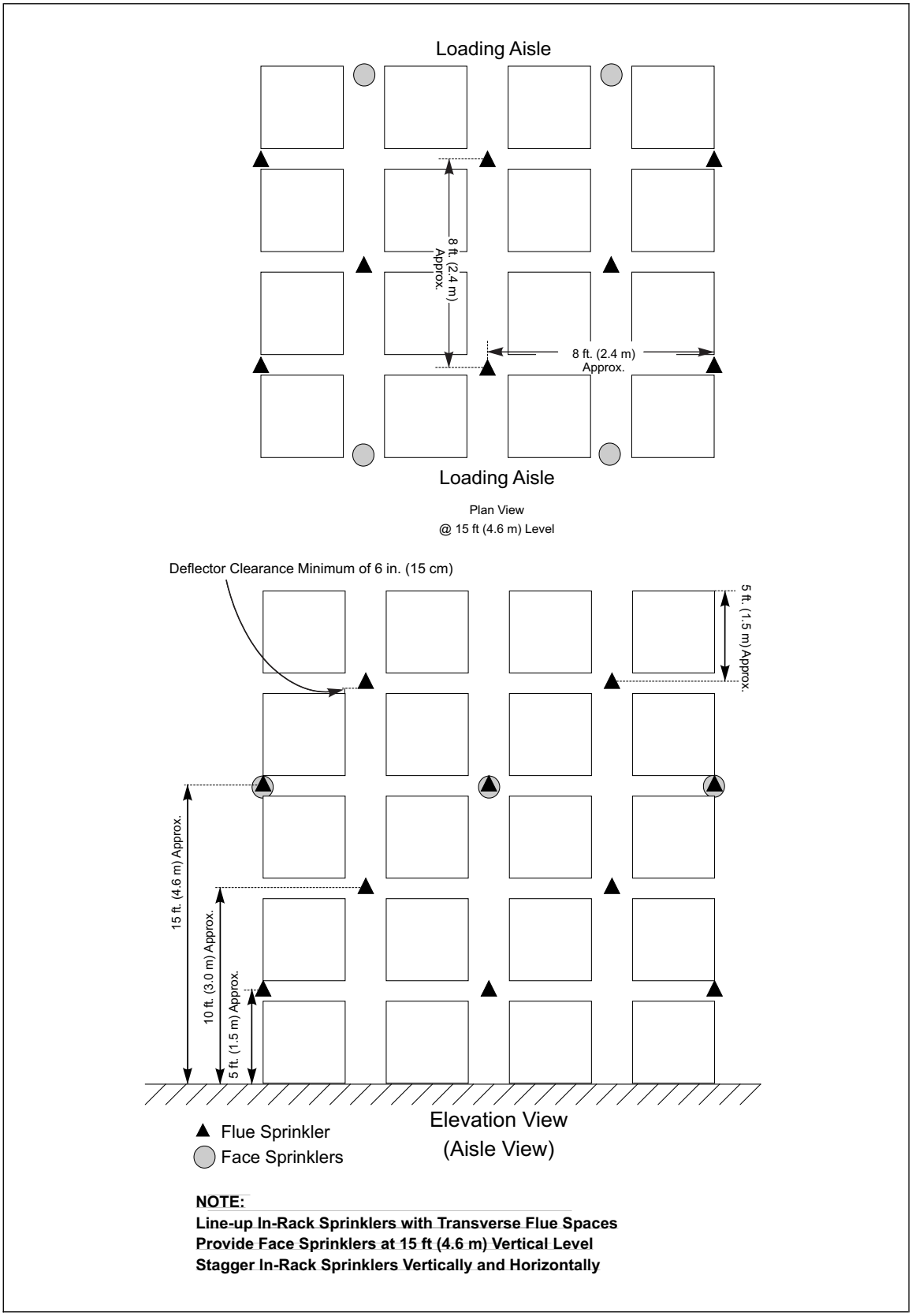


Fig. E.1-1c. Cartoned Level 2 Aerosol products and Level 3 Aerosol products – multiple row racks

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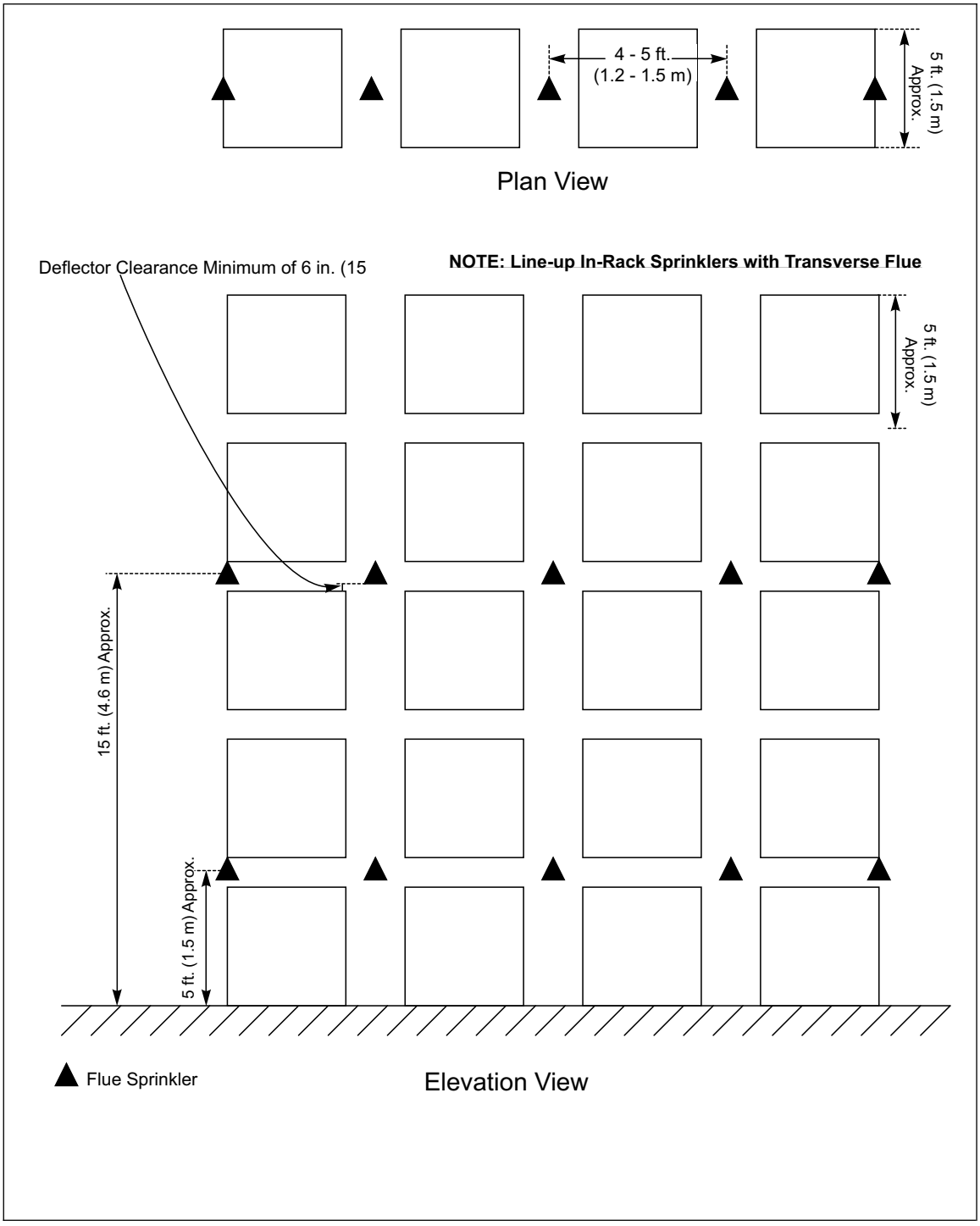


Fig. E.1-2a. Cartoned Level 3 Aerosol products — single row racks up to 25 ft (7.6 m) high storage in quick-response sprinkler protected building

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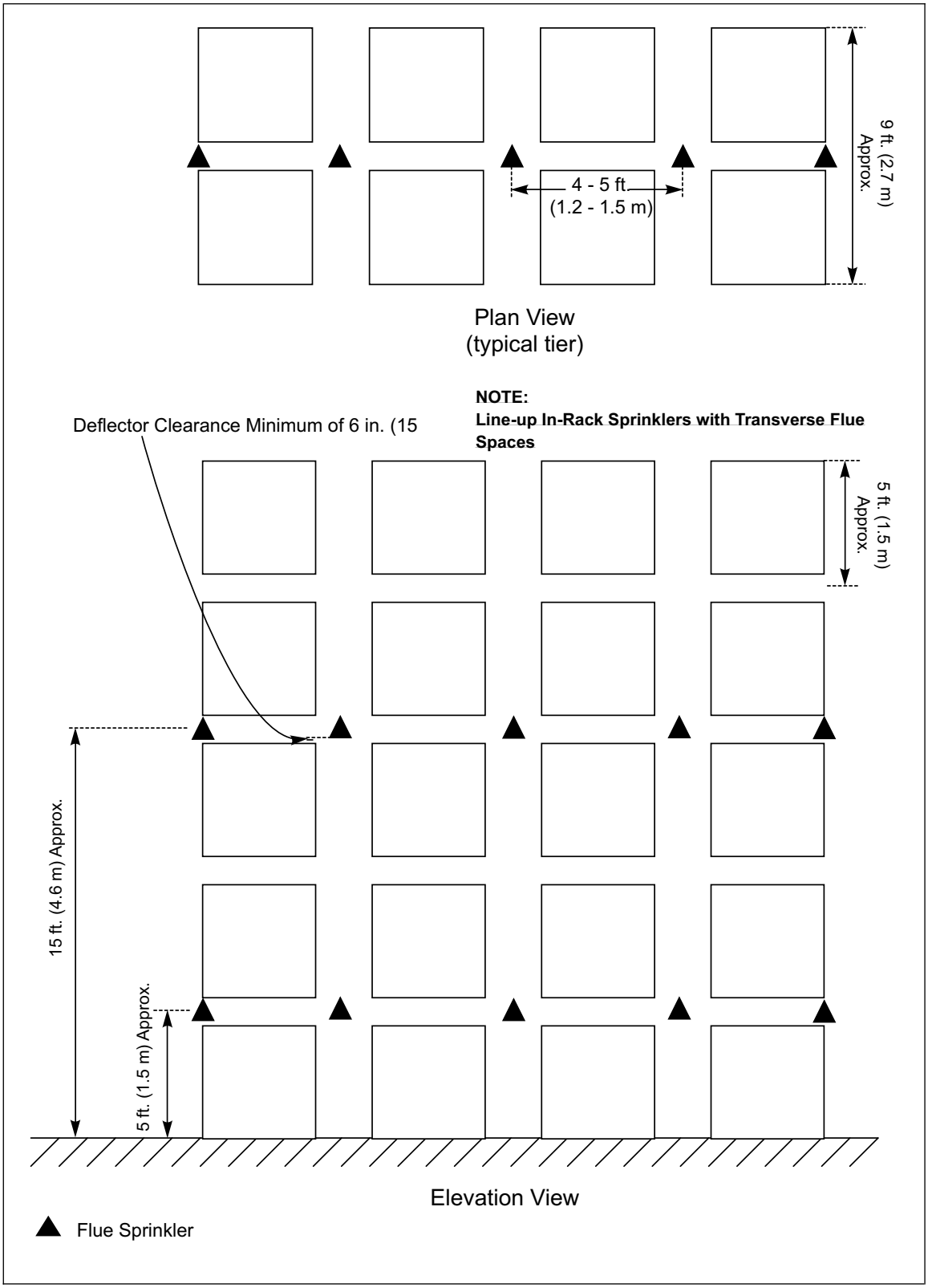


Fig. E.1-2b. Cartoned Level 3 Aerosol products — double row racks up to 25 ft (7.6 m) high storage in quick-response sprinkler protected building

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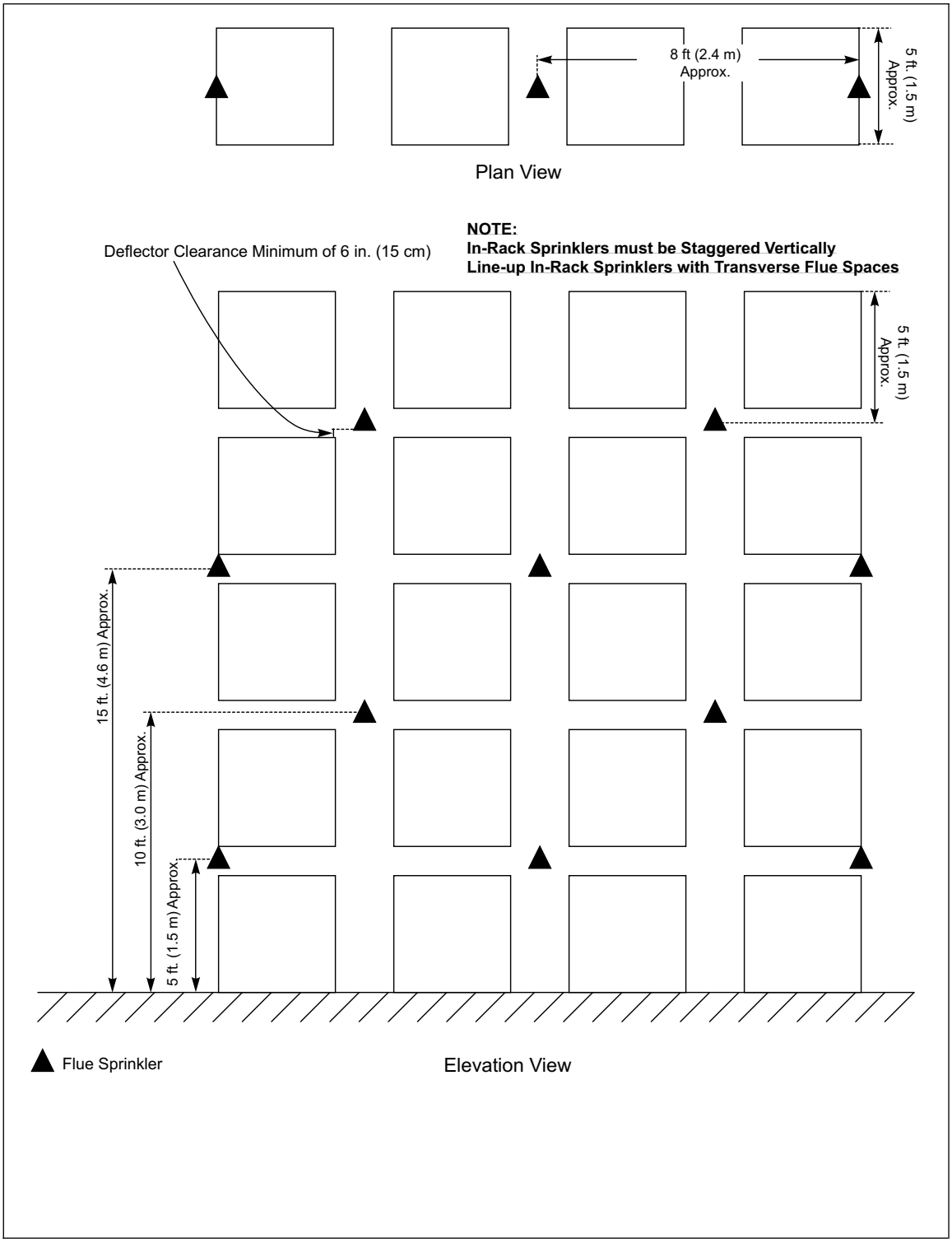


Fig. E.1-3a. Cartoned Level 3 Aerosol products – single row racks

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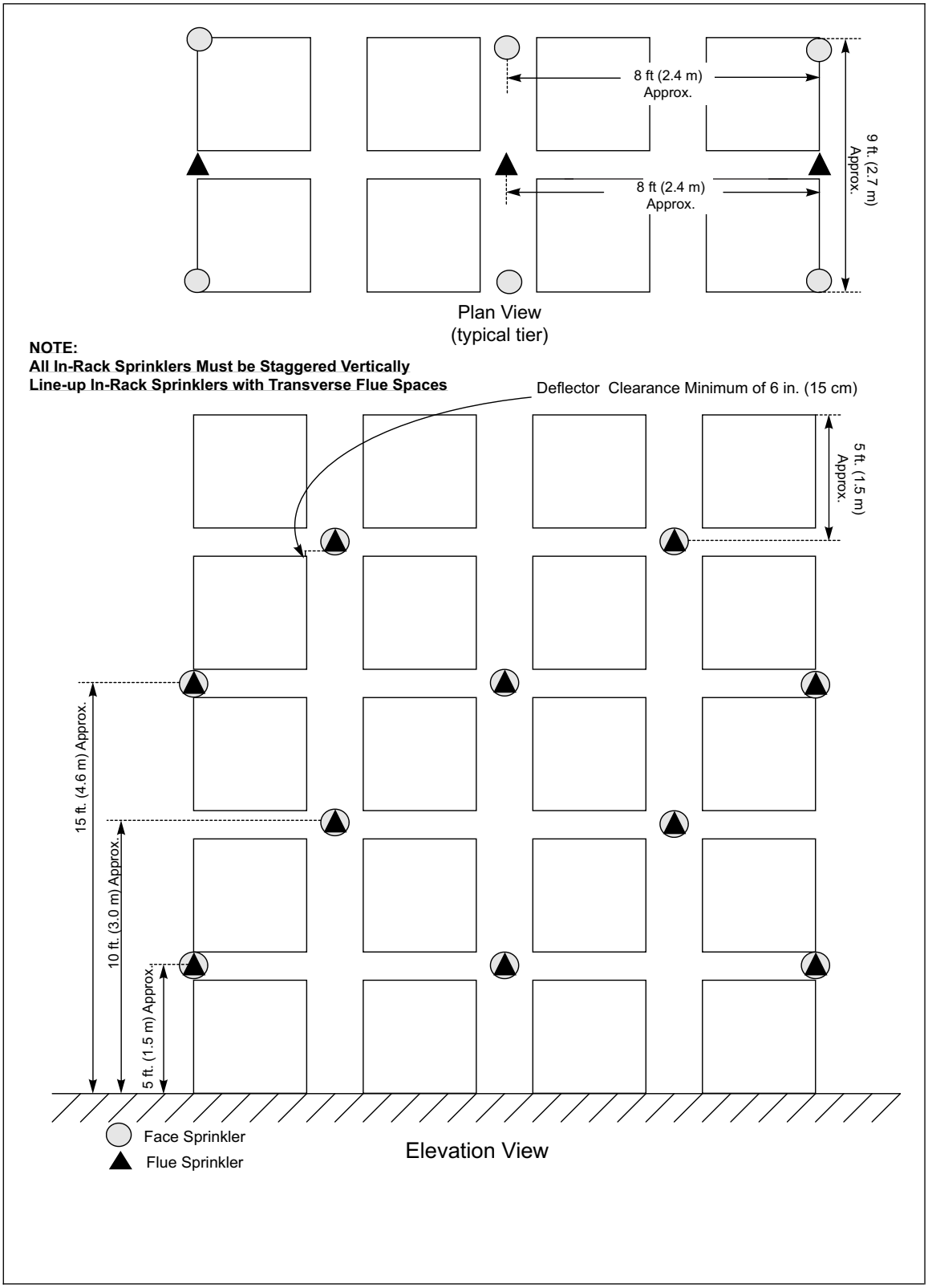
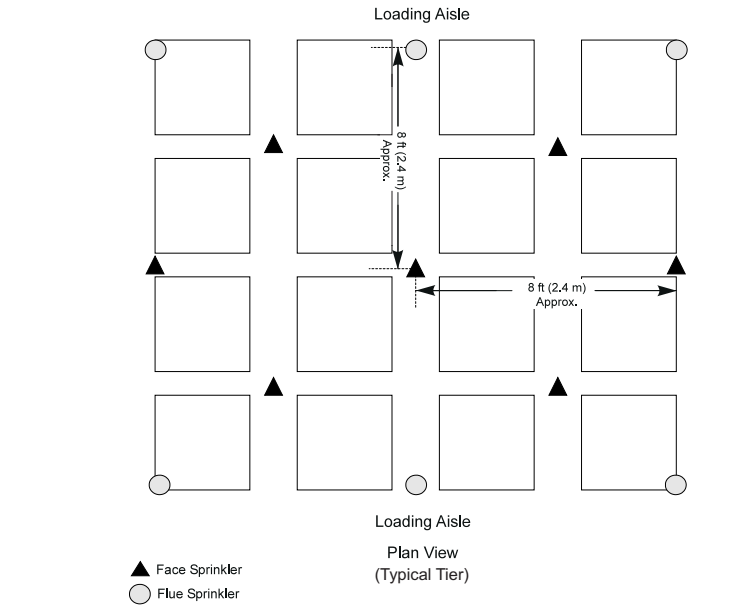


Fig. E.1-3b. Cartoned Level 3 Aerosol products – double row racks

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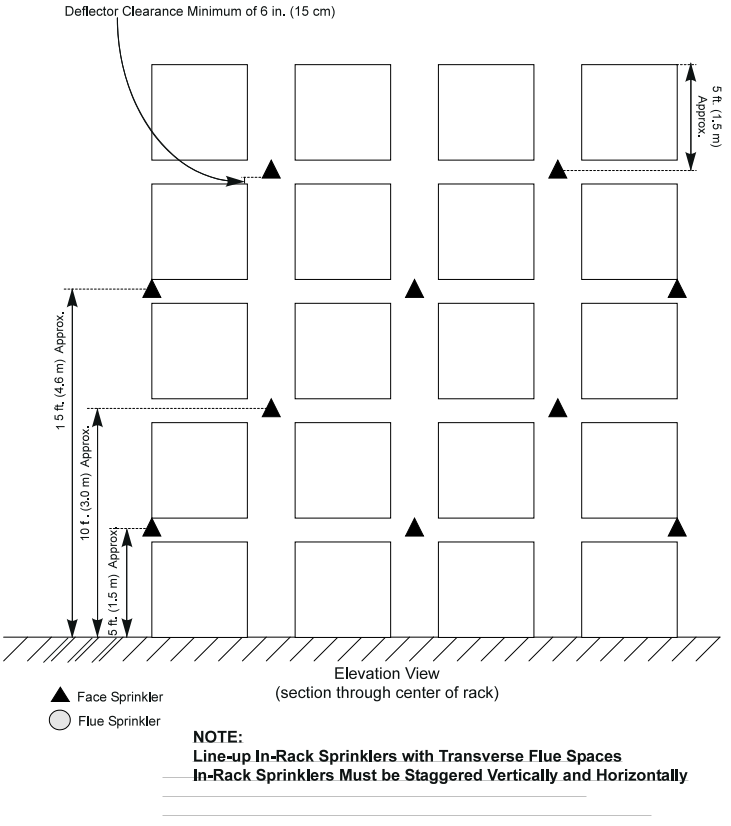


Fig. E.1-3c. Cartoned Level 3 Aerosol products – multiple row racks

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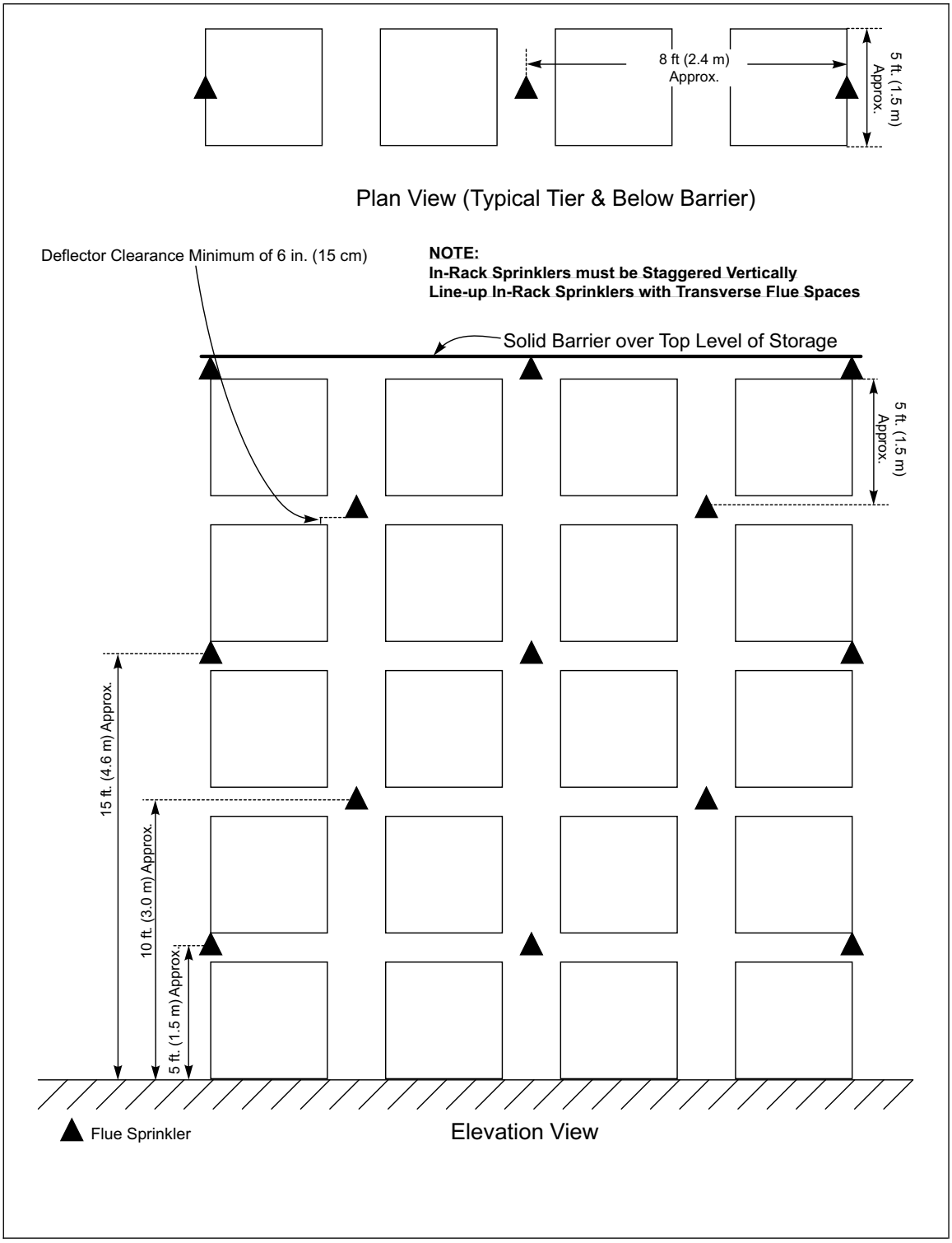


Fig. E.1-4a. Cartoned Level 2 Aerosol products and Level 3 Aerosol products, clearance more than 15 ft (4.6m) – single row racks

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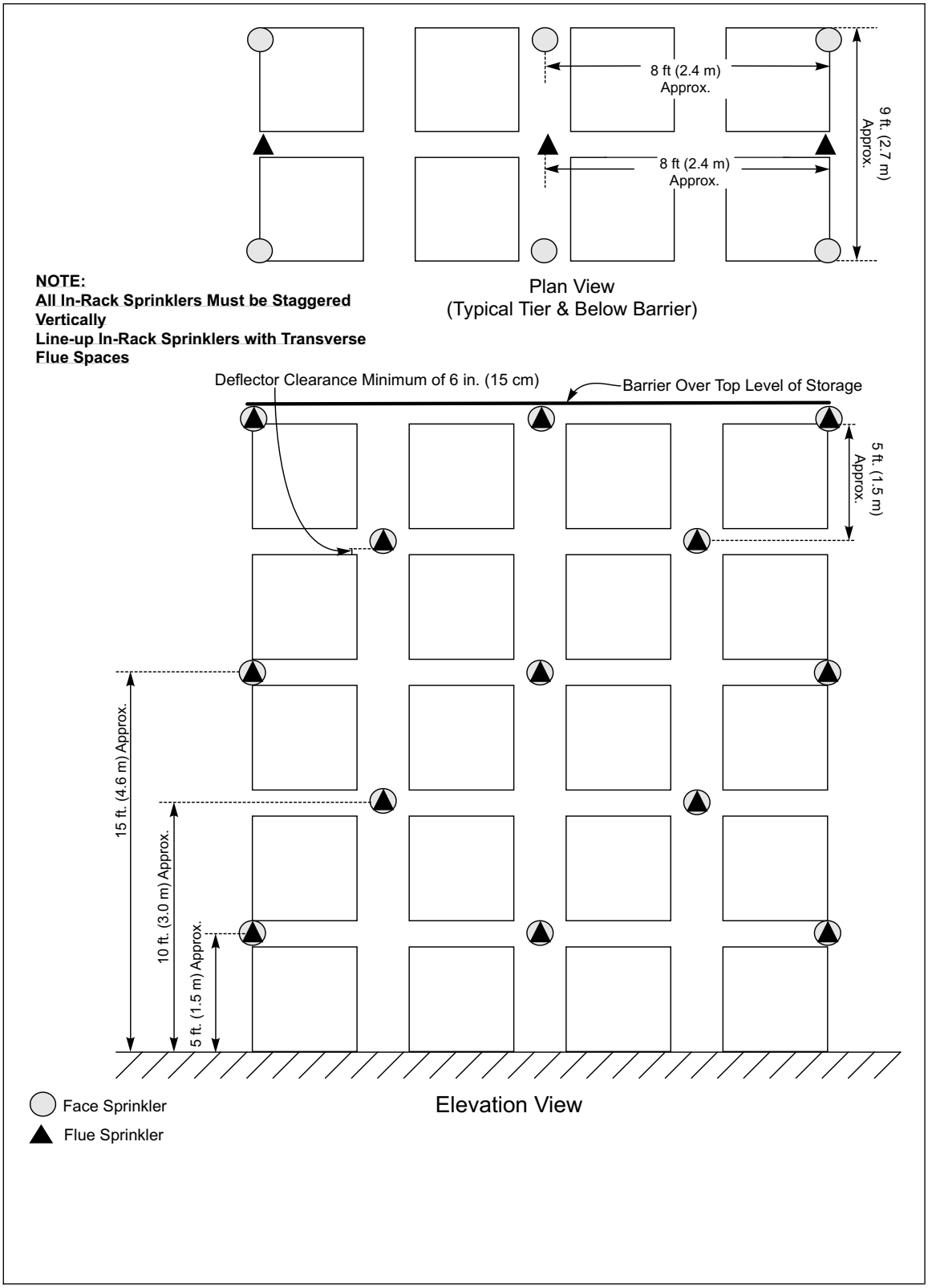


Fig. E.1-4b. Cartoned Level 2 Aerosol products and Level 3 Aerosol products, clearance more than 15 ft (4.6m) – double row racks

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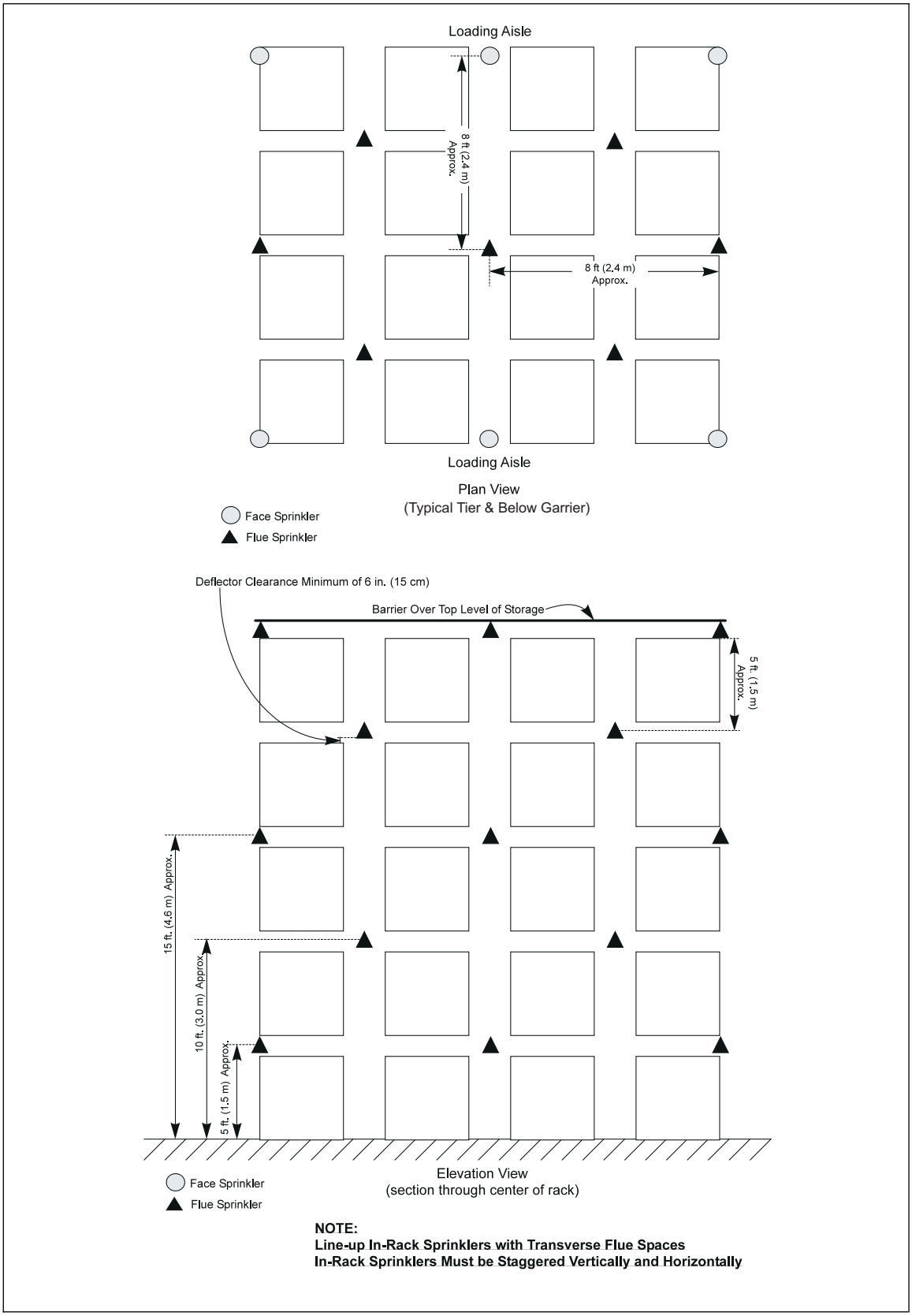


Fig. E.1-4c. Cartoned Level 2 Aerosol products and Level 3 Aerosol products, clearance more than 15 ft (4.6m) – multiple row racks

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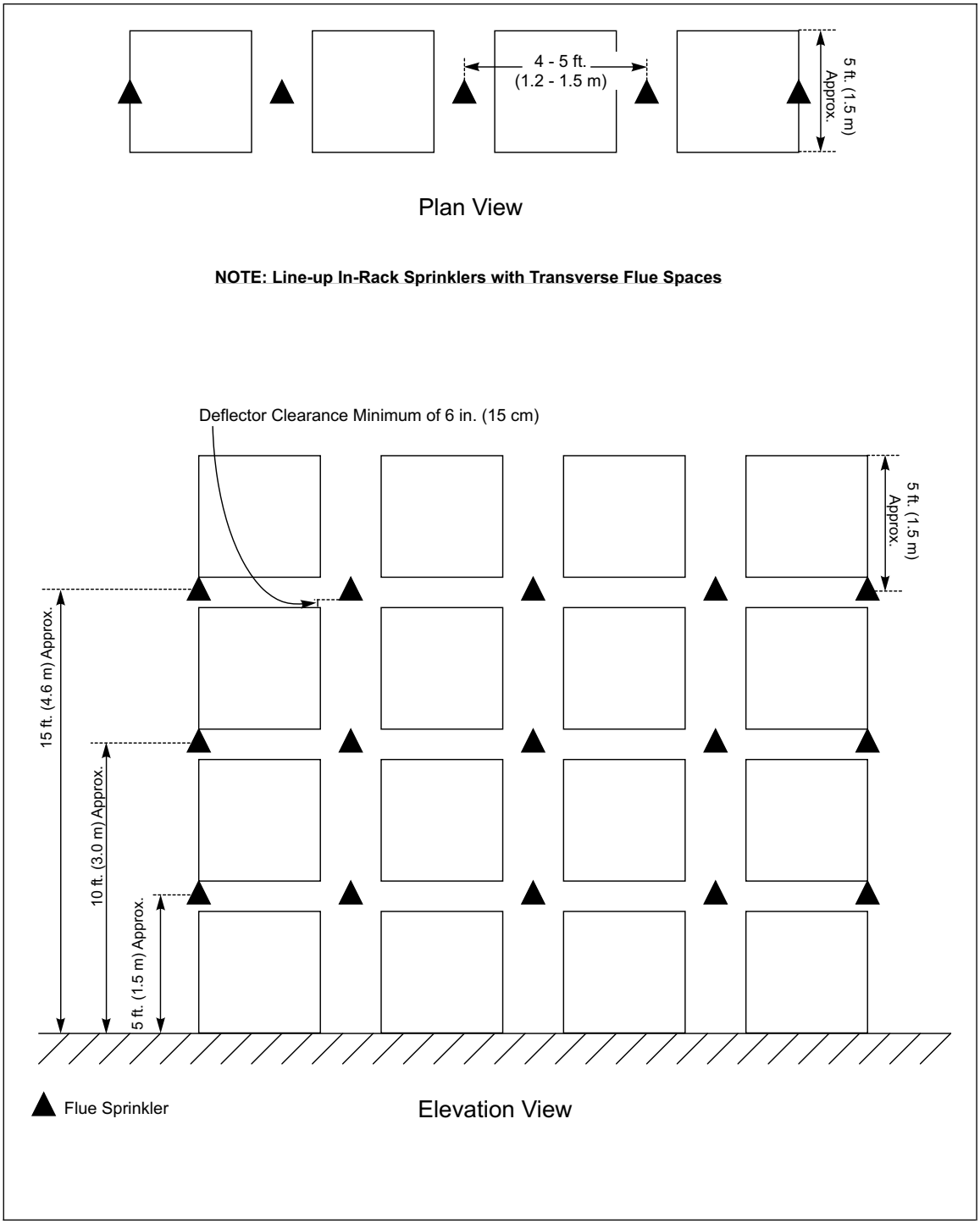


Fig. E.1-5a. Uncartoned Level 2 Aerosol products and Level 3 Aerosol products – single row racks up to 20 ft (6.1 m) high storage

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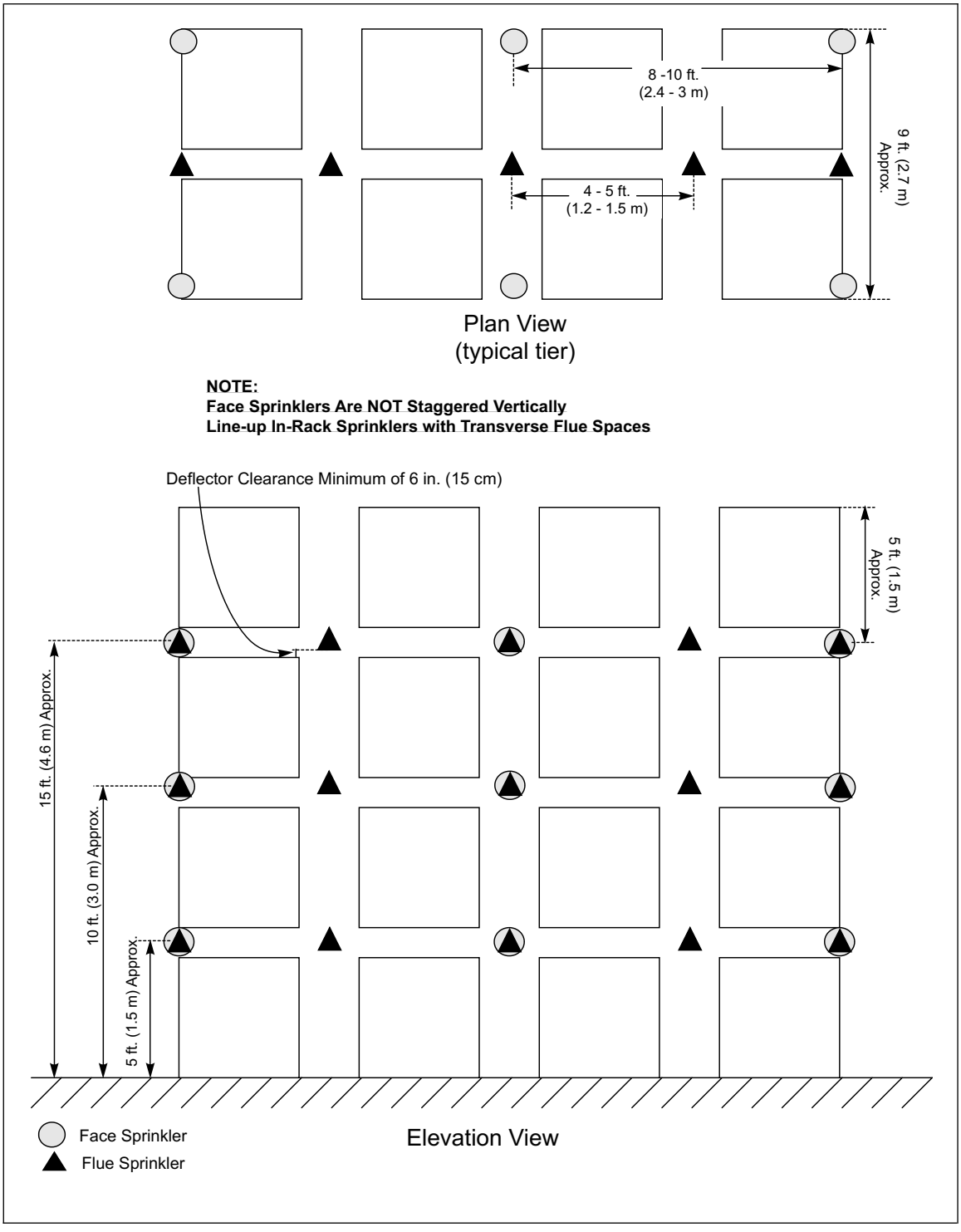
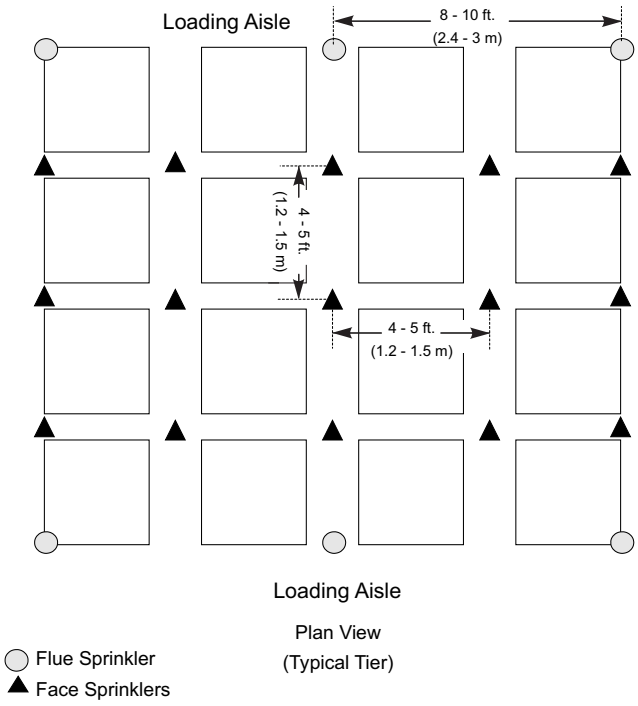


Fig. E.1-5b. Uncartoned Level 2 Aerosol products and Level 3 Aerosol products – double row racks up to 20 ft (6.1 m) high storage

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NOTE:
Face Sprinklers Are NOT Staggered Vertically
Line-up In-Rack Sprinklers with Transverse Flue Spaces

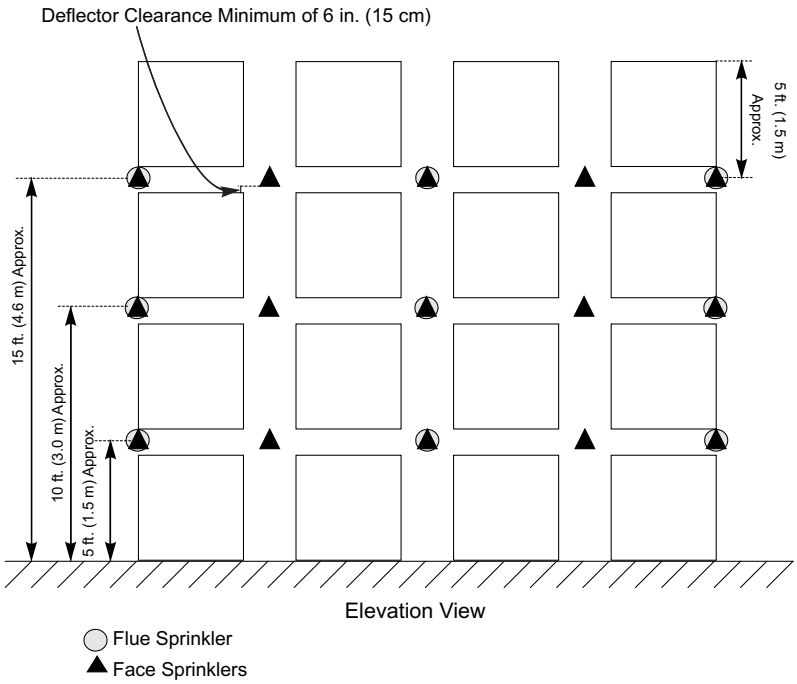


Fig. E.1-5c. Uncartoned Level 2 Aerosol products and Level 3 Aerosol products – multiple row racks up to 20 ft (6.1 m) high storage

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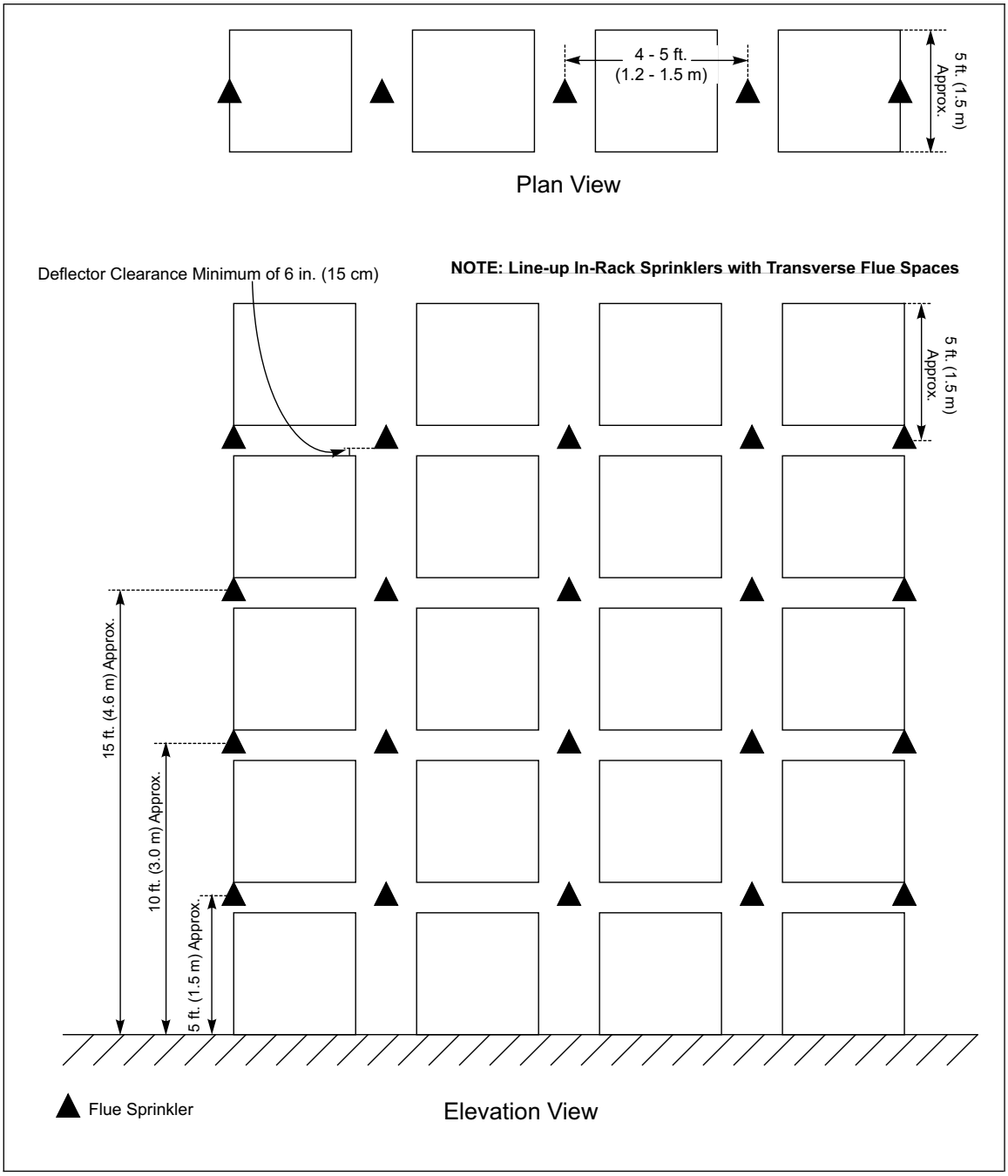


Fig. E.1-6a. Uncartoned Level 2 Aerosol products and Level 3 Aerosol products – single row racks up to 25 ft (7.6 m) high storage

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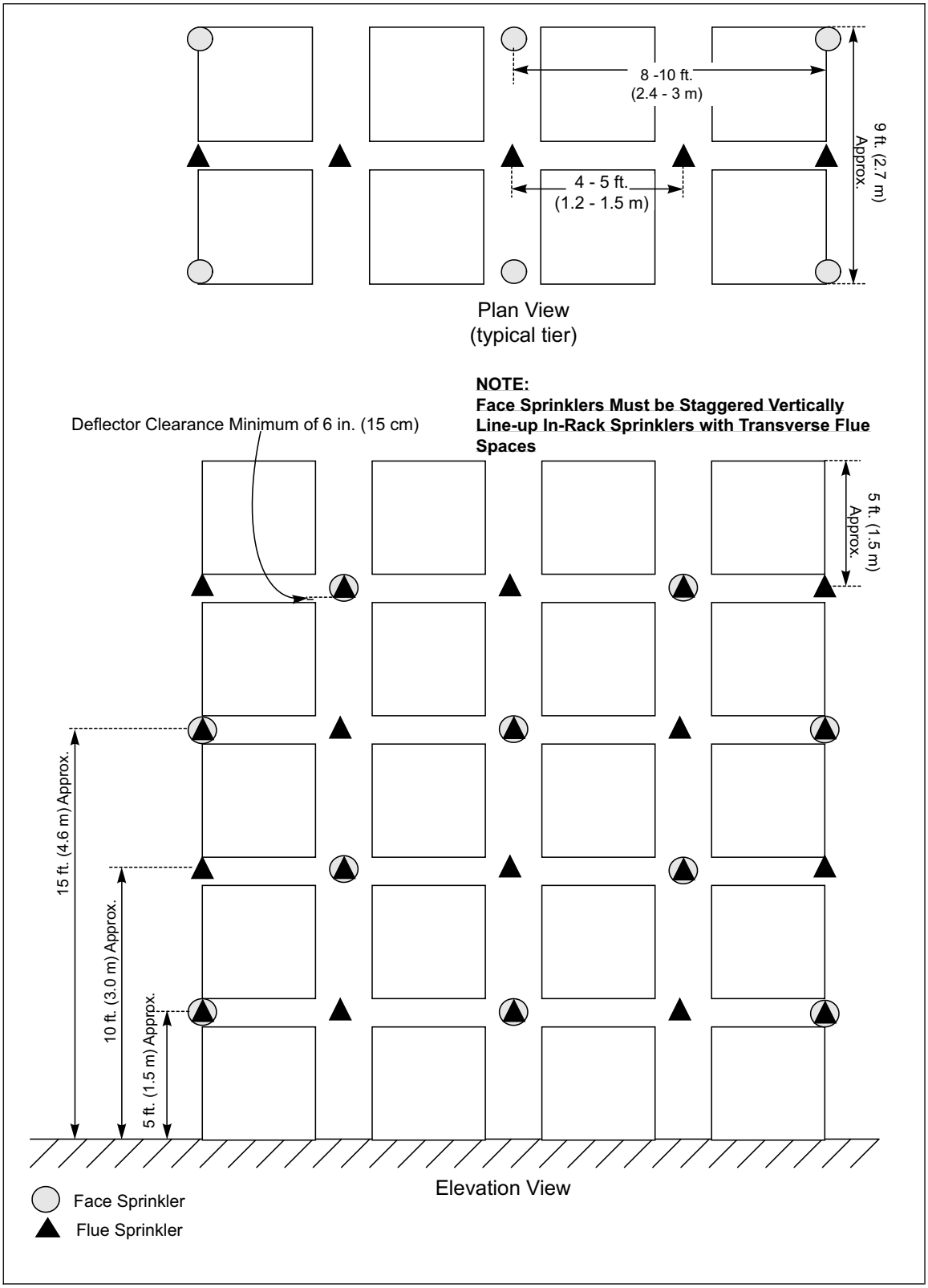


Fig. E.1-6b. Uncartoned Level 2 Aerosol products and Level 3 Aerosol products – double row racks up to 25 ft (7.6 m) high storage

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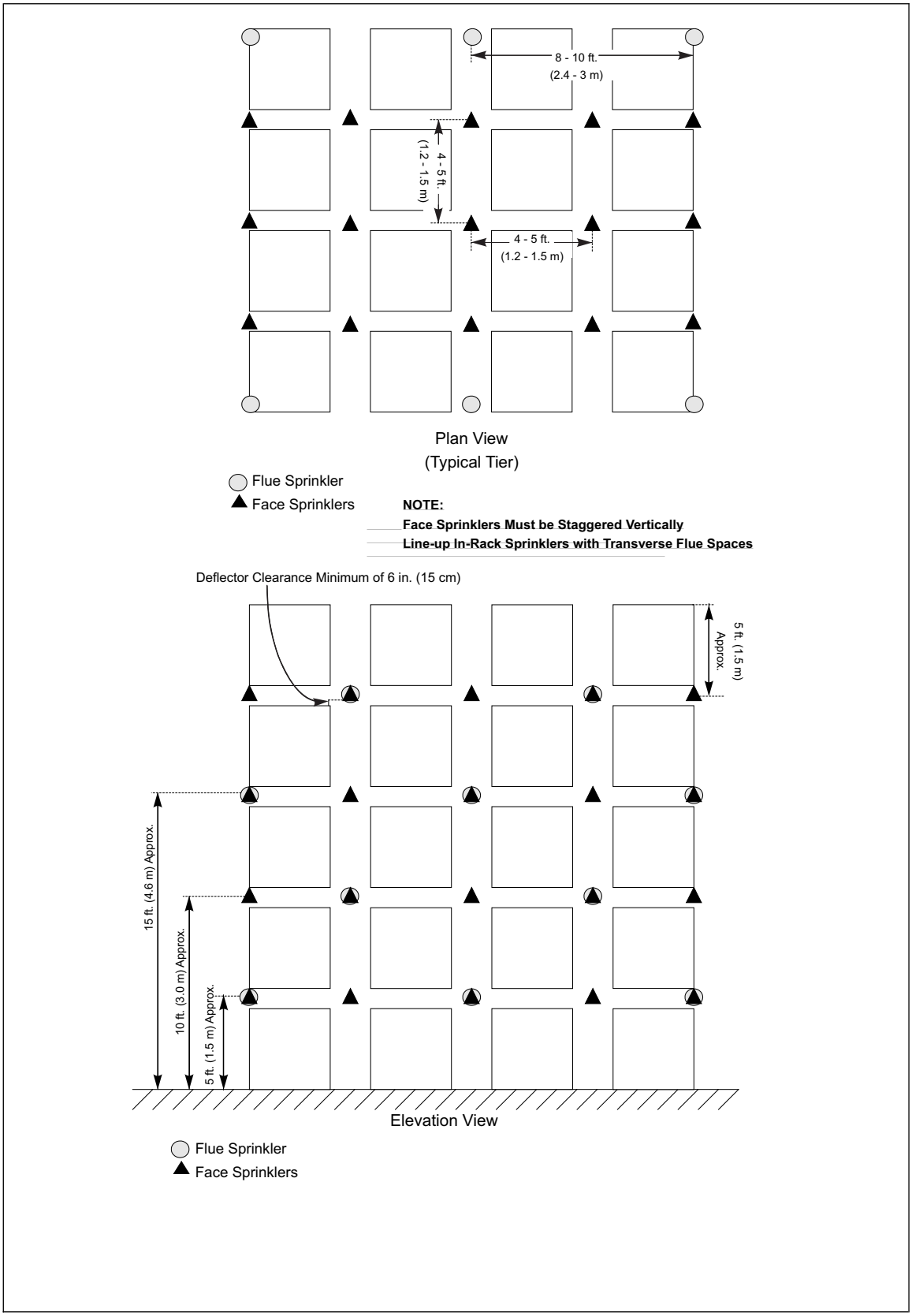


Fig. E.1-6c. Uncartoned Level 2 Aerosol products and Level 3 Aerosol products – multiple row racks up to 25 ft (7.6 m) high storage

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E.2 Fire Protection Scheme A

E.2.1 Provide plywood (minimum 3/8 in. [1 cm]) or sheet metal (minimum 22 gauge [0.7 mm]) barriers and in-rack sprinklers installed in accordance with Figures E.2-1, E.2-1, E.2-3, E.2-4. Use a maximum vertical spacing of 12 ft (3.7 m) between barriers.

E.2.2 Do not store aerosol products above the top barrier level.

E.2.3 Install FM Approved K8.0 (K115) or K11.2 (K161), 165°F (74°C) rated, quick-response in-rack sprinklers below each barrier level.

E.2.4 Provide in-rack sprinklers with a design flow of 57 gpm (220 L/min), with a minimum operating pressure of not less than 10 psi (0.69 Bar).

E.2.5 Provide an in-rack sprinkler demand based on the aerosol container material of construction, as follows:

A. For aerosol products in metal containers, base the hydraulic demand on the hydraulically most remote six (6) sprinklers (three on two lines) if one barrier level, or the most remote eight (8) sprinklers (four on two lines) if two or more barrier levels are provided.

B. For plastic Aerosol 3 products, base the hydraulic demand on the hydraulically most remote seven (7) sprinklers on one rack and the hydraulically most remote seven (7) sprinklers on the adjacent rack (14 total in-rack sprinklers).

E.2.6 Position face sprinklers no more than 9 in. (230 mm) in from the face of the commodity.

E.2.7 If there are adjacent bays of rack arrays not dedicated to aerosol product storage, provide one of the following:

A. Provide a noncombustible, solid vertical barrier (e.g., 22 gauge [0.7 mm] sheet metal) in each longitudinal and transverse flue space to separate the aerosol product storage from adjacent bays (see Figure 2.3.3.C).

1. For double-row racks with aerosol product storage on only one side of the rack, treat the side devoted to the storage of aerosol products as a single-row rack, with fire protection provided in accordance with Figure E.2-1. Protect the adjacent side based on the commodity stored in that area.

B. Extend Scheme A protection at least 8 ft (2.4 m) beyond the aerosol storage.

C. A vertical chain link fence may be used in lieu of a solid vertical barrier if the entire rack is protected with Scheme A (see Figure 2.3.3.B).

E.2.8 For aerosol products in metal containers, provide Scheme A protection for any adjacent rack separated by an aisle of 8 ft (2.4 m) or less.

E.2.8.1 For Plastic Aerosol 3 products classified in accordance with Section 2.1.3.3.F, provide Scheme A protection for any adjacent rack separated by an aisle of 8 ft (2.4 m) or less.

E.2.8.2 For all other Plastic Aerosol 3 products, provide Scheme A protection for any adjacent rack separated by an aisle of 10 ft (3 m) or less.

E.2.9 Ceiling sprinkler demand does not need to be included in the hydraulic calculations for in-rack sprinklers. Calculate the water demand at the point of supply separately for in-rack and ceiling sprinklers. Provide a 500 gpm (1900 L/min) hose stream allowance in the hydraulic calculations for the in-rack sprinkler protection. Provide the combined fire protection water demand for a 1-hour duration.

E.2.10 Design ceiling sprinklers to protect the surrounding occupancy, but not less than 7 psi (0.5 bar) using K8.0 (K115) sprinklers. If the aerosol product storage does not extend to the full height of the rack, protect the other commodities stored above the barrier (in accordance with the relevant data sheets) as if the entire rack height was filled with that commodity. If in-rack sprinklers are required for the other commodities, each level of barrier and in-rack sprinklers can be given credit as a level of in-rack sprinklers.

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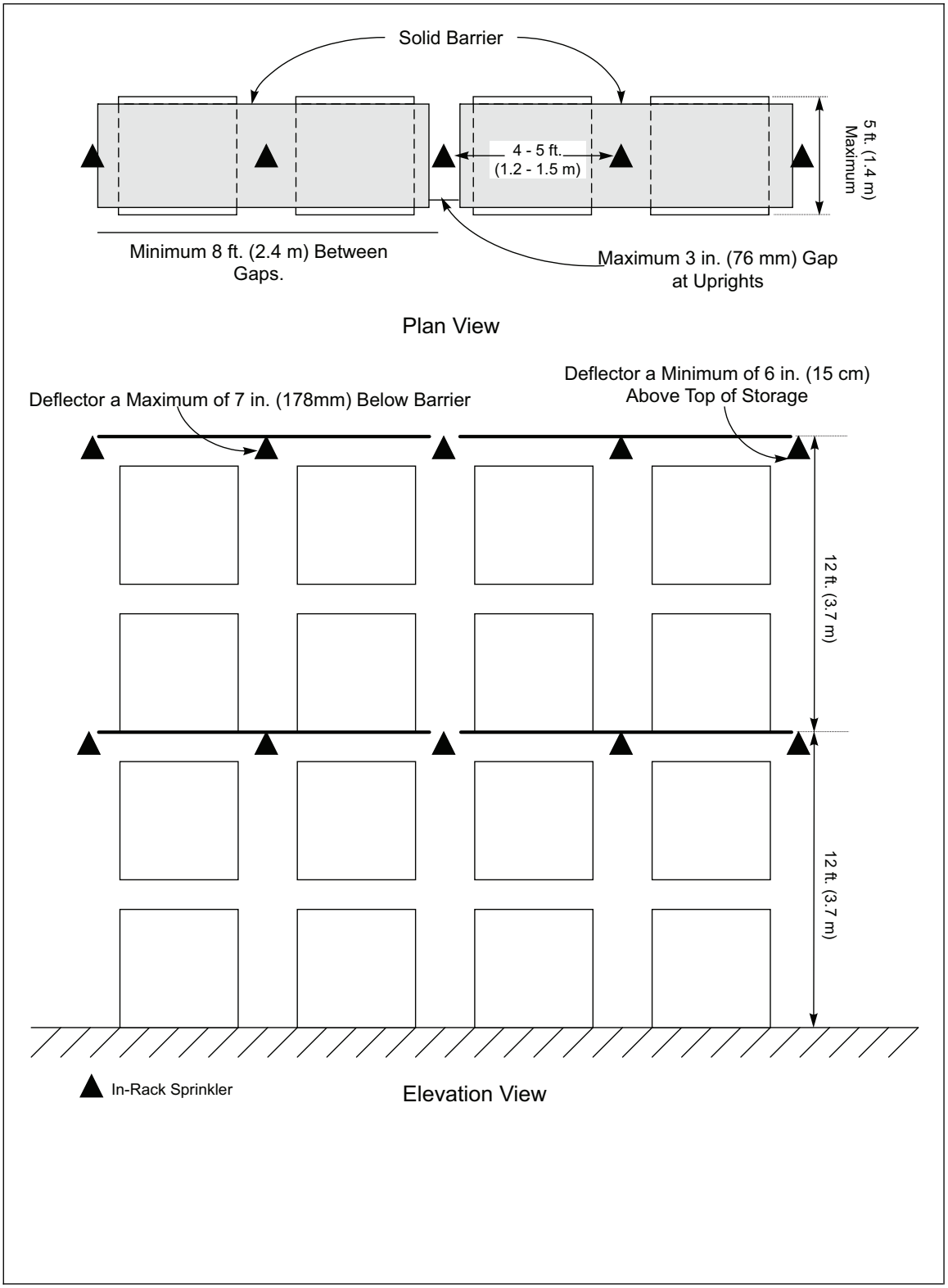


Fig. E.2-1. Single row rack in-rack sprinkler layout — Fire Protection Scheme A

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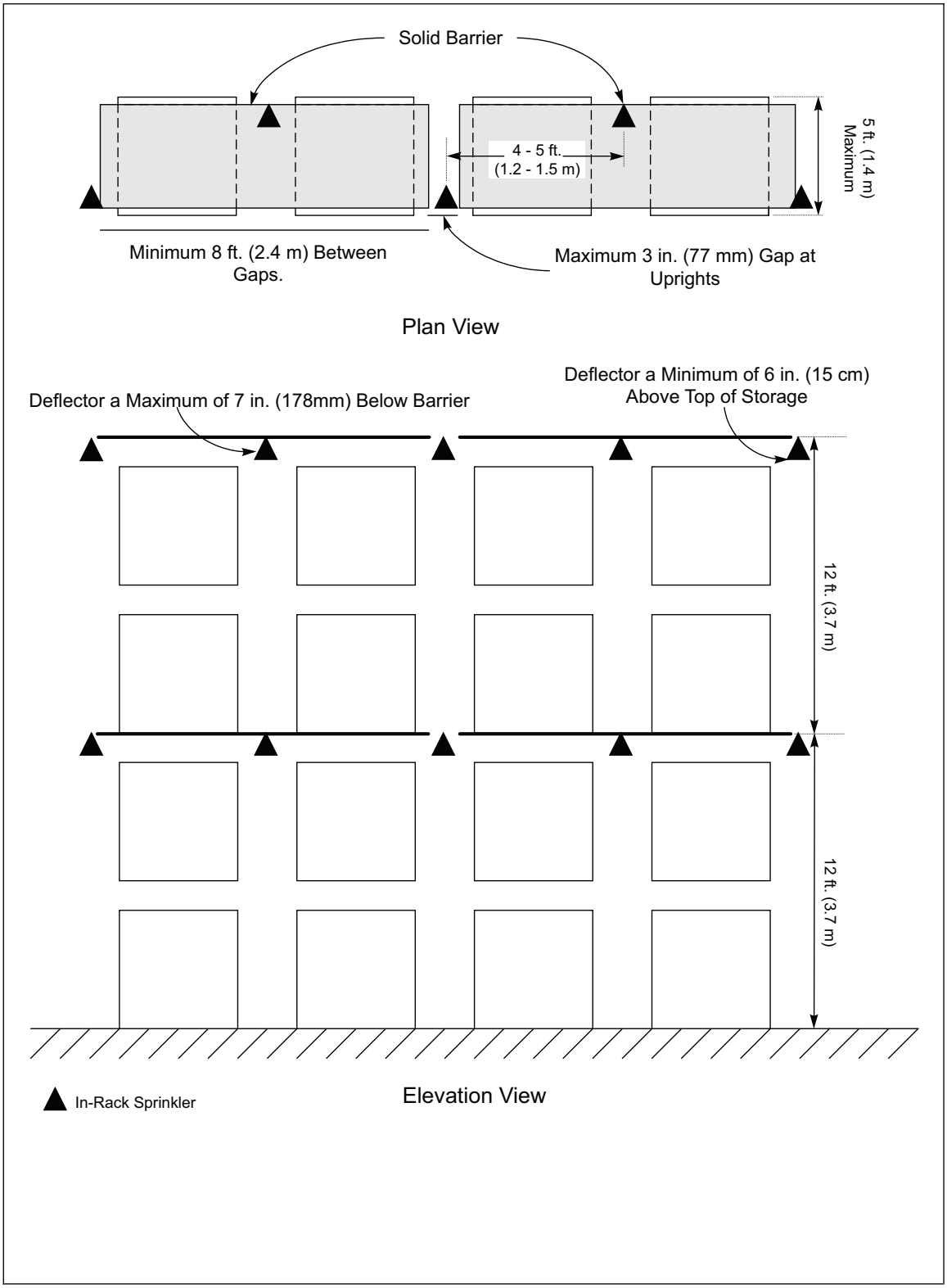


Fig. E.2-2. Single row rack in-rack sprinkler layout — Fire Protection Scheme A

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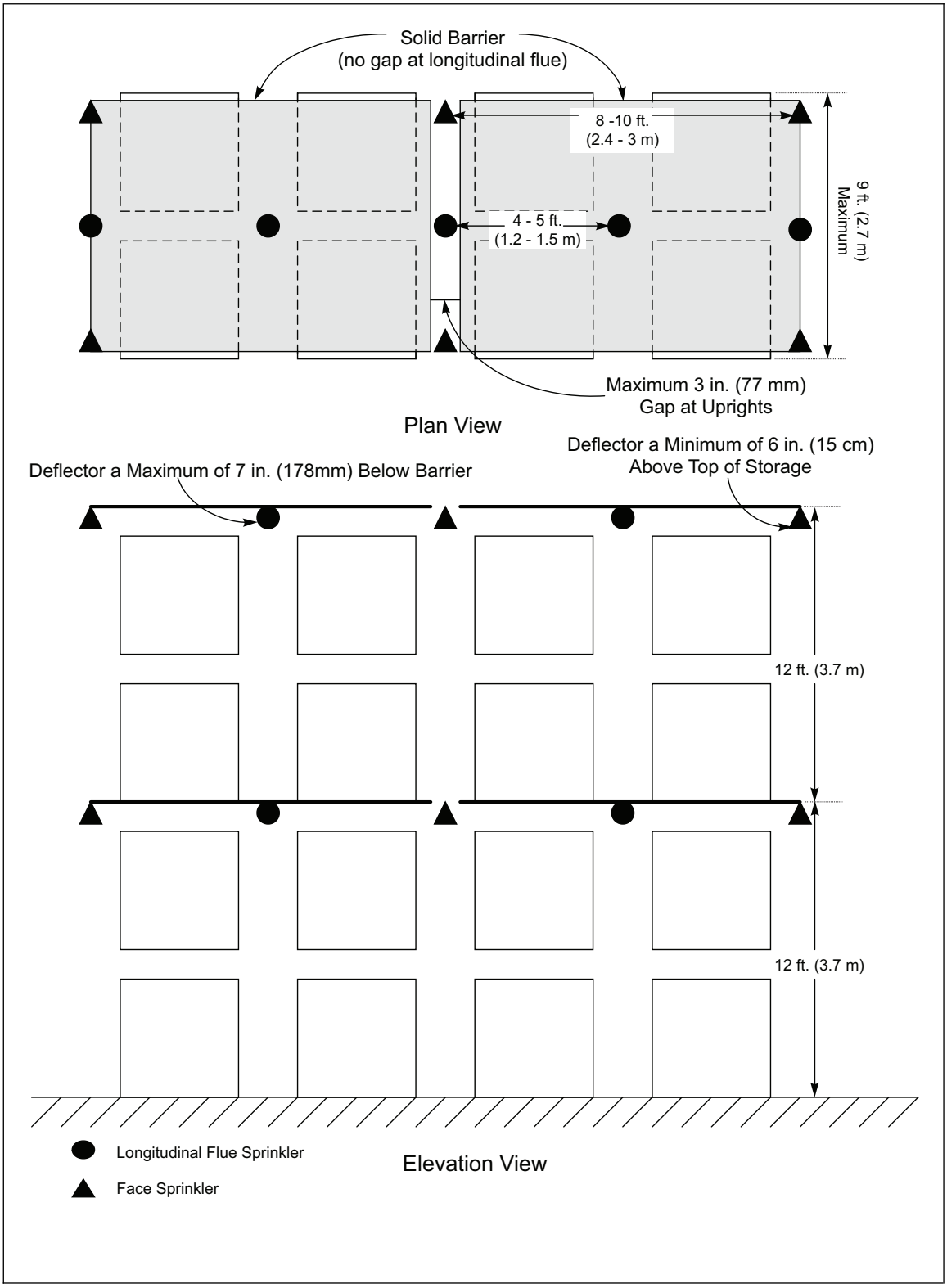


Fig. E.2-3. Double row rack in-rack sprinkler layout — Fire Protection Scheme A

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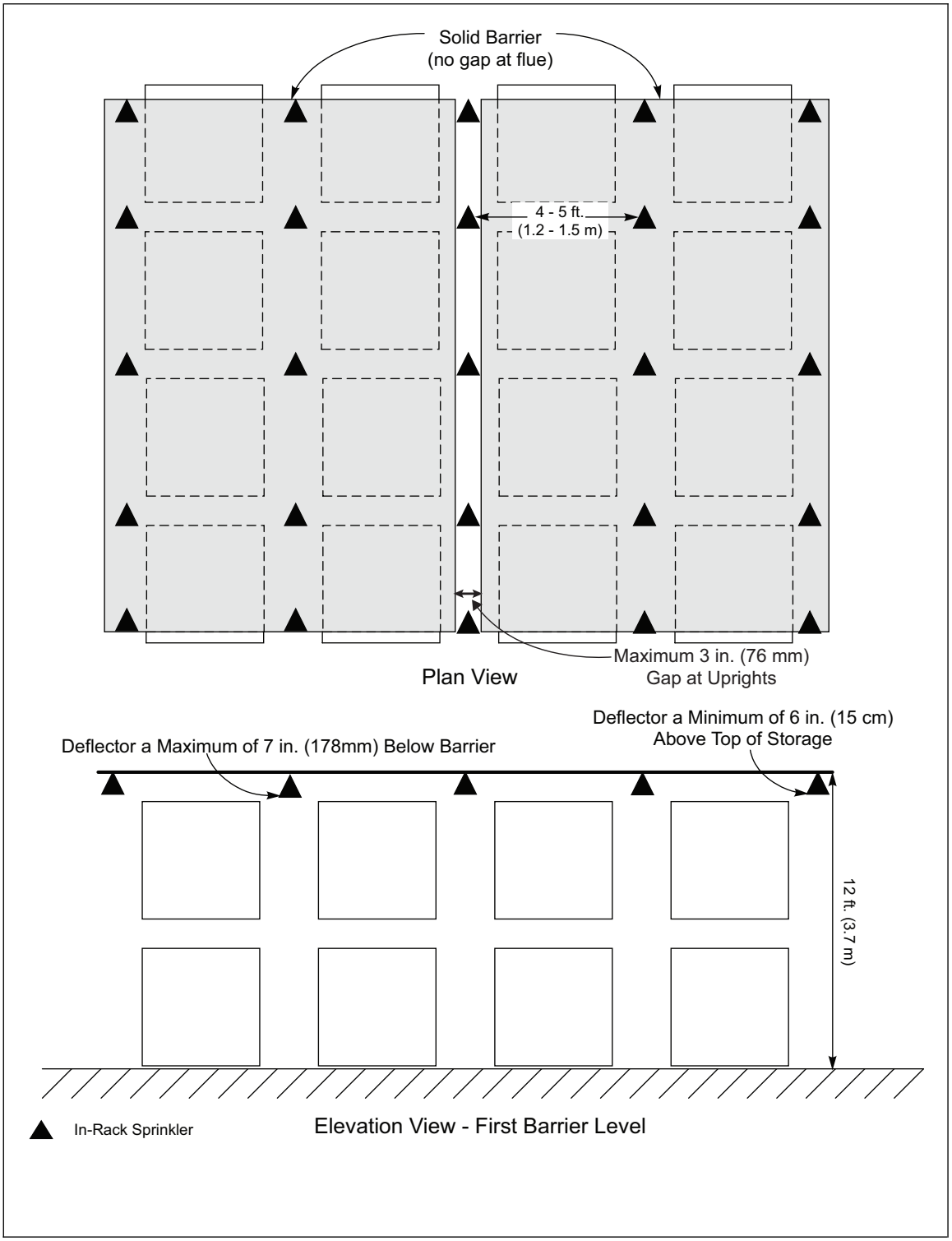


Fig. E.2-4. Multiple row rack in-rack sprinkler layout — Fire Protection Scheme A

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E.3 Aerosol Product Flow-Through Rack Protection Scheme

E.3.1 Install solid 3/8 in. (10 cm) plywood or 22 gauge (0.7 mm) sheet metal barrier at the 12 ft (3.7 m) level. The barrier must completely cover the longitudinal flue space. A 3 in. (76 mm) gap is permitted over the transverse flue spaces at the rack uprights. (See Figures E.3-1 and E.3-2)

E.3.2 To prevent potential horizontal fire spread within the roller racks, provide one the following:

A. Maintain a nominal 3 in. (76 mm) gap between rows of cartons. This would create at least 2 in. (51 mm) of free space between cartons (i.e., 3 in. [76 mm] space between cartons - 1 in. [25 mm] carton guide angle = 2 in. [51 mm] open space). It is recognized that the gaps between cartons will be inconsistent and not vertically aligned. However, limiting the number of carton spaces between rack uprights creating the potential for a nominal 3 in. (76 mm) gap will ensure adequate openings for in-rack sprinkler discharge to penetrate through the roller racks and prevent excessive horizontal spread of fire within the picking racks.

B. If the 3 in. (76 mm) gap between rows of cartons cannot be provided, install vertical barriers every 24 ft (7.3 m) horizontally. Ensure the barrier spans from the floor to the bottom of the horizontal barrier. The barrier may be constructed of either 3/8 in. (1 cm) plywood or 22 gauge (0.7 mm) sheet metal. Since the barrier will be located next to in-rack sprinklers, install additional in-rack sprinklers on both sides of the barrier.

E.3.3 Install in-rack sprinklers in accordance with Figures E.3-1 and E.3-2. Use FM Approved, K8.0 (K115), 165°F (74°C) rated, quick-response in-rack sprinklers. The number of lines of in-rack sprinklers is dependent on the rack width.

E.3.3.1 Position face sprinklers no more than 9 in. (230 mm) in from the face of the commodity.

E.3.3.2 Design the in-rack sprinklers to provide a minimum discharge pressure of 50 psi (3.5 bar) out of the hydraulically most remote of the following:

A. Twelve (12) sprinklers (i.e., four (4) sprinklers operating on each of three (3) lines) for three or more lines of in-racks, or

B. Eight (8) sprinklers if only two lines of in-racks are provided (i.e., four (4) sprinklers operating on two (2) lines), or

C. Six (6) sprinklers if only one line of in-rack sprinklers is provided

E.3.4 Ceiling sprinkler demand does not need to be included in the hydraulic calculations for in-rack sprinklers. Calculate the water demand at the point of supply separately for in-rack and ceiling sprinklers. Provide a 500 gpm (1900 L/min) hose stream allowance in the hydraulic calculations for the in-rack sprinkler protection. Provide the combined fire protection water demand for a 2-hour duration.

E.3.5 Design ceiling sprinklers to protect the surrounding occupancy, but not less than 7 psi (0.5 bar) using twenty (20) K8.0 (K115) sprinklers.

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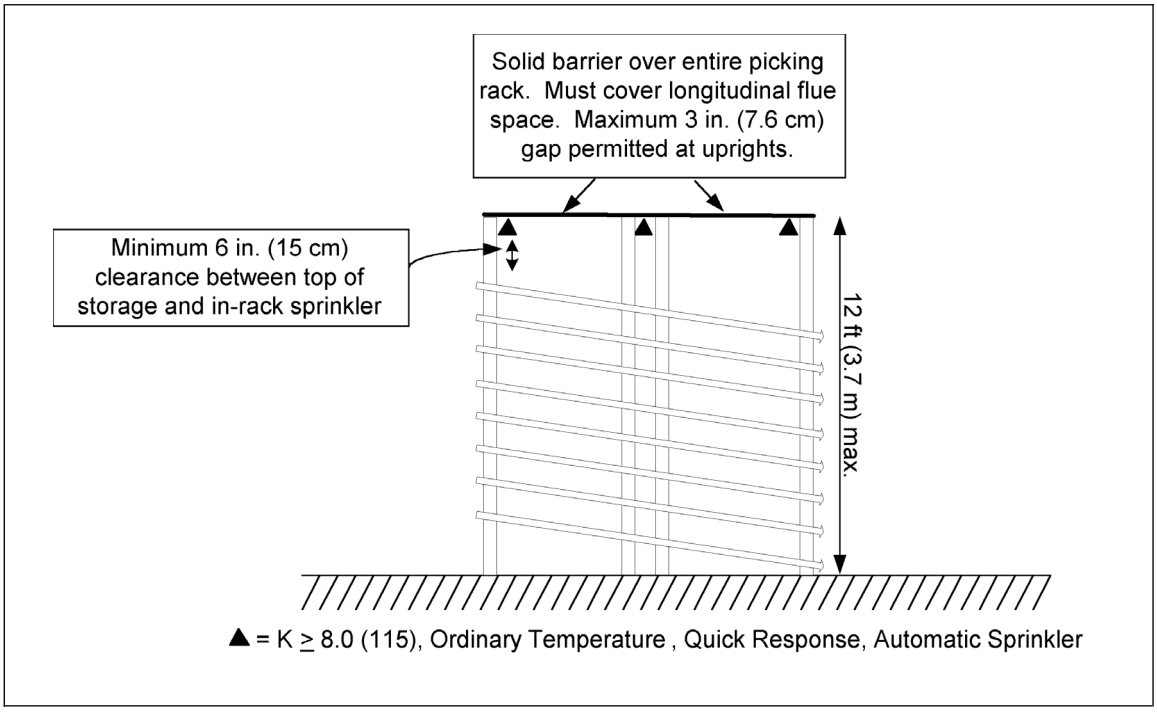


Fig. E.3-1. Aerosol product picking area elevation view

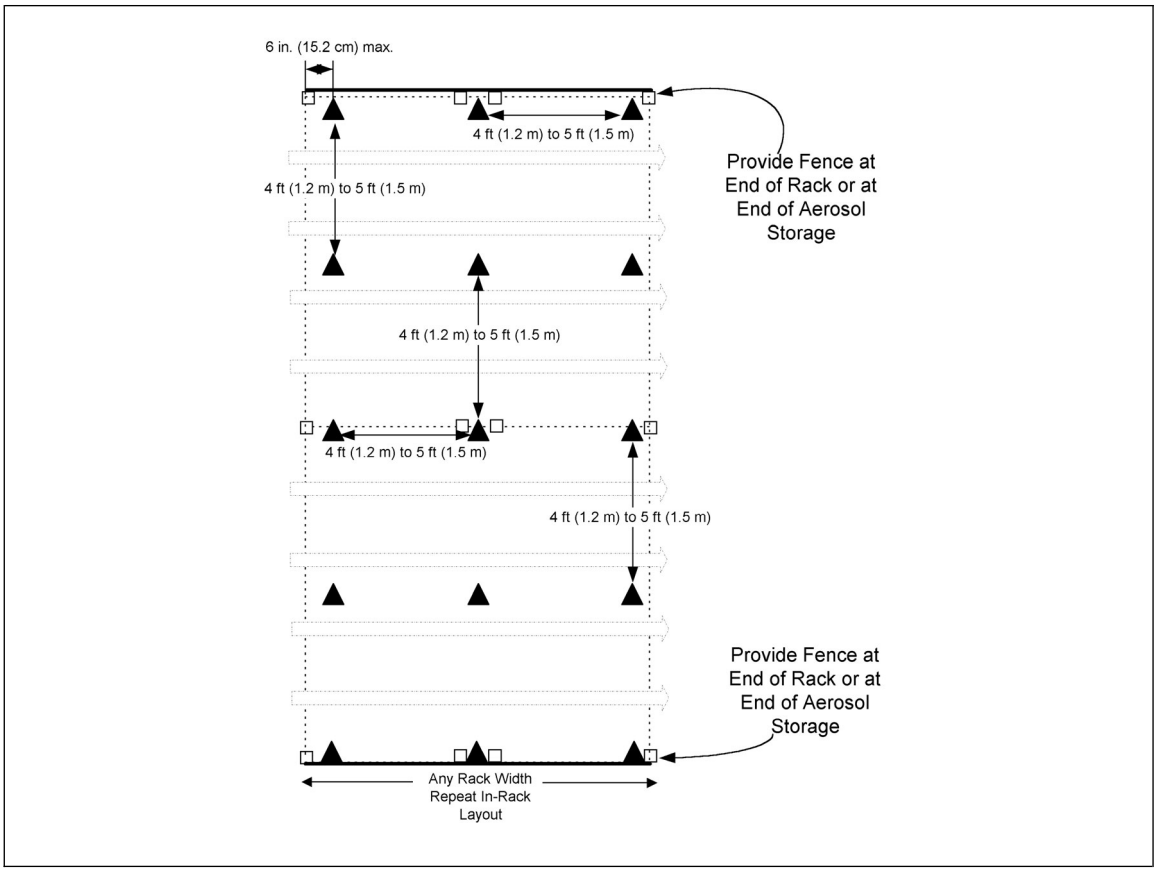


Fig. E.3-2. Aerosol product picking area plan view

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E.4 Mercantile Fire Protection Schemes

E.4.1 Provide a plywood (minimum 3/8 in. [1 cm]) or sheet metal (minimum 22 gauge [0.7 mm]) barrier at the top of the picking area, at a maximum height of 8 ft (2.4 m).

E.4.2 Install in-rack sprinklers in accordance with Figures E.4-1, E.4-2, or E.4-3 . Use FM Approved K8.0 (K115) or K11.2 (K161), 165°F (74°C) rated, quick-response in-rack sprinklers below the barrier level. Design the in-rack sprinklers to provide a minimum flow of 57 gpm (216 L/min) out of the hydraulically most remote six (6) sprinklers (three on two lines) if one barrier level, or the most remote eight (8) sprinklers (four on two lines) if two or more barrier levels are provided.

E.4.3 Where indicated (Figure E.4-3), provide a noncombustible, solid vertical barrier (e.g., 22 gauge (0.7 mm) sheet metal) in the longitudinal and transverse flue spaces to separate the aerosol product storage from adjacent areas.

E.4.4 Where aerosol products are stored above the display area, maintain storage in upper tiers within cartons and limit the total storage height to a maximum of 18 ft (5.5 m).

E.4.5 Provide Scheme A fire protection for the cartoned storage located within the upper tiers.

E.4.6 Design ceiling sprinklers to protect the surrounding occupancy, but not less than 7 psi (0.5 bar) using twenty (20) K8.0 (K115) sprinklers. If the aerosol product storage does not extend to the full height of the rack, protect the other commodities stored above the barrier in accordance with appropriate data sheets as if the entire rack height was filled with that commodity. If in-rack sprinklers are required for the other commodities, each level of barrier and in-rack sprinklers can be given credit as a level of in-rack sprinklers.

E.4.7 Ceiling sprinkler demand does not need to be included in the hydraulic calculations for in-rack sprinklers. Calculate the water demand at the point of supply separately for in-rack and ceiling sprinklers. Provide a 500 gpm (1900 L/min) hose stream allowance in the hydraulic calculations for the in-rack sprinkler protection. Provide the combined fire protection water demand for a 1-hour duration.

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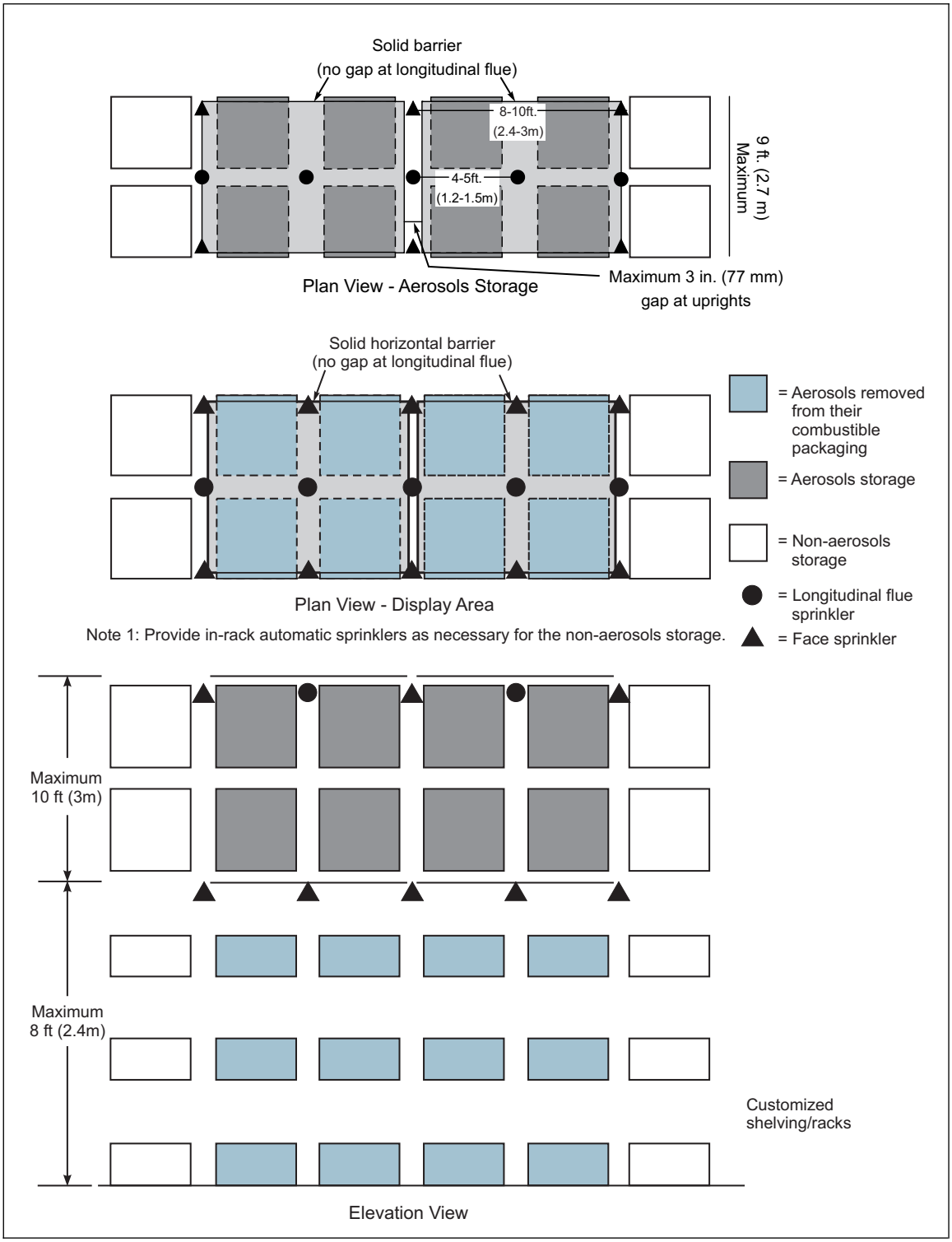


Fig. E.4-1. Mercantile storage, Option 1

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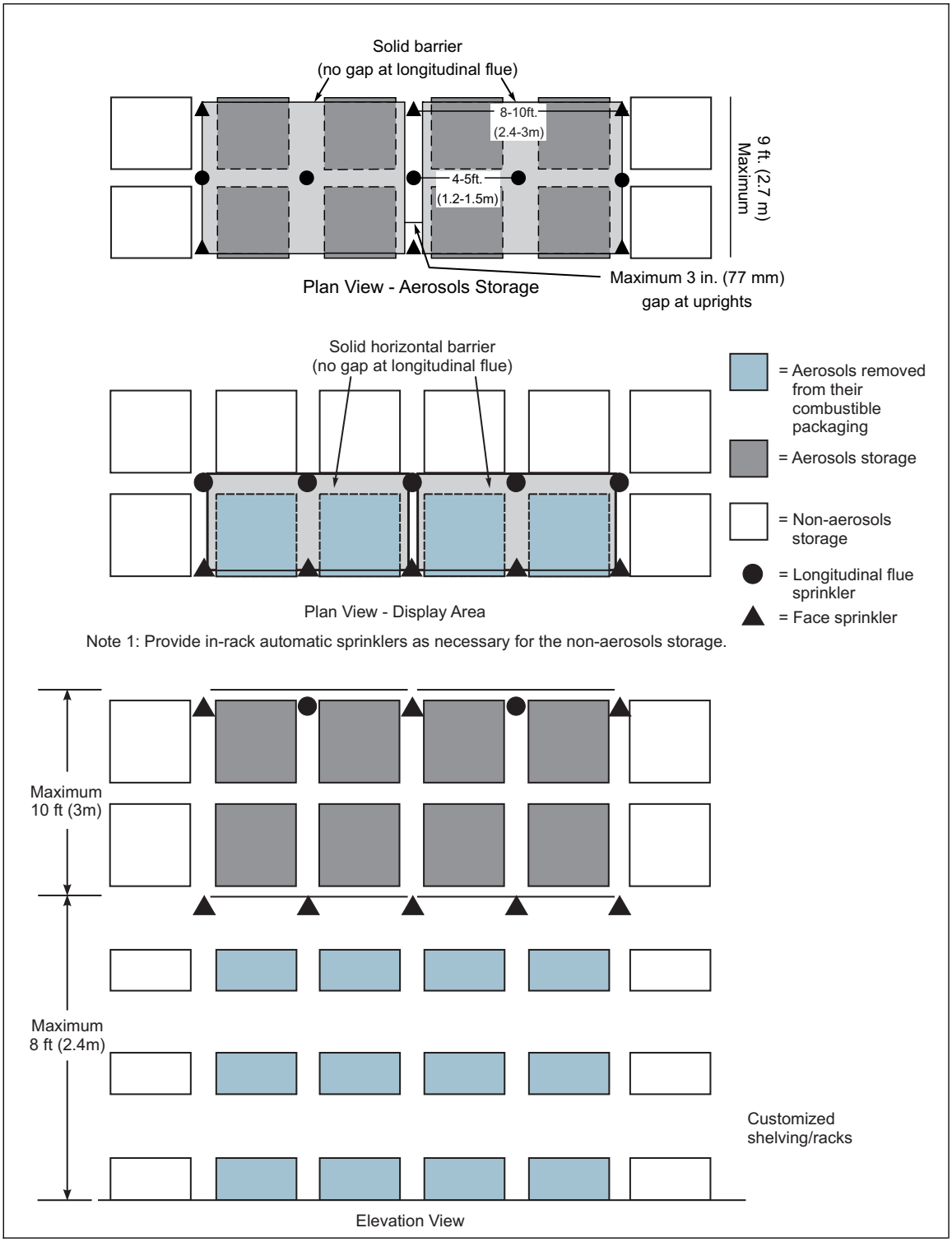


Fig. E.4-2. Mercantile storage, Option 2

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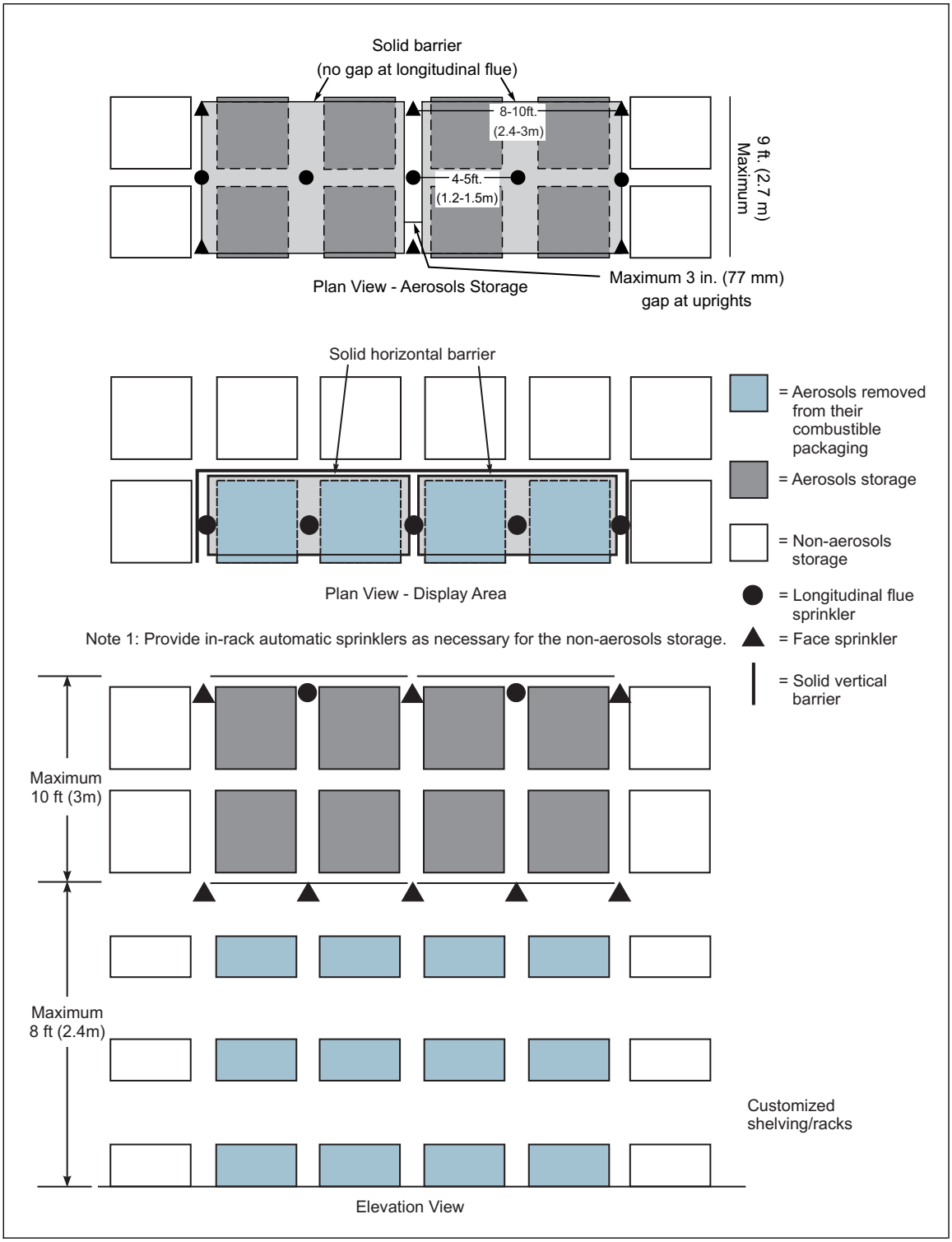


Fig. E.4-3. Mercantile storage, Option 3

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