



Automatic Storage and Retrieval Systems (ASRS)

27/28 May & 9/10 June 2026

Items

- 01** Introduction
- 02** Horizontal-Loading ASRS
- 03** Top-Loading ASRS
- 04** Final Extinguishment
- 05** Hazardous Goods in ASRS

Traditional Warehousing

Pallet sized goods

“Flue spaces”

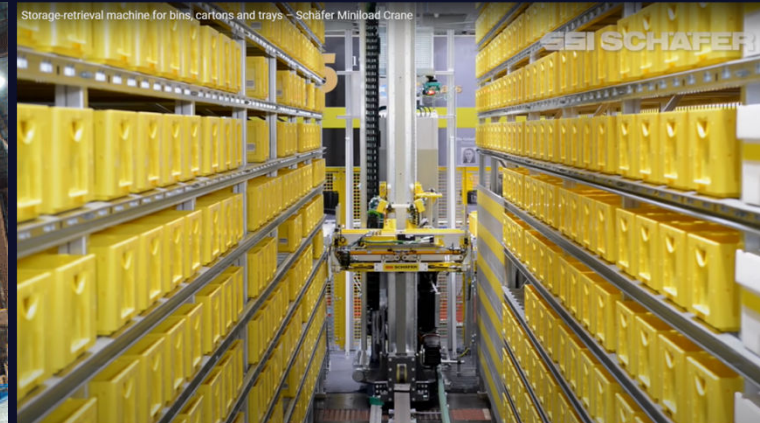
Limited storage height
(forklift trucks).



Changing Risk Profile of Warehousing

Efficiency, space, cost.

- Condensed storage
- Limited flue spaces
- Open-top containers
- Lots of plastic
- Electrical / li-ion powered robots
- Concentration of value
- Increased complexity
- Much greater rebuild times
- Cyber risks



FM Data Sheet 8-9 vs Data Sheet 8-34

- Which one to use?

FM Property Loss Prevention Data Sheets 8-9

March 2010
Interim Revision April 2025
Page 1 of 100

STORAGE OF CLASS 1, 2, 3, 4 AND PLASTIC COMMODITIES

Table of Contents	
	Page
1.0 SCOPE	5
1.1 Changes	5
1.2 Superseded Information	5
1.3 How to Use This Data Sheet	5
2.0 LOSS PREVENTION RECOMMENDATIONS	8
2.1 Construction and Location	8
2.1.1 General	8
2.1.2 Steel Column Protection	8
2.1.3 Heat and Smoke Venting and Draft Curtains	8
2.2 Occupancy	8
2.2.1 General	8
2.2.2 Commodity Hazard	9
2.2.3 Storage Arrangements	9
2.2.4 Open-Top Containers Maintained in Storage Racks	22
2.2.5 Pallets	25
2.2.6 Clearance Between Top of Storage and Ceiling-Level Sprinkler Deflector	25
2.3 Protection	25
2.3.1 General	25
2.3.2 Sprinkler System Types	25
2.3.3 Ceiling-Level Storage Sprinklers	26
2.3.4 In-Rack Sprinklers (IRAS)	40
2.3.5 Hose Demands, Hose Connections, and System Duration	61
2.3.6 Special Applications	62
3.0 SUPPORT FOR RECOMMENDATIONS	79
3.1 General	79
3.2 Loss History	79
3.3 Illustrative Losses	80
3.3.1 Roll Cloth in Racks Obstruct Flue Spaces, Resulting in Extensive Fire and Water Damage	80
3.3.2 Many Loss Prevention Principles Compromised in Warehouse Fire	80
3.3.3 Inadequate Sprinkler Protection Unable to Control Fire Involving Aisle Storage and Racks with Solid Shelves	80
3.3.4 Fire in High Rack-Storage Controlled by In-Rack Sprinklers	80
3.3.5 Lack of In-Rack Sprinklers for Racks With Solid Shelves Results in Extensive Fire Damage	80
3.3.6 Open-Top Containers in Racks Interfere with Sprinkler Water Penetration Resulting in Uncontrolled Fire	81
3.3.7 Poor Housekeeping Leads to Excessive Fire Spread	81
3.3.8 Strong Water Supply Overcomes Plugged Sprinklers	81
4.0 REFERENCES	81
4.1 FM Global	81
APPENDIX A: GLOSSARY OF TERMS	82
APPENDIX B: DOCUMENT REVISION HISTORY	87



FM Property Loss Prevention Data Sheets 8-34

July 2017
Interim Revision July 2024
Page 1 of 119

PROTECTION FOR AUTOMATIC STORAGE AND RETRIEVAL SYSTEMS

Table of Contents	
	Page
1.0 SCOPE	7
1.1 Changes	7
1.2 How to Use this Data Sheet	7
2.0 LOSS PREVENTION RECOMMENDATIONS	9
2.1 General Recommendations for All Automatic Storage and Retrieval Systems	9
2.1.1 FM Approved Equipment, Materials, and Services	9
2.1.2 Construction and Location	9
2.1.3 Occupancy	9
2.1.4 Protection	10
2.1.5 Final Extinguishment	12
2.1.6 Electrical Systems for ASRS Storage Arrangements	13
2.1.7 Control Systems for ASRS Storage Arrangements	13
2.2 Horizontal-Loading Automatic Storage and Retrieval Systems (ASRS) Using Small Containers or Small Trays	14
2.2.1 General Guidelines for Horizontal-Loading ASRS Storage Arrangements	14
2.2.2 Protection of Horizontal-Loading Shuttle ASRS Storage Arrangements Where Closed-Top, Noncombustible, Solid-Walled Containers, or FM Approved, Non-Propagating, Open-Top Containers are Being Used	20
2.2.3 Protection of Horizontal-Loading Shuttle ASRS Storage Arrangements Using (1) Closed-Top Combustible Containers, or (2) Products that Do Not Collect Water that are Stored on Trays	20
2.2.4 Protection of Horizontal-Loading Shuttle ASRS Storage Arrangements Where Open-Top, Combustible Containers are Being Used	48
2.2.5 Protection of Horizontal-Loading, Mini-Load ASRS Storage Arrangements Where Closed-Top, Noncombustible, Solid-Walled Containers, or FM Approved, Non-Propagating, Open-Top Containers are Being Used	61
2.2.6 Protection of Horizontal-Loading Mini-Load ASRS Storage Arrangements Using (1) Closed-Top Combustible Containers, or (2) Products that Do Not Collect Water that are Stored on Trays	61
2.2.7 Protection of Horizontal-Loading, Mini-Load ASRS Storage Arrangements Where Open-Top, Combustible Containers are Being Used	75
2.3 Top-Loading Automatic Storage and Retrieval Systems (TL-ASRS)	88
2.3.1 General Guidelines for TL-ASRS Storage Arrangements	88
2.3.2 Drainage	88
2.3.3 Robots and Robot Holding Areas	88
2.3.4 Fire Detection	88
2.3.5 Protection of Noncombustible Solid-Walled Containers	89
2.3.6 Protection of Combustible Solid-Walled Containers	92
2.3.7 Protection of Non-Solid-Walled Containers	103
2.4 Vertically Enclosed Automatic Storage and Retrieval System Storage Arrangements	107
2.4.1 General	107
2.4.2 Storage Trays for Vertically Enclosed Storage Units	107
2.4.3 Protection Options for Vertically Enclosed Storage Units	108
2.4.4 Final Extinguishment – Small Hose Connection Stations	110
3.0 SUPPORT FOR RECOMMENDATIONS	110
3.1 Description of Automatic Storage and Retrieval Systems (ASRS)	110



Automated Pallet Racking

- Normal pallet sized goods with adequate flue spaces.
- “Rack structure ASRS”.
- Use Data Sheet 8-9.



Rack structure ASRS storage arrangement: An automatic storage and retrieval system that is similar to traditional open-frame storage racks except that (1) the horizontal distance between rack uprights is sized for only one pallet load, and (2) the support within the rack for the pallet loads tends to be either roller-type conveyors or horizontal supports that are oriented perpendicular to the loading aisle as opposed to parallel to it. Protection guidelines for these storage arrangements are provided in Data Sheet 8-9, *Storage of Class 1, 2, 3, 4 and Plastic Commodities*.

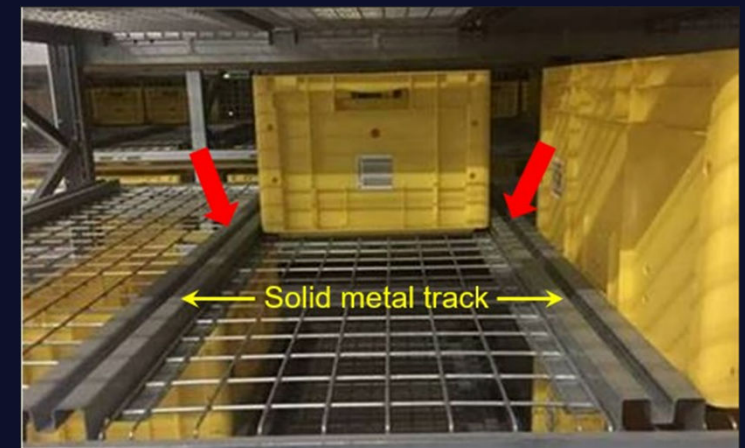
Horizontal-Loading ASRS: Miniload

Horizontal loading mini-load systems: boxes sit on angle iron supports between uprights



Horizontal-Loading ASRS: Shuttle

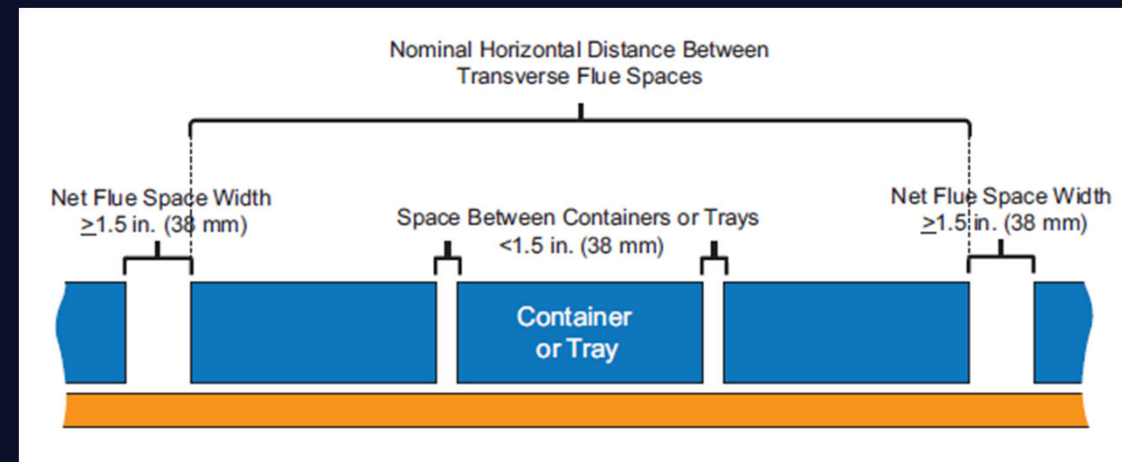
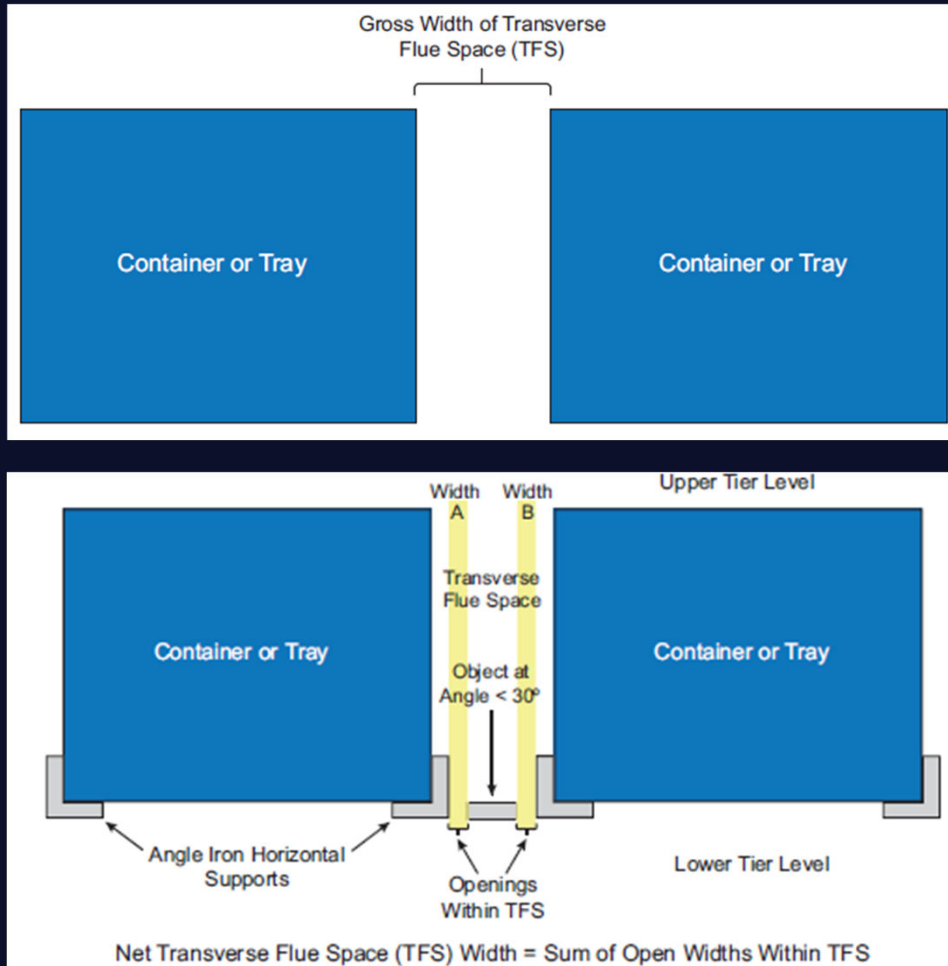
Horizontal loading shuttle systems: Boxes sit on beams, mesh shelves or similar



Challenges

- In-rack sprinklers almost always required
- In-rack spacing may be very tight
- Larger in-rack sprinklers (K160 and larger), high flows (up to 500 litres/min)
- Transverse vertical barriers may be needed
- Protection largely limited to “ordinary combustibles”
- Guidance for *some* aerosols, ignitable liquids, and li-ion batteries

Horizontal-Loading ASRS: Flue Spaces



< 38 mm gaps are not "flues" (i.e., ignore)

> 38 mm net = acceptable flue

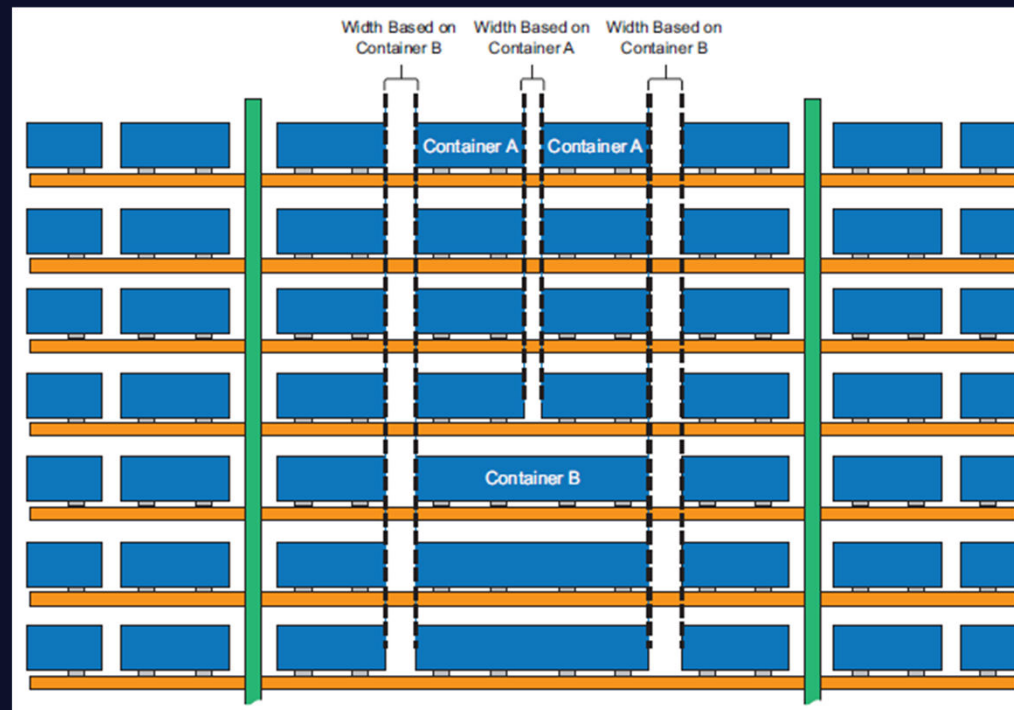
Horizontal-Loading ASRS: Flue Spaces

- Net flue width excludes any rack structure $\leq 100\text{mm}$ wide pitched at more than 30°
- Adequate transverse flue sizes/spacing
 - Vertically aligned net 38 mm wide every 0.6 m, or
 - Vertically aligned net 50 mm wide every 0.75 m, or
 - Vertically aligned net 75 mm wide every 1.5 m, or
 - Vertically aligned net 150 mm wide every 3 m
- Adequate transverse flues = in-rack sprinklers on up to maximum 4.5 m vertical spacing



Horizontal-Loading ASRS: Flue Spaces

- If transverse flue spaces are not vertically aligned, based flue space dimensions and horizontal distance based on where vertical alignment occurs e.g., at rack uprights



Horizontal-Loading ASRS: Flue Spaces

Table 2.2.1.4.2.1. Recommended Minimum Net Transverse Flue Space Widths within a Horizontal-Loading ASRS

<i>Nominal Horizontal Distance Between Transverse Flue Spaces, ft (m)</i>	<i>Recommended Minimum Nominal Net Transverse Flue Space Width, in. (mm)</i>
2 (0.6)	1.5 (38)
2.5 (0.75)	2 (50)
5 (1.5)	3 (75)
10 (3.0)	6 (150)
> 10 (3.0)	In-rack sprinklers are needed. See Section 2.2.1.5 to see if vertical barriers are needed too

Horizontal-Loading ASRS: Adequate Flue Spaces

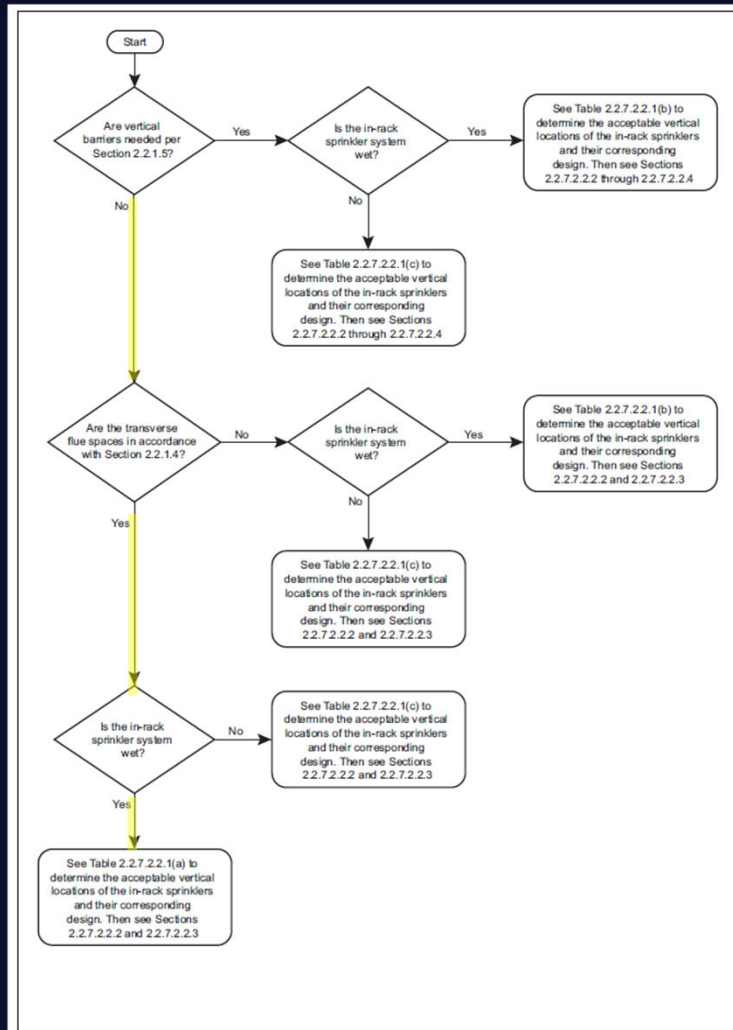


Table 2.2.7.2.2.1(a). Wet, Vertical In-Rack Sprinkler Locations and In-Rack Sprinkler Designs for the Protection of Open-Top, Combustible Containers Stored in a Mini-Load Type System *with Flue Spaces in Accordance with Section 2.2.1.4*

Recommended IRAS Arrangement per Table 2.2.7.2.1	Maximum Vertical Distance Between IRAS, ft (m)	Minimum IRAS Design Flow, gpm (L/min)*	Minimum IRAS K-factor	No. of IRAS in Design	Hydraulically Balance IRAS System with Ceiling System?
Figure 2.2.7.2.1(a)	10 (3.0)	100 (380)	11.2 (160)	4 on top IRAS level	No
	15 (4.6)	140 (530)	22.4 (320) Pendent	6 on top IRAS level	No
Figures 2.2.7.2.1(b), 2.2.7.2.1(c), or 2.2.7.2.1(e)	10 (3.0)	100 (380)	11.2 (160)	6 on top IRAS level	No
	15 (4.6)	140 (530)	22.4 (320) Pendent	6 on top IRAS level	No

* The indicated in-rack sprinkler design flow is based on a minimum 9 in. (225 mm) vertical distance between storage tier levels. If the vertical distance between vertical tier levels is less than 9 in. (225 mm), add 20 gpm (75 L/min) to the indicated design flow.

Horizontal-Loading ASRS: Inadequate Flue Spaces

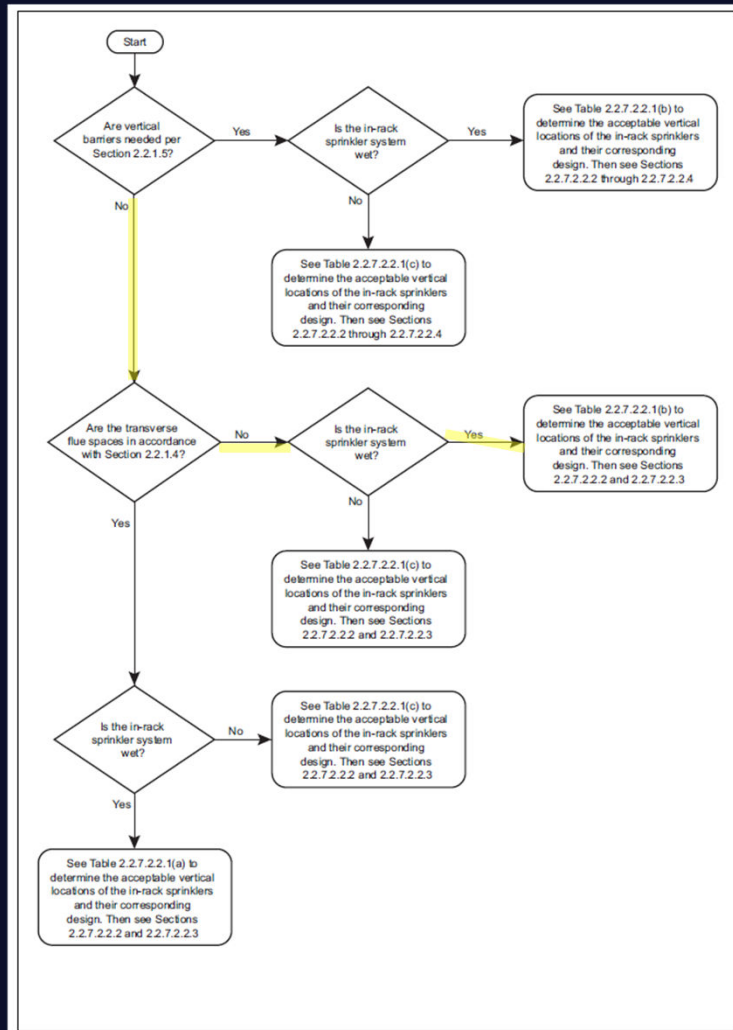
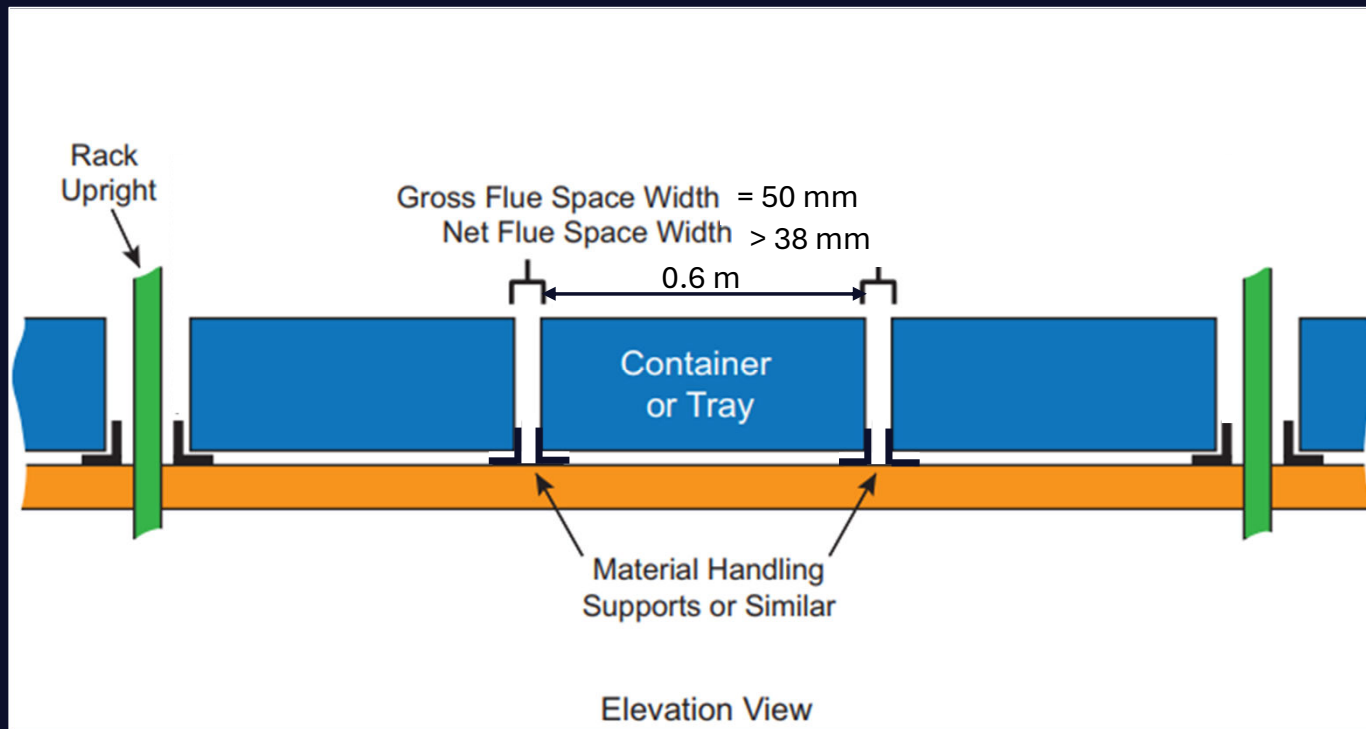


Table 2.2.7.2.2.1(b). Wet, Vertical In-Rack Sprinkler Locations and In-Rack Sprinkler Designs for the Protection of Open-Top, Combustible Containers Stored in a Mini-Load Type System with Flue Spaces Not in Accordance with Section 2.2.1.4

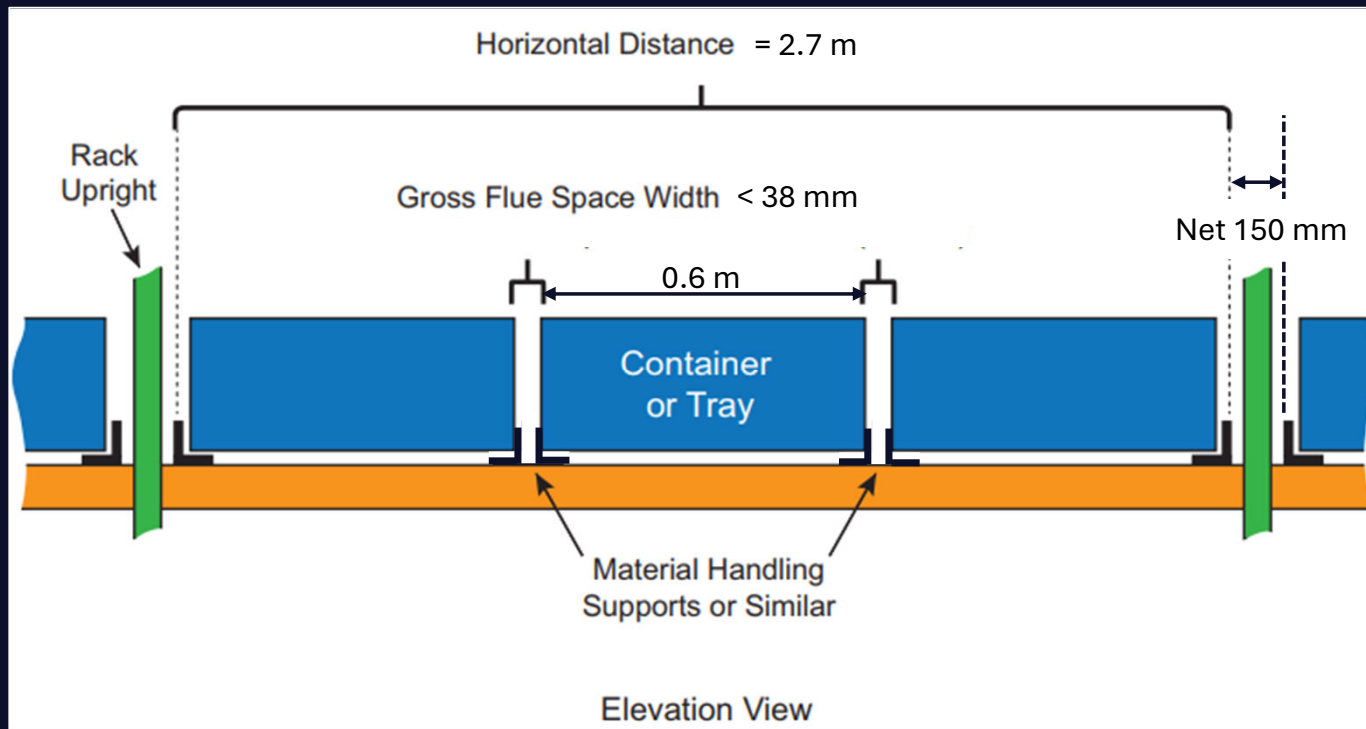
<i>Recommended IRAS Arrangement per Table 2.2.7.2.1</i>	<i>Maximum Vertical Distance Between IRAS, ft (m)</i>	<i>Minimum IRAS Design Flow, gpm(L/min)*</i>	<i>Minimum IRAS K-factor</i>	<i>No. of IRAS in Design</i>	<i>Hydraulically Balance IRAS System with Ceiling System?</i>
<i>Figure 2.2.7.2.1(a)</i>	10 (3.0)	100 (380)	11.2 (160)	4 on top IRAS level	No
<i>Figures 2.2.7.2.1(b), 2.2.7.2.1(c), or 2.2.7.2.1(e)</i>	10 (3.0)	100 (380)	11.2 (160)	6 on top IRAS level	No

- Inadequate transverse flues = in-rack sprinklers up to maximum 3.0 m vertical spacing
- Check if you need vertical barriers also

Horizontal-Loading ASRS: Flue Space Examples

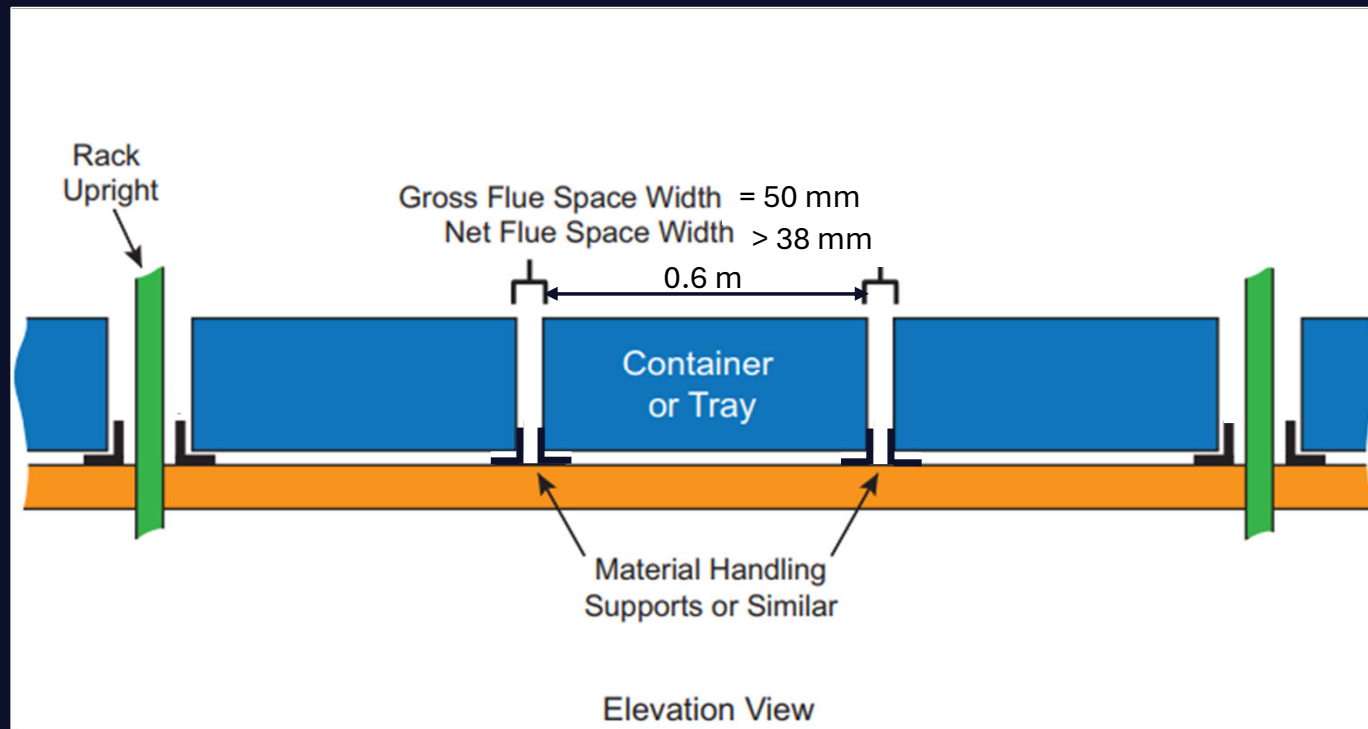


Horizontal-Loading ASRS: Flue Space Examples



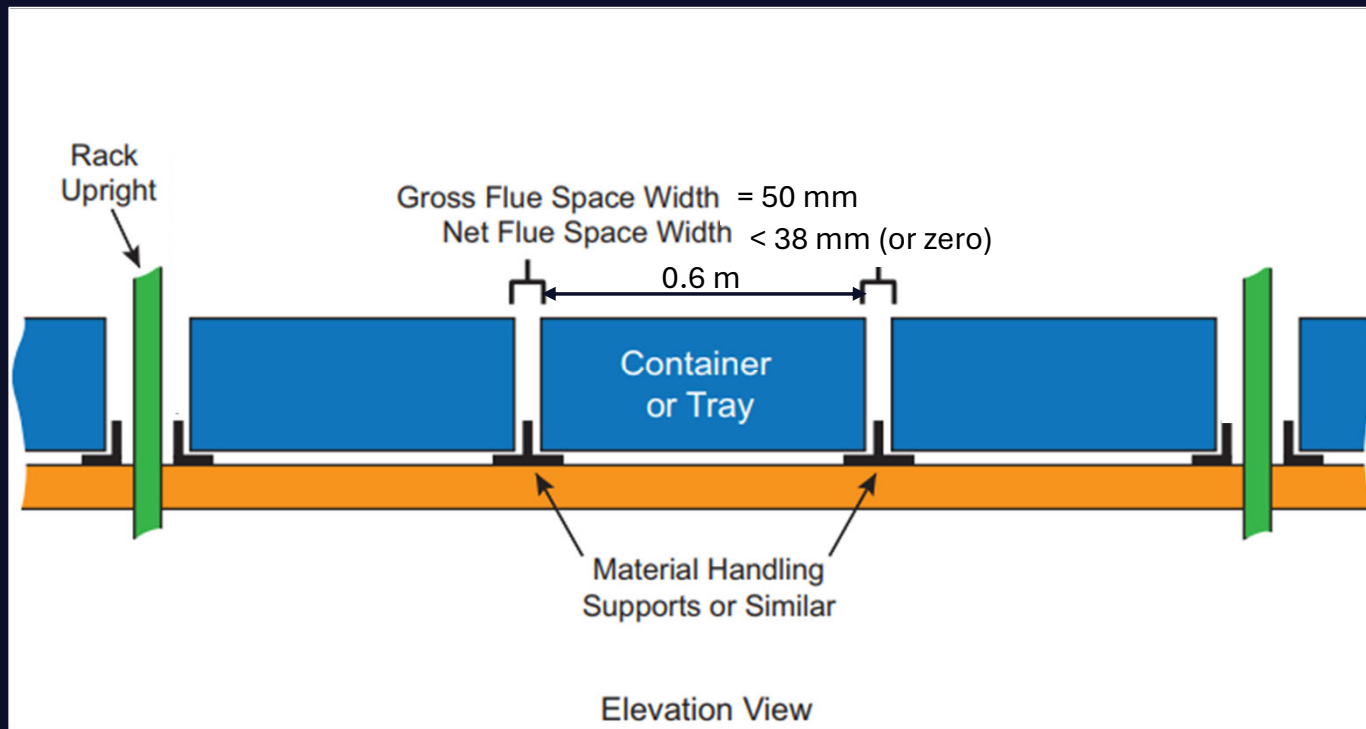
Horizontal-Loading ASRS: Flue Space Examples

- Back to the first example



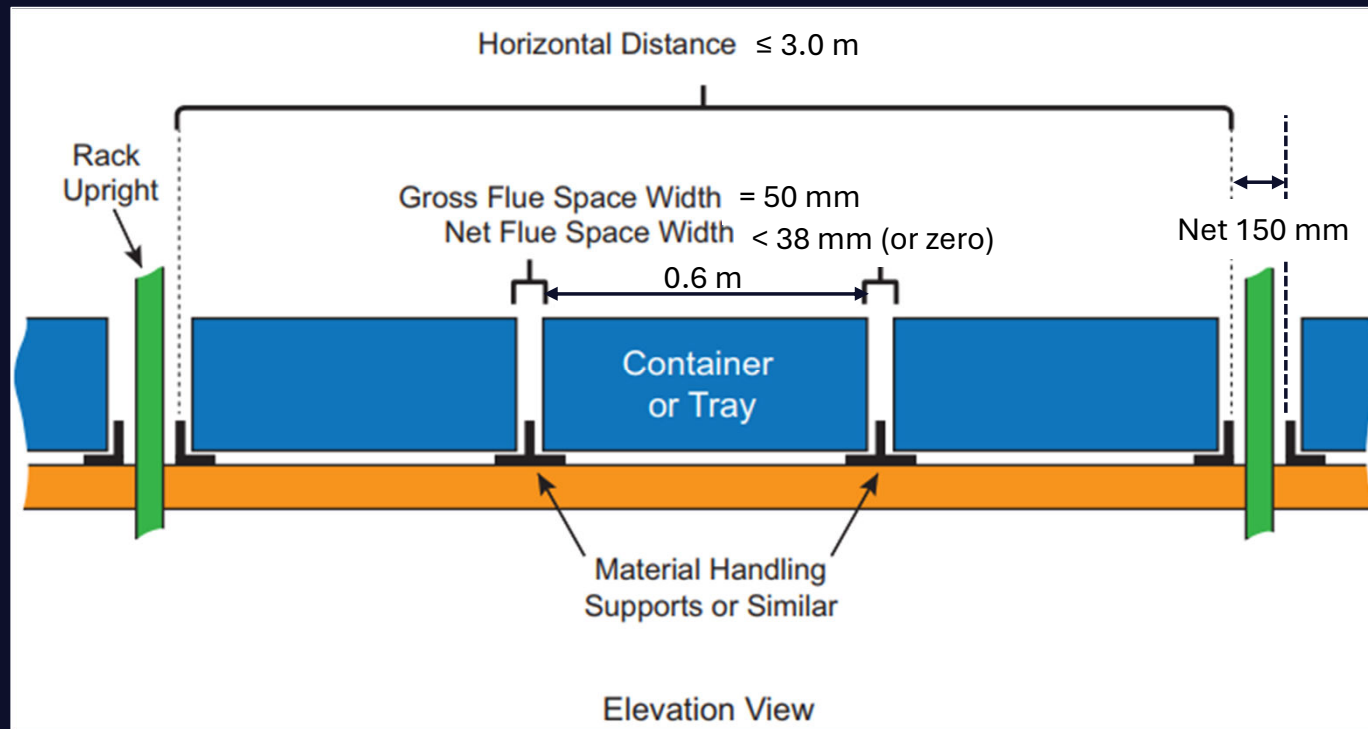
Horizontal-Loading ASRS: Flue Space Examples

- But now the flues are blocked by guides



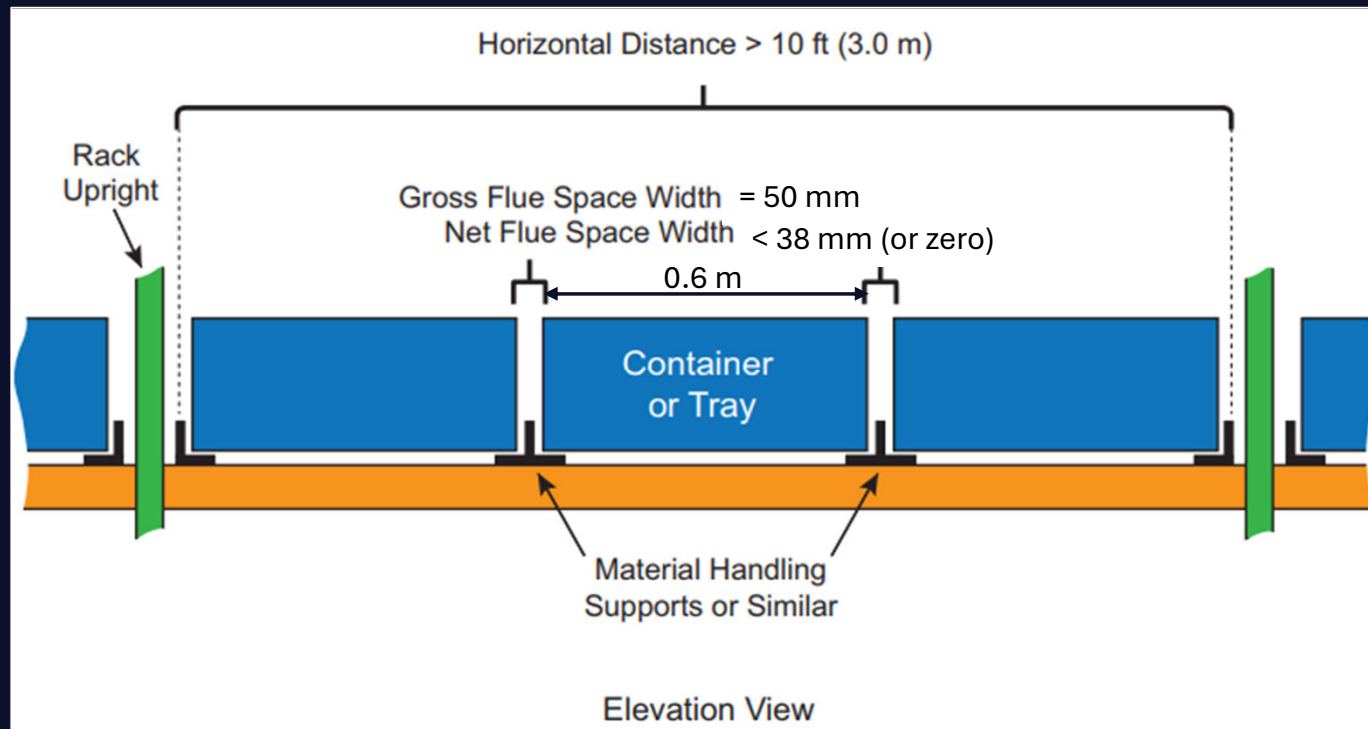
Horizontal-Loading ASRS: Flue Space Examples

- This would be ok if we have a larger flue (≥ 150 mm) every 3 m or less



Horizontal-Loading ASRS: Flue Space Examples

- But if there is no adequate flue for a distance of more than 3 m, see if vertical barriers are needed



Horizontal-Loading ASRS: Flue Space Examples

2.2.1.5 Vertical Barriers for Horizontal-Loading ASRS Storage Arrangements

2.2.1.5.1 Vertical barriers are recommended at rack uprights on spacing not exceeding 12 ft (3.7 m) when:

1. Transverse flue spaces between rack uprights have a minimum gross width of 1.5 in. (38 mm), and
2. Material handling supports within the rack structure, such as vertical alignment guides or similar, result in the transverse flue spaces between rack uprights having a maximum net width of 0.5 in. (13 mm), and
3. The horizontal distance between the affected transverse flue spaces outlined above is greater than 10 ft (3.0 m)

See Figure 2.2.1.5.1 for a visual demonstration of this guidance.

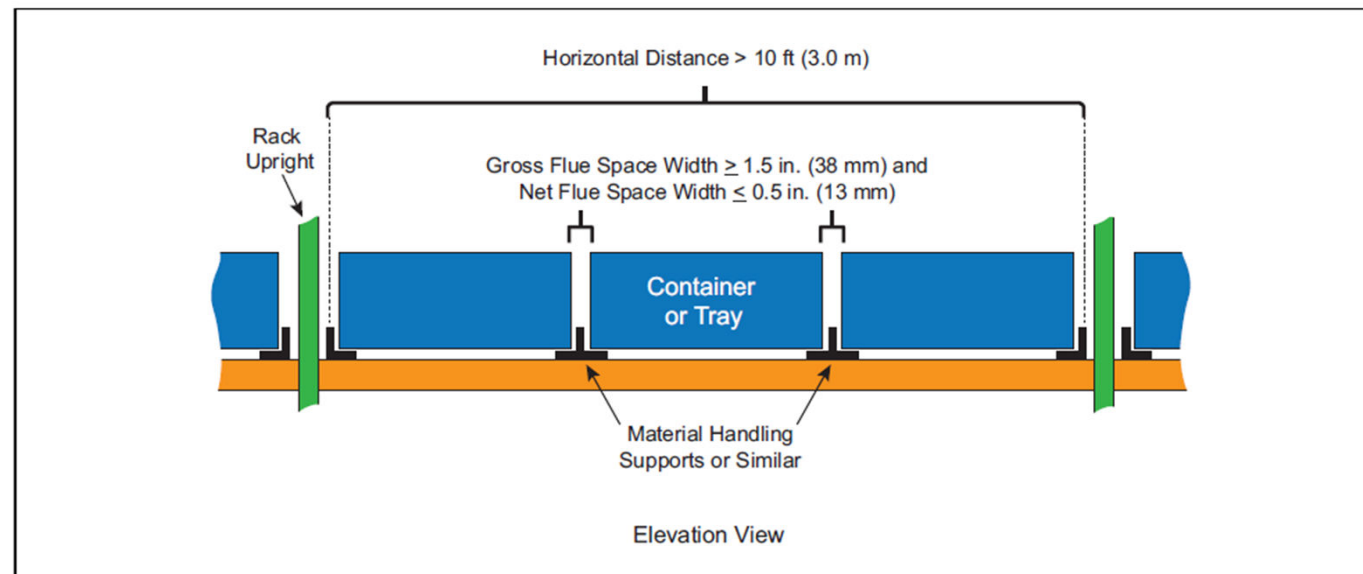
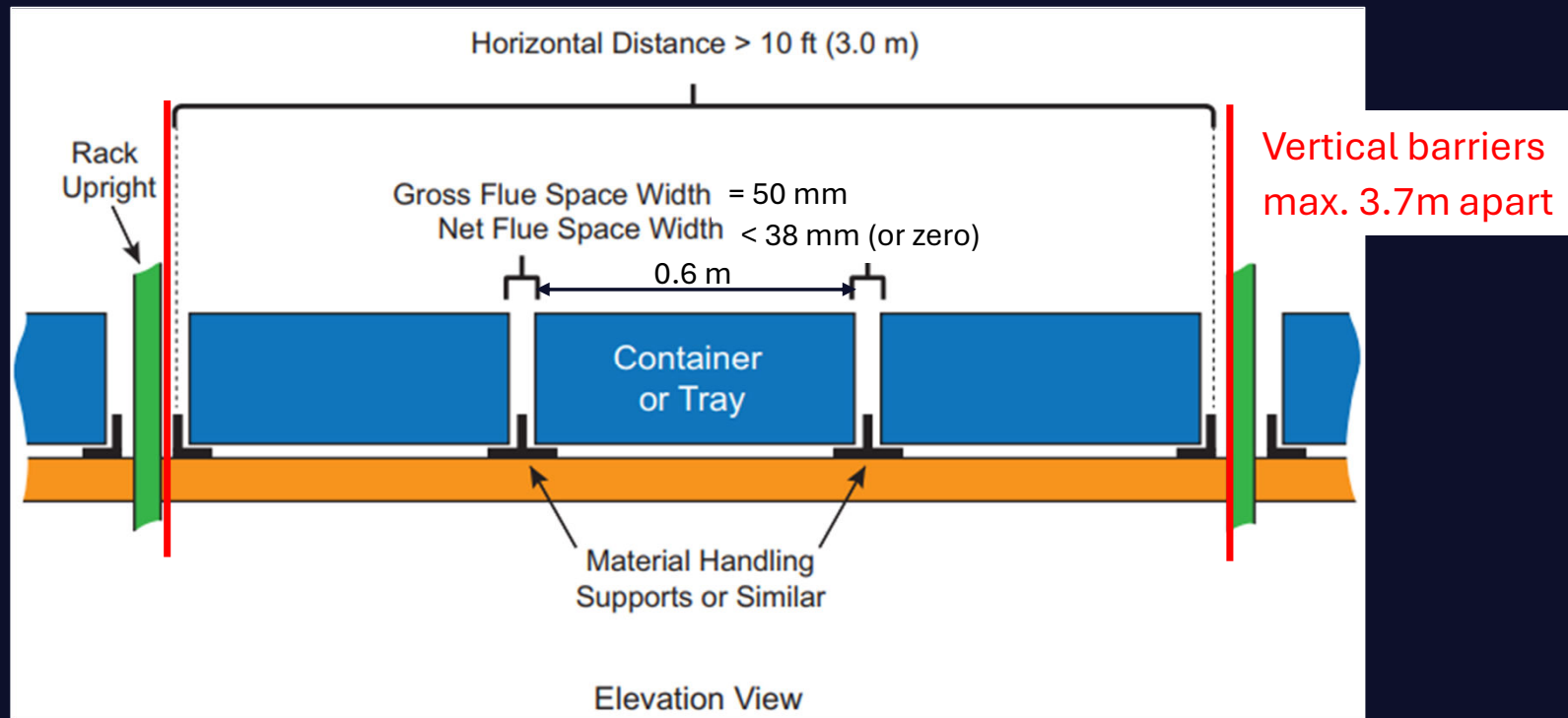


Fig. 2.2.1.5.1. Example of material handling supports creating a condition where vertical barriers would be needed

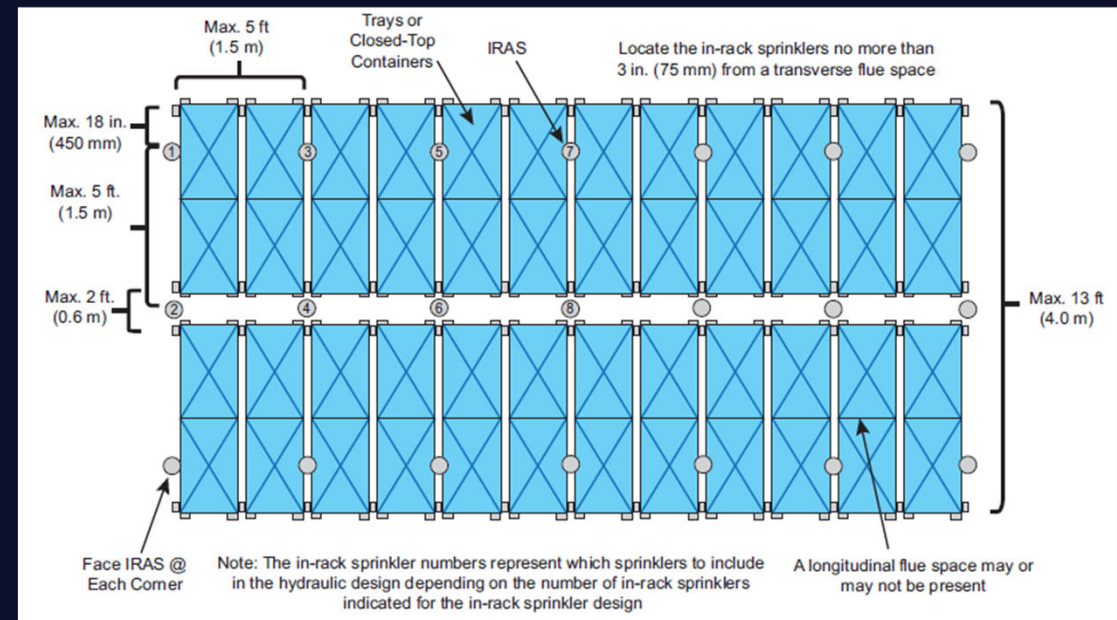
Horizontal-Loading ASRS: Flue Space Examples

- This example would be a case where vertical barriers are needed (in addition to in-racks on maximum 3 m vertical spacing)



Horizontal-Loading ASRS: Horizontal IRAS Arrangements

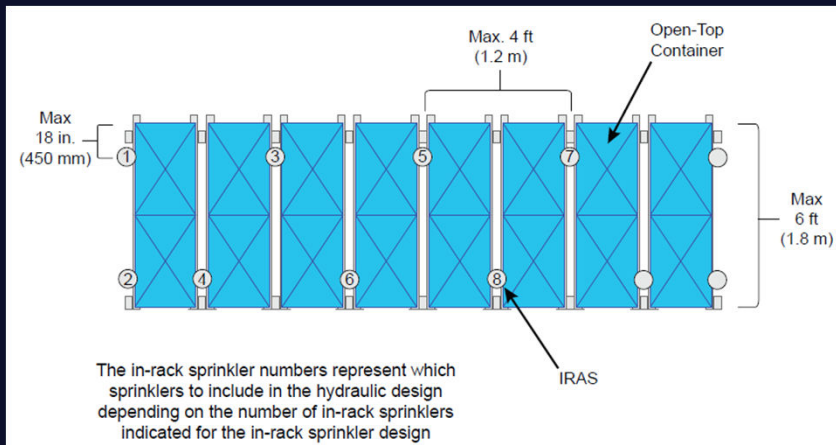
- In-rack layouts and sprinkler designs vary slightly depending on:
 - Mini-load or shuttle system.
 - Cardboard or plastic containers.
 - Open or closed-up containers.
- April 2026 revision includes some useful changes
 - Increase horizontal spacing to max 1.5 m
 - Heads can be up to 75mm from the flues
 - Longitudinal flue between containers may or may not be present



Horizontal-Loading ASRS: Horizontal IRAS Arrangements

Previously in 8-34:

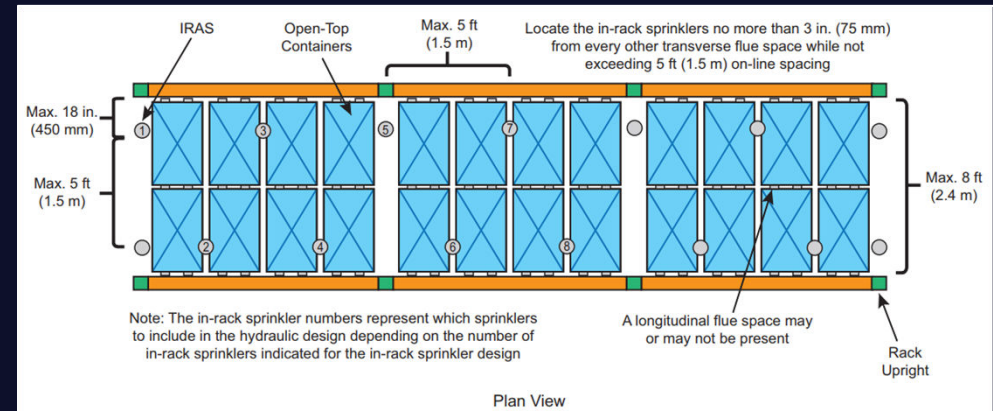
- 10 IRAS Figures in Section 2.2.3.2.1
- 12 IRAS Figures in Section 2.2.4.2.1
- 8 IRAS Figures in Section 2.2.6.2.1
- 12 IRAS Figures in Section 2.2.7.2.1



Shuttle System IRAS Figure

New for 2026:

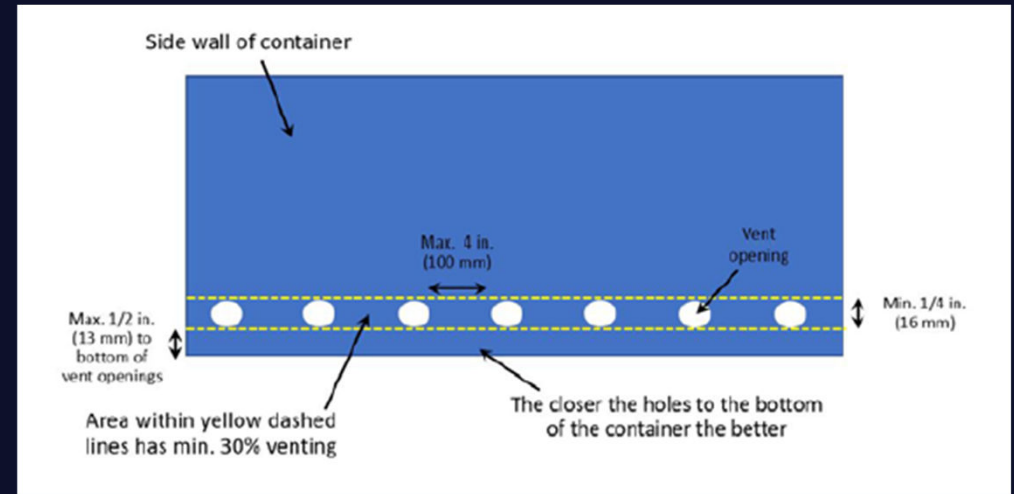
- 5 IRAS Figures in Section 2.2.3.2.1
- 5 IRAS Figures in Section 2.2.4.2.1
- 5 IRAS Figures in Section 2.2.6.2.1
- 5 IRAS Figures in Section 2.2.7.2.1



Shuttle System IRAS Figure

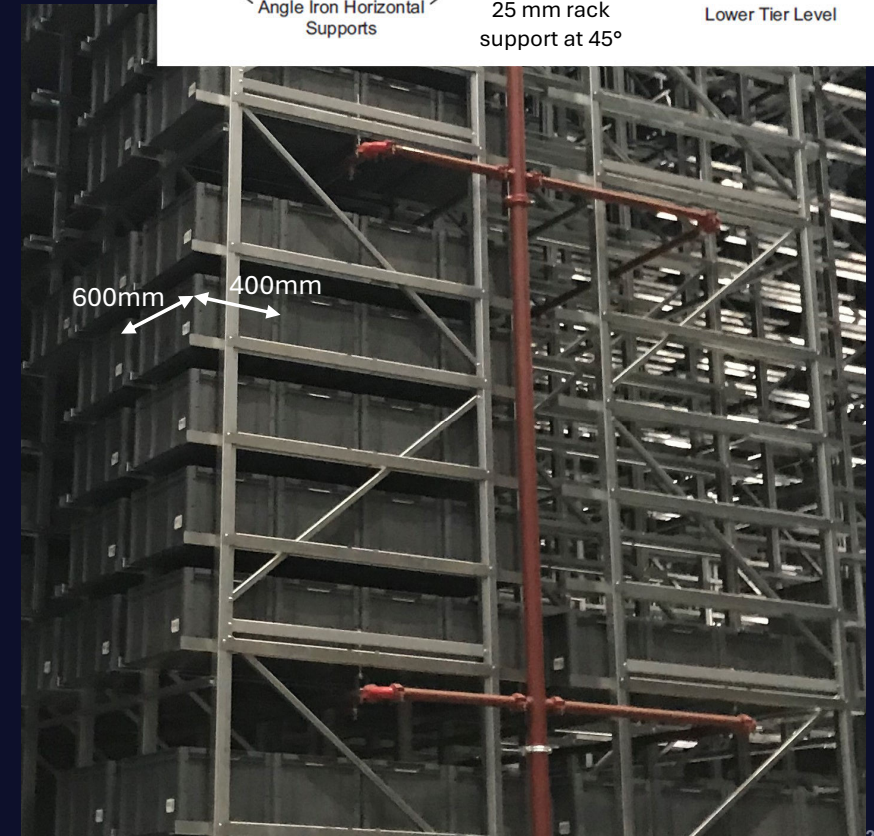
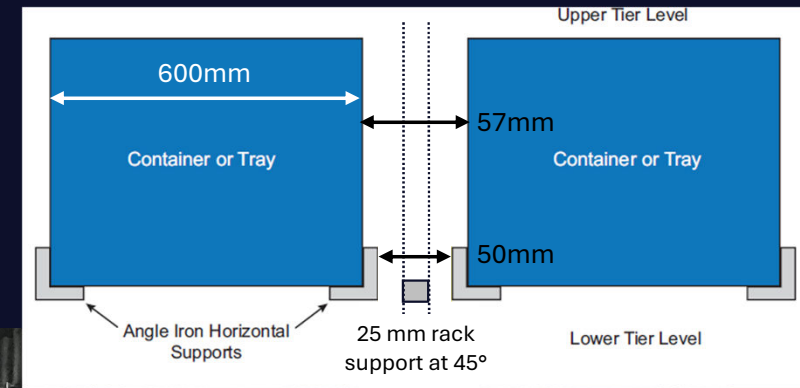
Horizontal-Loading ASRS: Vented Containers

- Previous versions of DS8-34 allowed lower protection criteria for containers that would shed water through holes around the base
- Concept was problematic (blockage of holes)
- Removed references to venting



ASRS Protection: Example 1

- 600mm wide x 400mm deep x 300mm high open-top plastic boxes holding metal parts
- Supported on angle irons
- Distance between the containers is 57 mm
- 50mm gaps between angle irons
- 25mm diagonal cross bracing at 45° in the gaps
- Eight boxes deep with central 150 mm longitudinal flue, each rack “half” 1.6 m wide
- 18 m tall in 23 m heated warehouse



Type of System

- Horizontal-loading system
- Angle iron supports so “mini-load”

FM Property Loss Prevention Data Sheets

8-34

July 2017
Interim Revision April 2026
Page 1 of 122

PROTECTION FOR AUTOMATIC STORAGE AND RETRIEVAL SYSTEMS

Table of Contents

	Page
1.0 SCOPE	7
1.1 Changes	7
1.2 How to Use this Data Sheet	7
2.0 LOSS PREVENTION RECOMMENDATIONS	9
2.1 General Recommendations for All Automatic Storage and Retrieval Systems	9
2.1.1 FM Approved Equipment, Materials, and Services	9
2.1.2 Construction and Location	9
2.1.3 Occupancy Related Recommendations	9
2.1.4 Protection	10
2.1.5 Final Extinguishment	13
2.1.6 Electrical Systems for ASRS Storage Arrangements	13
2.1.7 Control Systems for ASRS Storage Arrangements	14
2.2 Horizontal-Loading Automatic Storage and Retrieval Systems (ASRS) Using Small Containers or Small Trays	14
2.2.1 General Guidelines for Horizontal-Loading ASRS Storage Arrangements	15

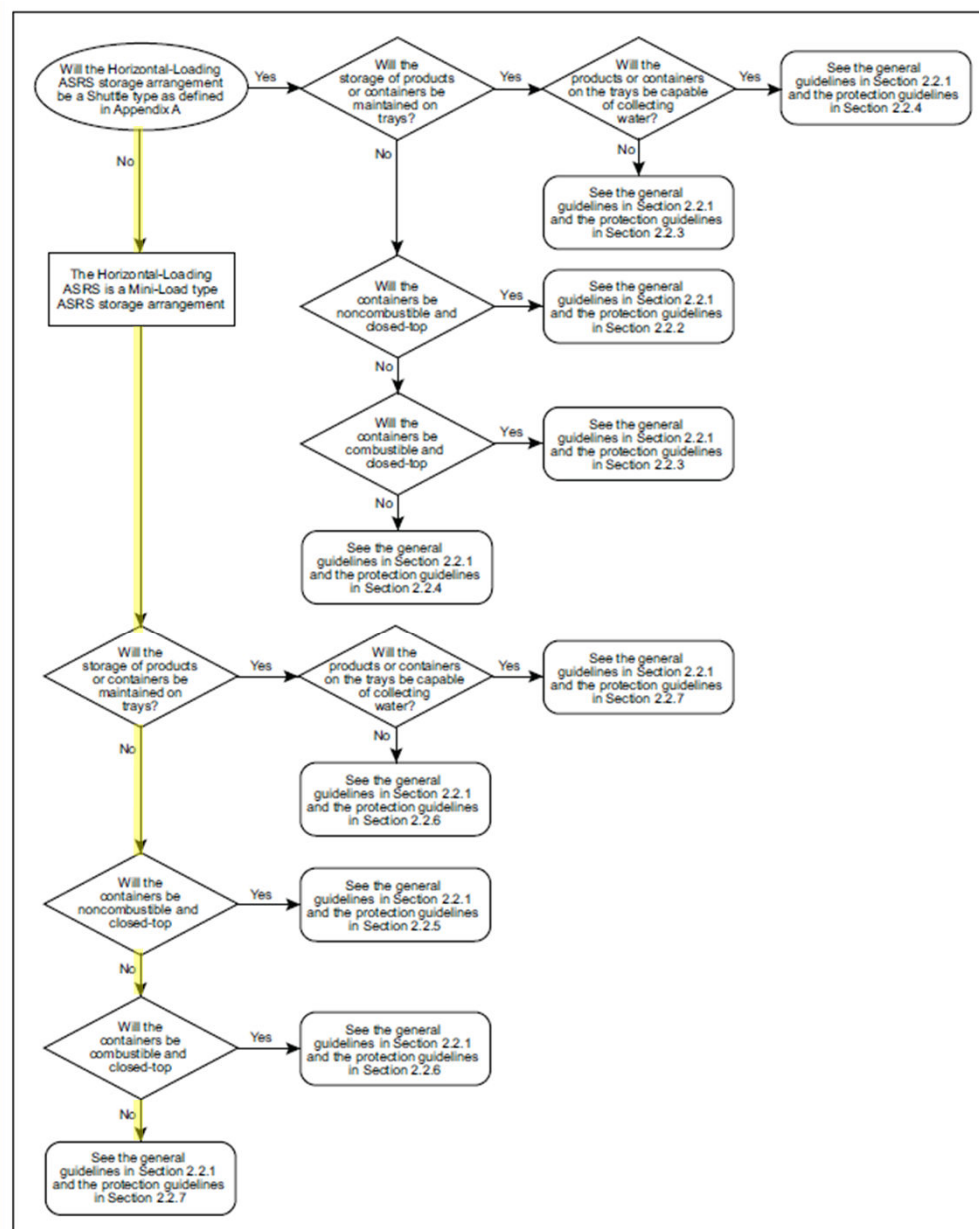
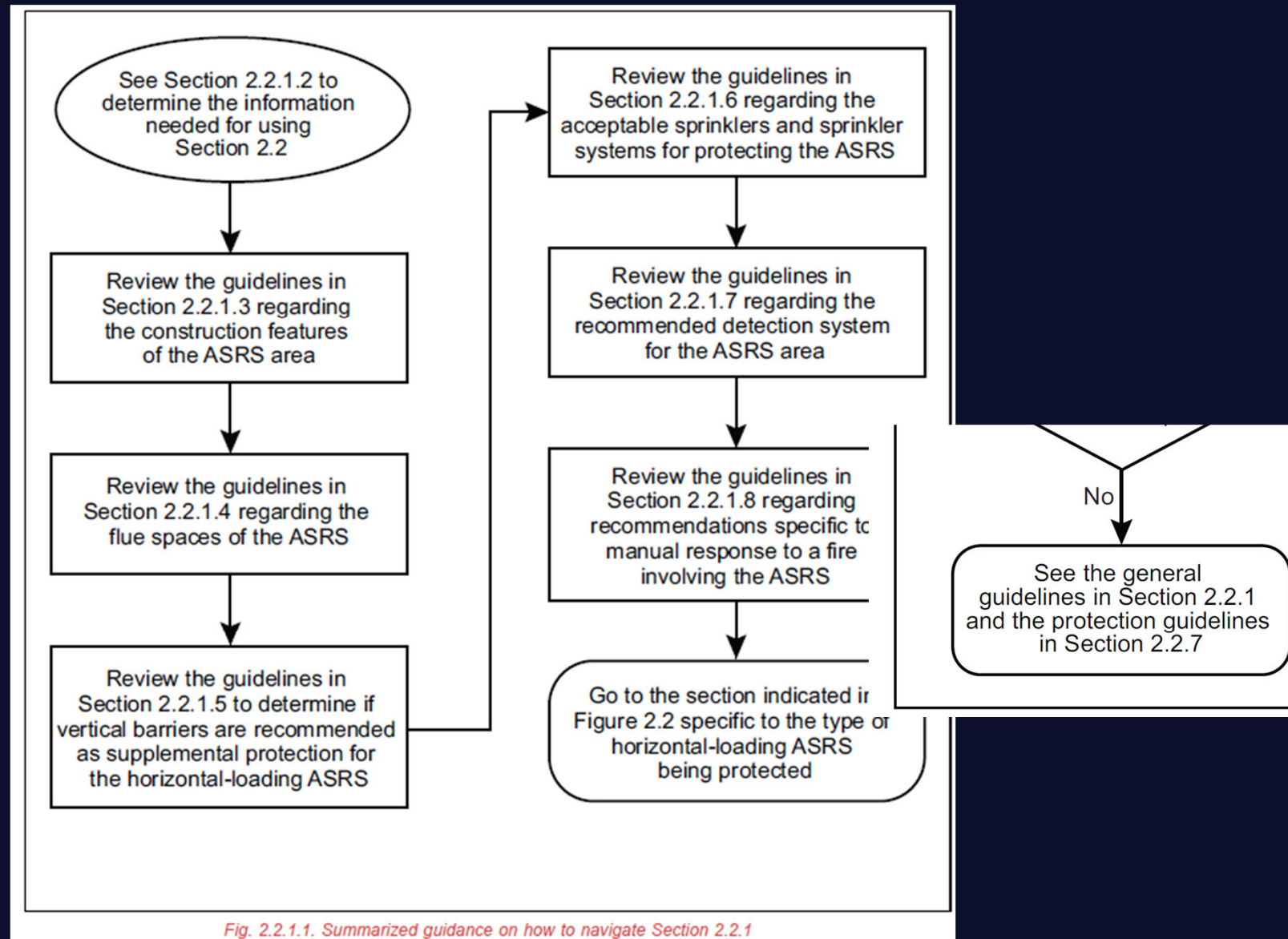
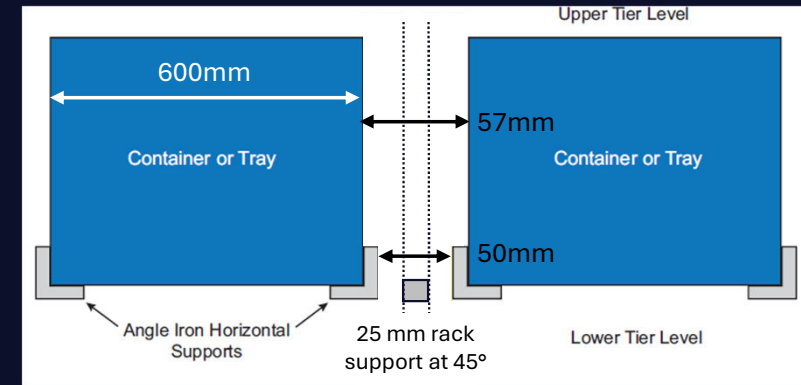


Fig. 2.2. Summarized guidance on how to navigate Section 2.2



Flue Spaces

- 25 mm diagonal cross bracing at 45° in the gaps can be ignored
- Gross transverse flue space = 57 mm
- Net transverse flue space = 57 mm
- Distance between transverse flues is 0.607 m
- Adequate flues
- Vertical barriers not needed

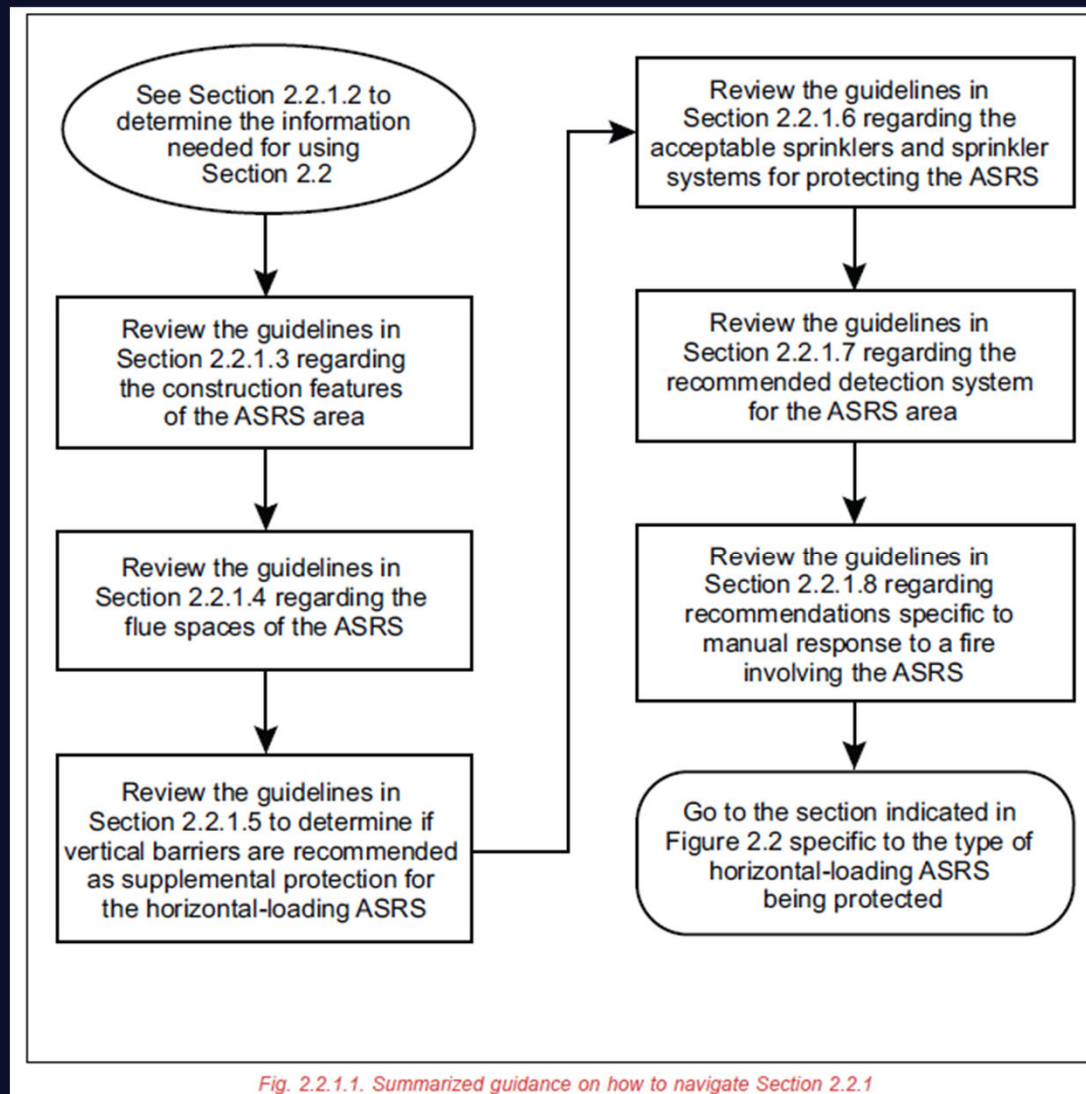


2.2.1.4.1.3 When determining the net width of a transverse flue space, an object located within the transverse flue space can be ignored when:

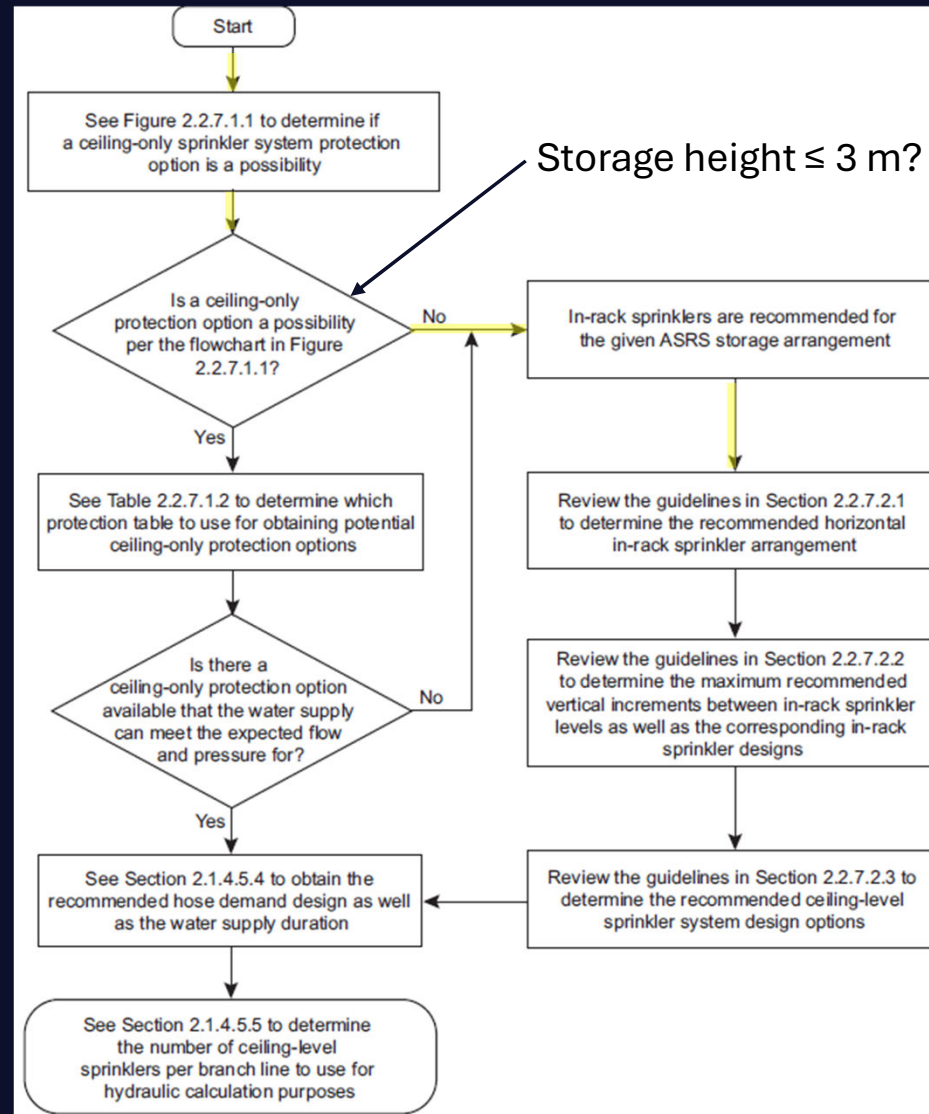
1. The object has a horizontal profile that is equal to or greater than 70% uniformly open (e.g., mesh shelving) as represented in Figure 2.2.1.4.1.3(a), or
2. The object is no wider than 4 in. (100 mm) and is at an angle of 30° or more (e.g., cross bracing within a rack upright) as represented in Figure 2.2.1.4.1.3(b).

Table 2.2.1.4.2.1. Recommended Minimum Net Transverse Flue Space Widths within a Horizontal-Loading ASRS

Nominal Horizontal Distance Between Transverse Flue Spaces, ft (m)	Recommended Minimum Nominal Net Transverse Flue Space Width, in. (mm)
2 (0.6)	1.5 (38)
2.5 (0.75)	2 (50)
5 (1.5)	3 (75)
10 (3.0)	6 (150)
> 10 (3.0)	In-rack sprinklers are needed. See Section 2.2.1.5 to see if vertical barriers are needed too



2.2.7 Protection of Horizontal-Loading, Mini-Load ASRS Storage Arrangements Where Open-Top, Combustible Containers are Being Used



2.2.7.2.1 Horizontal Arrangement of In-Rack Sprinklers for the Protection of Open-Top, Combustible Containers in a Mini-Load ASRS

Use Table 2.2.7.2.1 to determine the recommended horizontal in-rack sprinkler arrangement for the storage rack to be protected.

Table 2.2.7.2.1. Recommended Horizontal In-Rack Sprinkler Arrangements for the Protection of Open-Top, Combustible Containers in a Mini-Load ASRS

<i>Overall Maximum Rack Depth, ft (m)</i>	<i>In-Rack Sprinkler Type</i>	<i>Applicable Horizontal IRAS Arrangement Figures</i>
3 (0.9)	Wet or Dry	2.2.7.2.1(a)
8 (2.4)	Wet or Dry	2.2.7.2.1(b)
13 (4.0)	Wet	2.2.7.2.1(c)
	Dry	2.2.7.2.1(d)
Over 13 (4.0)	Wet or Dry	2.2.7.2.1(e)

APPENDIX A GLOSSARY OF TERMS

ASRS overall rack row depth: The horizontal length of storage within a horizontal-loading ASRS storage arrangement, measured perpendicular to the loading aisle, between (1) the face of the rack, and (2) a horizontal opening that is more than 2 ft (0.6 m) wide. See Figure A-1 for a visual representation of this term.

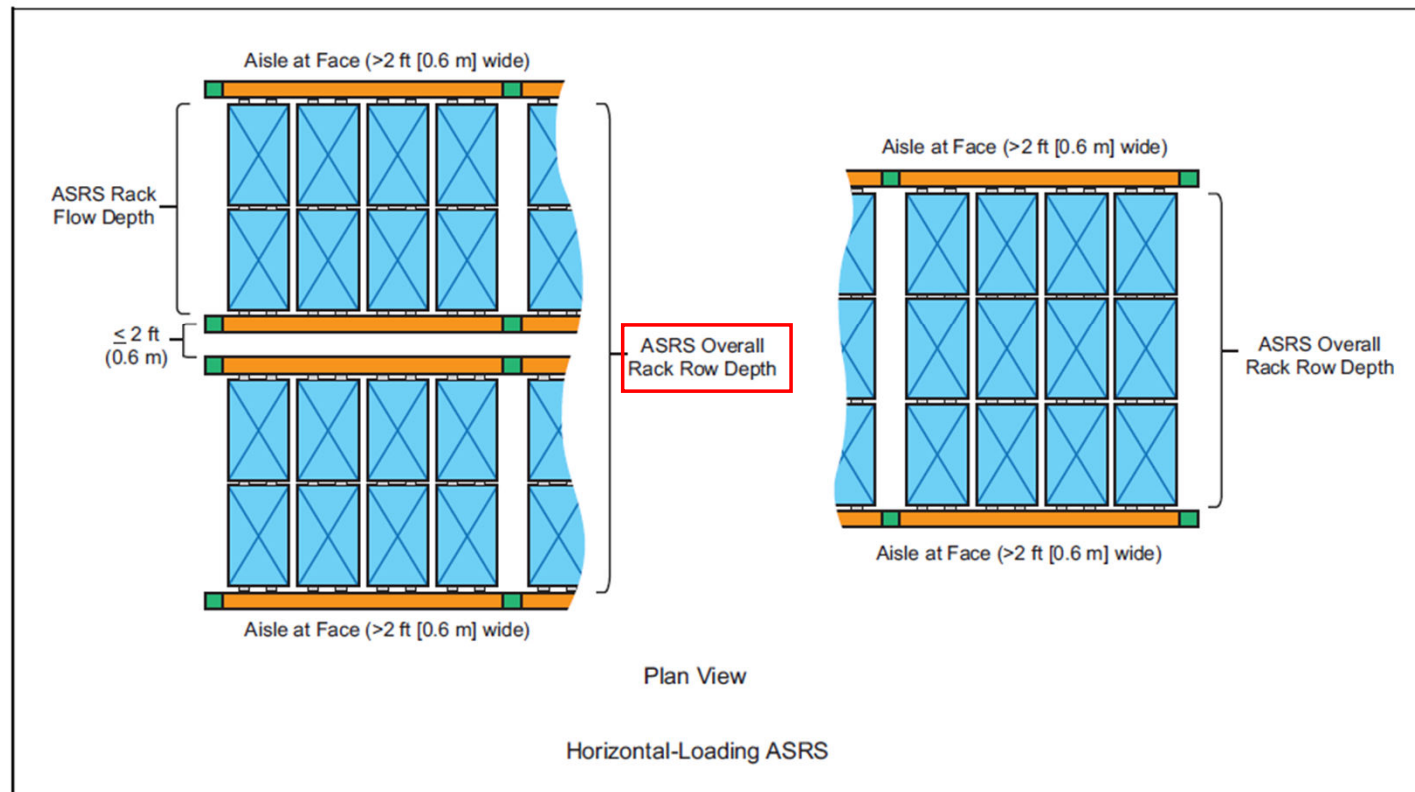


Fig. A-1. Example of ASRS overall rack row depth

Horizontal In-Rack Arrangement

- Eight boxes deep with central 150 mm longitudinal flue, each rack “half” 1.6 m wide
- Rack row depth = 1.6 m
- Overall rack row depth = 3.35 m



2.2.7.2.1 Horizontal Arrangement of In-Rack Sprinklers for the Protection of Open-Top, Combustible Containers in a Mini-Load ASRS

Use Table 2.2.7.2.1 to determine the recommended horizontal in-rack sprinkler arrangement for the storage rack to be protected.

Table 2.2.7.2.1. Recommended Horizontal In-Rack Sprinkler Arrangements for the Protection of Open-Top, Combustible Containers in a Mini-Load ASRS

<i>Overall Maximum Rack Depth, ft (m)</i>	<i>In-Rack Sprinkler Type</i>	<i>Applicable Horizontal IRAS Arrangement Figures</i>
3 (0.9)	Wet or Dry	2.2.7.2.1(a)
8 (2.4)	Wet or Dry	2.2.7.2.1(b)
13 (4.0)	Wet	2.2.7.2.1(c)
	Dry	2.2.7.2.1(d)
Over 13 (4.0)	Wet or Dry	2.2.7.2.1(e)

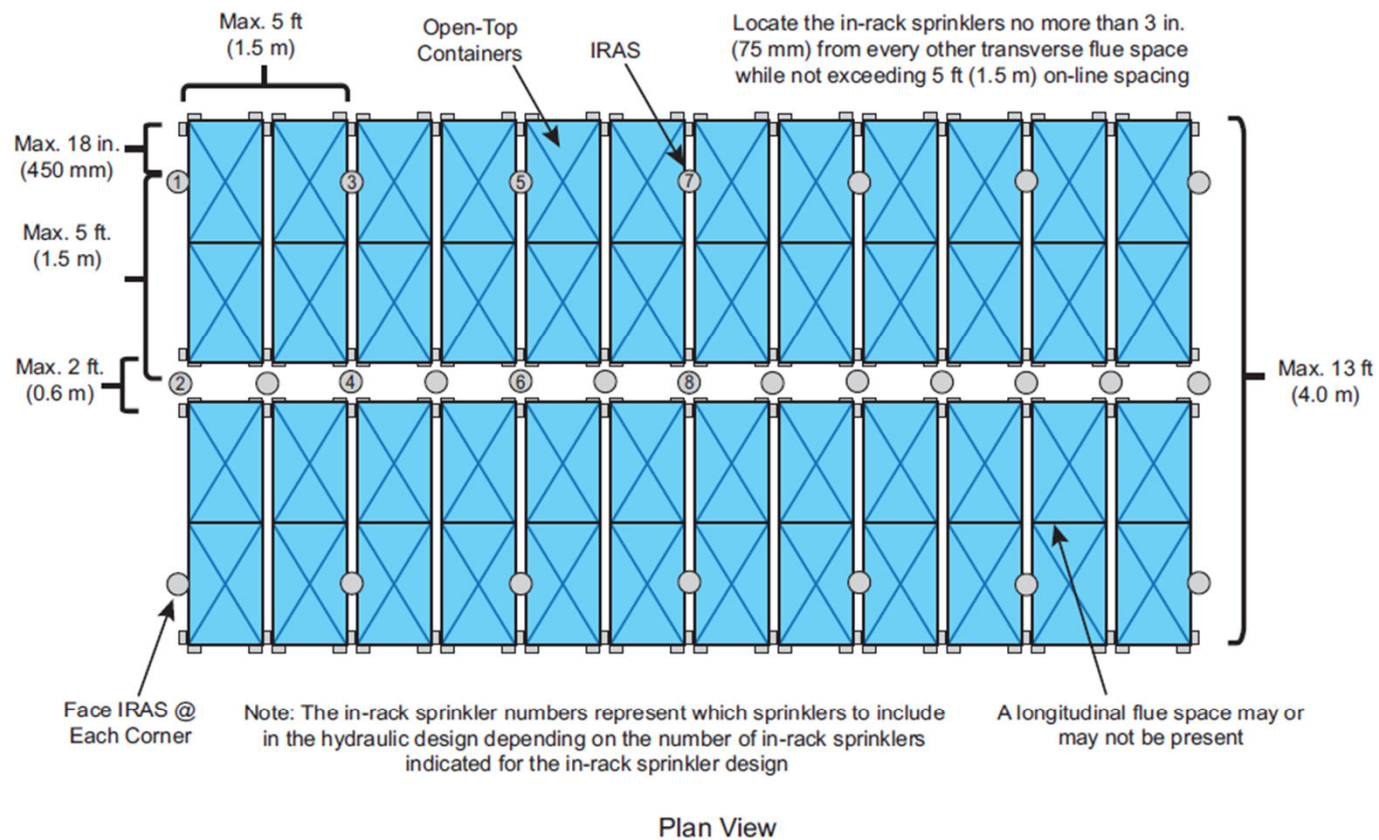
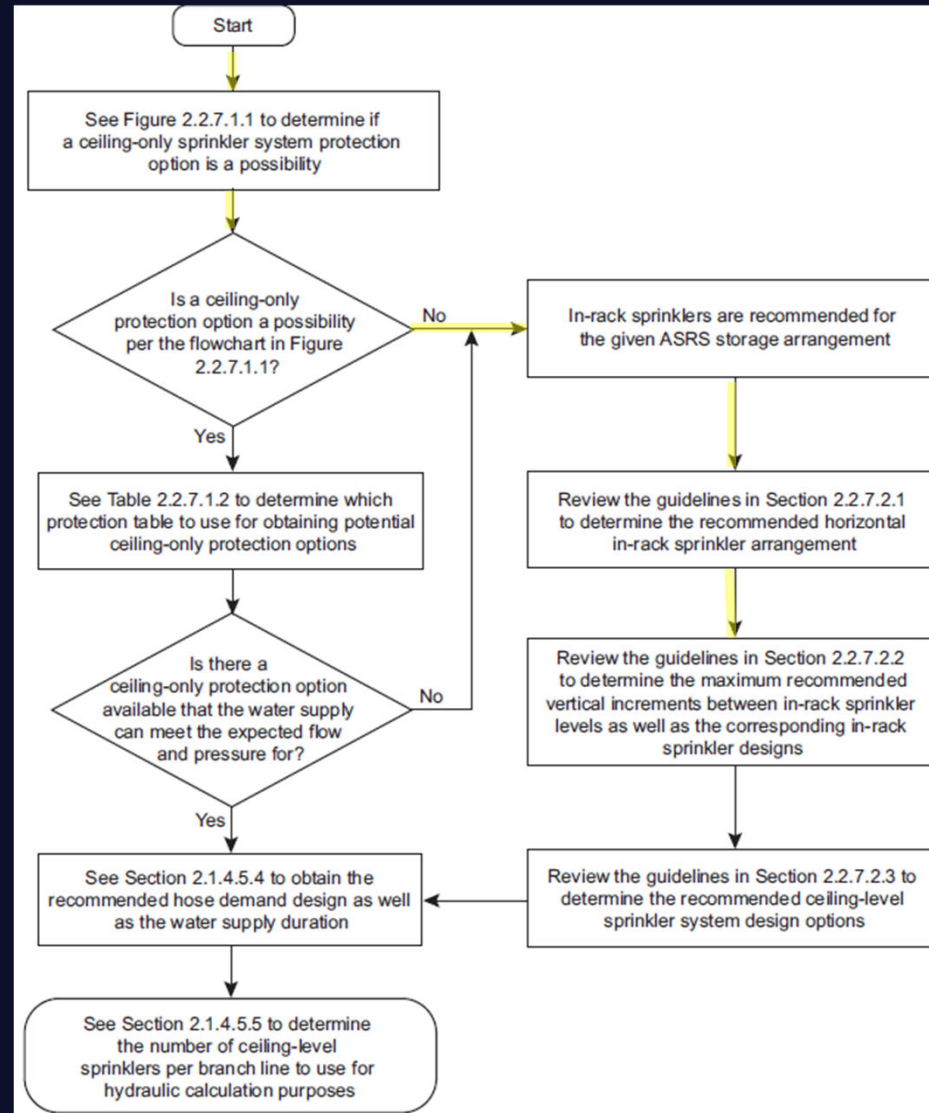


Fig. 2.2.7.2.1(c). Horizontal IRAS for Open-Top Combustible Containers within a Mini-Load ASRS Where the Overall Rack Depths Do Not Exceed 13 ft (4.0 m) per Table 2.2.7.2.1

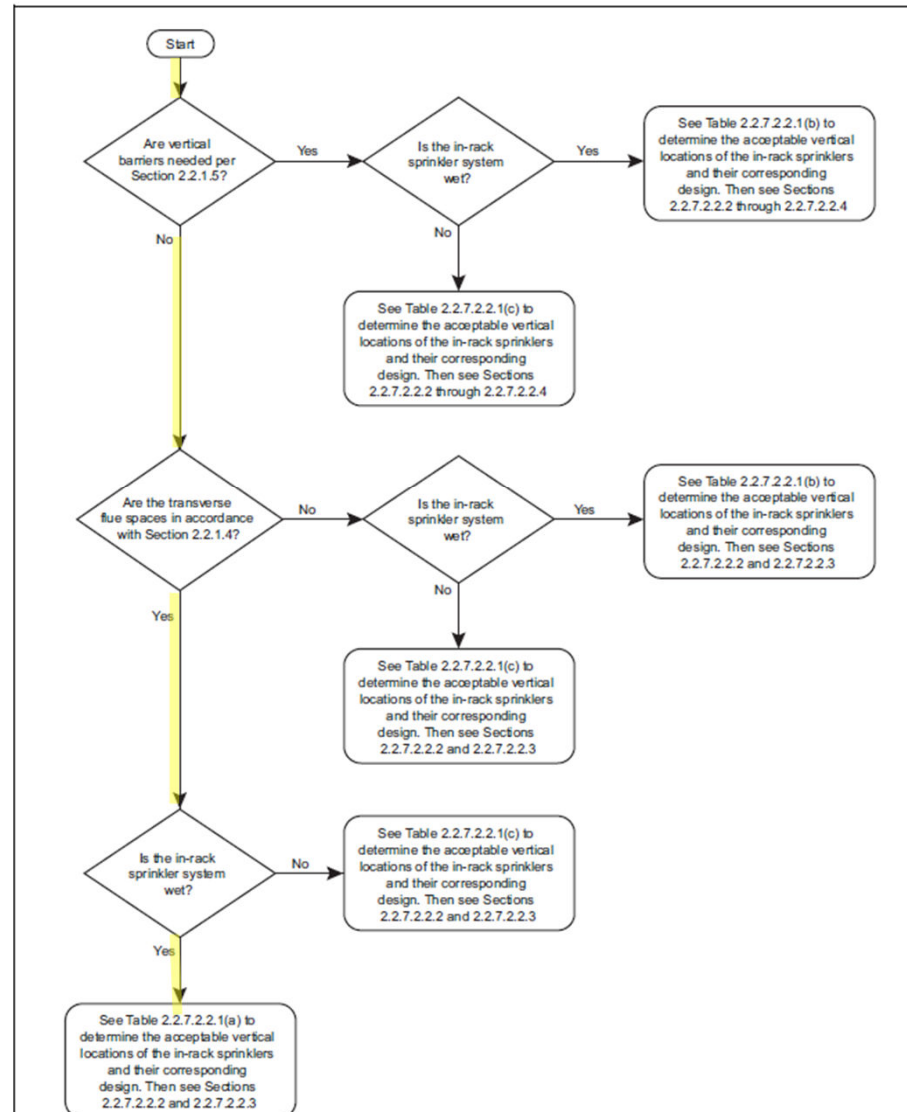
2.2.7 Protection of Horizontal-Loading, Mini-Load ASRS Storage Arrangements Where Open-Top, Combustible Containers are Being Used



Vertical In-Rack Spacing and Design

2.2.7.2.2 Vertical Location of In-Rack Sprinklers and In-Rack Sprinkler System Designs for the Protection of Open-Top, Combustible Containers in a Mini-Load ASRS

2.2.7.2.2.1 See the flowchart in Figure 2.2.7.2.2.1 to determine which protection table to use for obtaining the allowable in-rack sprinkler vertical locations, as well as the corresponding recommended in-rack sprinkler design.



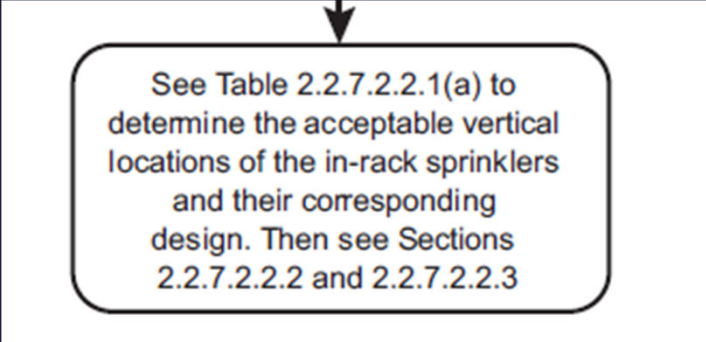
Vertical In-Rack Spacing and Design

Table 2.2.7.2.2.1(a). Wet, Vertical In-Rack Sprinkler Locations and In-Rack Sprinkler Designs for the Protection of Open-Top, Combustible Containers Stored in a Mini-Load Type System *with Flue Spaces in Accordance with Section 2.2.1.4*

Recommended IRAS Arrangement per Table 2.2.7.2.1	Maximum Vertical Distance Between IRAS, ft (m)	Minimum IRAS Design Flow, gpm (L/min)*	Minimum IRAS K-factor	No. of IRAS in Design	Hydraulically Balance IRAS System with Ceiling System?
Figure 2.2.7.2.1(a)	10 (3.0)	100 (380)	11.2 (160)	4 on top IRAS level	No
	15 (4.6)	140 (530)	22.4 (320) Pendent	6 on top IRAS level	No
Figures 2.2.7.2.1(b), 2.2.7.2.1(c), or 2.2.7.2.1(e)	10 (3.0)	100 (380)	11.2 (160)	6 on top IRAS level	No
	15 (4.6)	140 (530)	22.4 (320) Pendent	6 on top IRAS level	No

* The indicated in-rack sprinkler design flow is based on a minimum 9 in. (225 mm) vertical distance between storage tier levels. If the vertical distance between vertical tier levels is less than 9 in. (225 mm), add 20 gpm (75 L/min) to the indicated design flow.





See Table 2.2.7.2.2.1(a) to determine the acceptable vertical locations of the in-rack sprinklers and their corresponding design. Then see Sections 2.2.7.2.2.2 and 2.2.7.2.2.3

2.2.7.2.2.2 Limit the storage height above the top in-rack sprinkler level to a maximum height of 10 ft (3.0 m) when flue spaces are in accordance with Section 2.2.1.4, otherwise limit the storage height above the top in-rack sprinkler level to a maximum of 5 ft (1.5 m).

2.2.7.2.2.3. While the in-rack sprinkler designs given in Tables 2.2.7.2.2.1(a) through 2.2.7.2.2.1(c) are based on flow, the corresponding design pressure for the chosen in-rack sprinkler cannot be less than 7 psi (0.5 bar). When the design pressure will be less than 7 psi (0.5 bar), use a minimum pressure of 7 psi (0.5 bar) for design purposes, regardless of the in-rack sprinkler's K-factor value.

Ceiling Sprinkler Design

- Determine the ceiling design by using the vertical distance between the top in-rack level and ceiling height

Table 2.2.7.2.3.1. Ceiling-Level Sprinkler Protection Guidelines, in Combination with In-Rack Sprinklers, on a Wet System for the Protection of Open-Top Combustible Containers in a Mini-Load ASRS; No. of AS @ psi (bar)

Max. Storage Height Above Top IRAS Level, ft (m)	Max. Vertical Distance Between Top IRAS Level and Ceiling, ft (m)	Ceiling-Level Sprinkler Protection Options for Mini-Load ASRS Arrangements with Open-Top Combustible Containers; No. of AS @ psi (bar)															
		Wet System, Pendent Storage Sprinklers, 160°F (70°C)								Wet System, Upright Storage Sprinklers, 160°F (70°C)							
		Quick-Response				Standard-Response				Quick-Response				Standard-Response			
		K11.2 (160)	K14.0 (200)	K16.8 (240)	K22.4 (320)	K25.2 (360)	K25.2EC (360EC)	K28.0 (400)K	33.6 (480)	K11.2 (160)	K14.0 (200)	K19.6 (280)	K25.2 (360)	K11.2 (160)	K14.0 (200)	K16.8 (240)	K25.2EC (360EC)
0 (0)	Any	20 @ 7 (0.5)	9 @ 20 (1.4)	9 @ 20 (1.4)	9 @ 20 (1.4)	9 @ 20 (1.4)	6 @ 20 (1.4)	9 @ 40 (2.8)	9 @ 55 (3.8)	20 @ 7 (0.5)	9 @ 20 (1.4)	9 @ 16 (1.1)	9 @ 7 (0.5)	20 @ 7 (0.5)	9 @ 20 (1.4)	9 @ 20 (1.4)	6 @ 20 (1.4)
5 (1.5)	10 (3.0)	20 @ 30 (2.1)	12 @ 25 (1.7)	12 @ 18 (1.2)	9 @ 20 (1.4)	9 @ 20 (1.4)	10 @ 22 (1.5)	9 @ 40 (2.8)	9 @ 55 (3.8)	20 @ 30 (2.1)	20 @ 18 (1.2)	20 @ 16 (1.1)	20 @ 7 (0.5)	20 @ 30 (2.1)	20 @ 18 (1.2)	20 @ 13 (0.9)	10 @ 22 (1.0)
	15 (4.6)	25 @ 50 (3.5)	10 @ 35 (2.4)	10 @ 25 (1.7)	9 @ 20 (1.4)	9 @ 20 (1.4)	12 @ 38 (2.6)	9 @ 40 (2.8)	9 @ 55 (3.8)	25 @ 50 (3.5)	25 @ 32 (2.2)	25 @ 16 (1.1)	25 @ 10 (0.7)	25 @ 50 (3.5)	25 @ 32 (2.2)	25 @ 22 (1.5)	12 @ 38 (2.6)
	20 (6.1)		12 @ 50 (3.5)	12 @ 35 (2.4)	12 @ 20 (1.4)	12 @ 20 (1.4)		9 @ 40 (2.8)	9 @ 55 (3.8)								
10 (3.0)	15 (4.6)	25 @ 50 (3.5)	10 @ 35 (2.4)	10 @ 25 (1.7)	9 @ 20 (1.4)	9 @ 20 (1.4)	12 @ 38 (2.6)	9 @ 40 (2.8)	9 @ 55 (3.8)	25 @ 50 (3.5)	25 @ 32 (2.2)	25 @ 16 (1.1)	25 @ 10 (0.7)	25 @ 50 (3.5)	25 @ 32 (2.2)	25 @ 22 (1.5)	12 @ 38 (2.6)
	20 (6.1)		12 @ 50 (3.5)	12 @ 35 (2.4)	12 @ 20 (1.4)	12 @ 20 (1.4)		9 @ 40 (2.8)	9 @ 55 (3.8)								

Note: The ceiling-level protection options highlighted in green represent those for which the hose stream demand is 250 gpm (950 L/min) and the sprinkler system duration is 1 hour.

- If there is no option:
 - False (suspended) ceiling, or
 - Install sprinklers over the top of the storage (and use Table 2.2.7.2.3.1)

Ceiling Sprinkler Design

- Storage is 18 m high, ceiling is 23 m
- In-racks on 3 m vertical spacing i.e., at 3 m, 6 m, 9 m, 12 m, 15 m (3 m storage above top level of in-racks)
- 8 m between the top in-racks and ceiling
- No option
- Install in-racks above the top of storage
- Total 5 levels of in-rack sprinklers

Table 2.2.7.2.3.1. Ceiling-Level Sprinkler

Max. Storage Height Above Top IRAS Level, ft (m)	Max. Vertical Distance Between Top IRAS Level and Ceiling, ft (m)	Ceiling-Level		
		K11.2 (160)	K14.0 (200)	K16.8 (250)
0 (0)	Any	20 @ 7 (0.5)	9 @ 20 (1.4)	5 @ 25 (1.7)
5 (1.5)	10 (3.0)	20 @ 30 (2.1)	12 @ 25 (1.7)	7 @ 35 (2.4)
	15 (4.6)	25 @ 50 (3.5)	10 @ 35 (2.4)	6 @ 50 (3.5)
	20 (6.1)		12 @ 50 (3.5)	8 @ 50 (3.5)
10 (3.0)	15 (4.6)	25 @ 50 (3.5)	10 @ 35 (2.4)	6 @ 50 (3.5)
	20 (6.1)		12 @ 50 (3.5)	8 @ 50 (3.5)

Note: The ceiling-level protection options high

Ceiling Sprinkler Design

- In-racks on 4.5 m vertical spacing i.e., at 4.5 m, 9 m, 13.5 m, 18 m
- Total 4 levels of in-rack sprinklers and plenty of ceiling options

Table 2.2.7.2.3.1. Ceiling-Level Sprinkler

Max. Storage Height Above Top IRAS Level, ft (m)	Max. Vertical Distance Between Top IRAS Level and Ceiling, ft (m)	Ceiling-Level		
		K11.2 (160)	K14.0 (200)	K17.0 (250)
0 (0)	Any	20 @ 7 (0.5)	9 @ 20 (1.4)	5 @ 30 (0.9)
5 (1.5)	10 (3.0)	20 @ 30 (2.1)	12 @ 25 (1.7)	10 @ 30 (0.9)
	15 (4.6)	25 @ 50 (3.5)	10 @ 35 (2.4)	10 @ 30 (0.9)
	20 (6.1)		12 @ 50 (3.5)	10 @ 30 (0.9)
10 (3.0)	15 (4.6)	25 @ 50 (3.5)	10 @ 35 (2.4)	10 @ 30 (0.9)
	20 (6.1)		12 @ 50 (3.5)	10 @ 30 (0.9)

Note: The ceiling-level protection options high



Top Loading ASRS

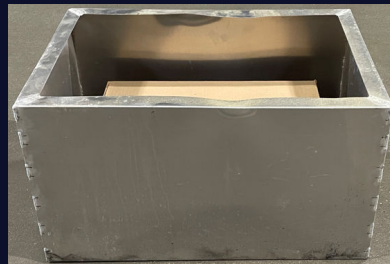
Top-Loading ASRS

Ocado Smart Platform (UK)



None flame
proagating?

Non-Solid-Wall
Containers



AutoStore (Norway)

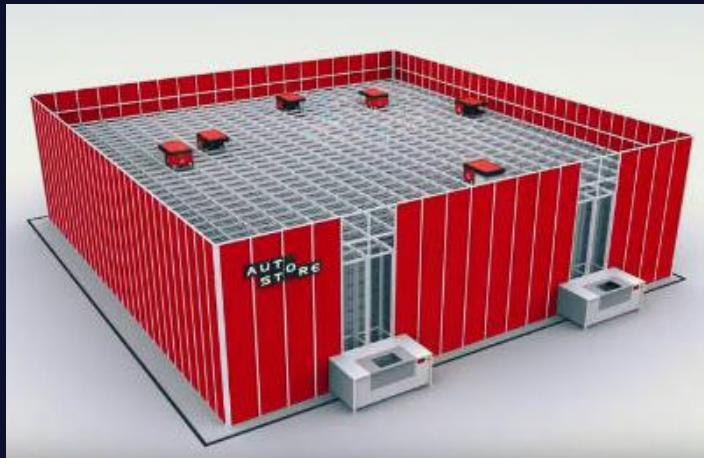


Solid-Wall
Containers



Top-Loading ASRS

- Boxes stack on each other in an array.
- Small flues.
- Limited storage height (6 m). But check...
- “Robots” on top of grid, raise and lower boxes and deliver to pick points



Full-Scale Fire Testing

Configuration

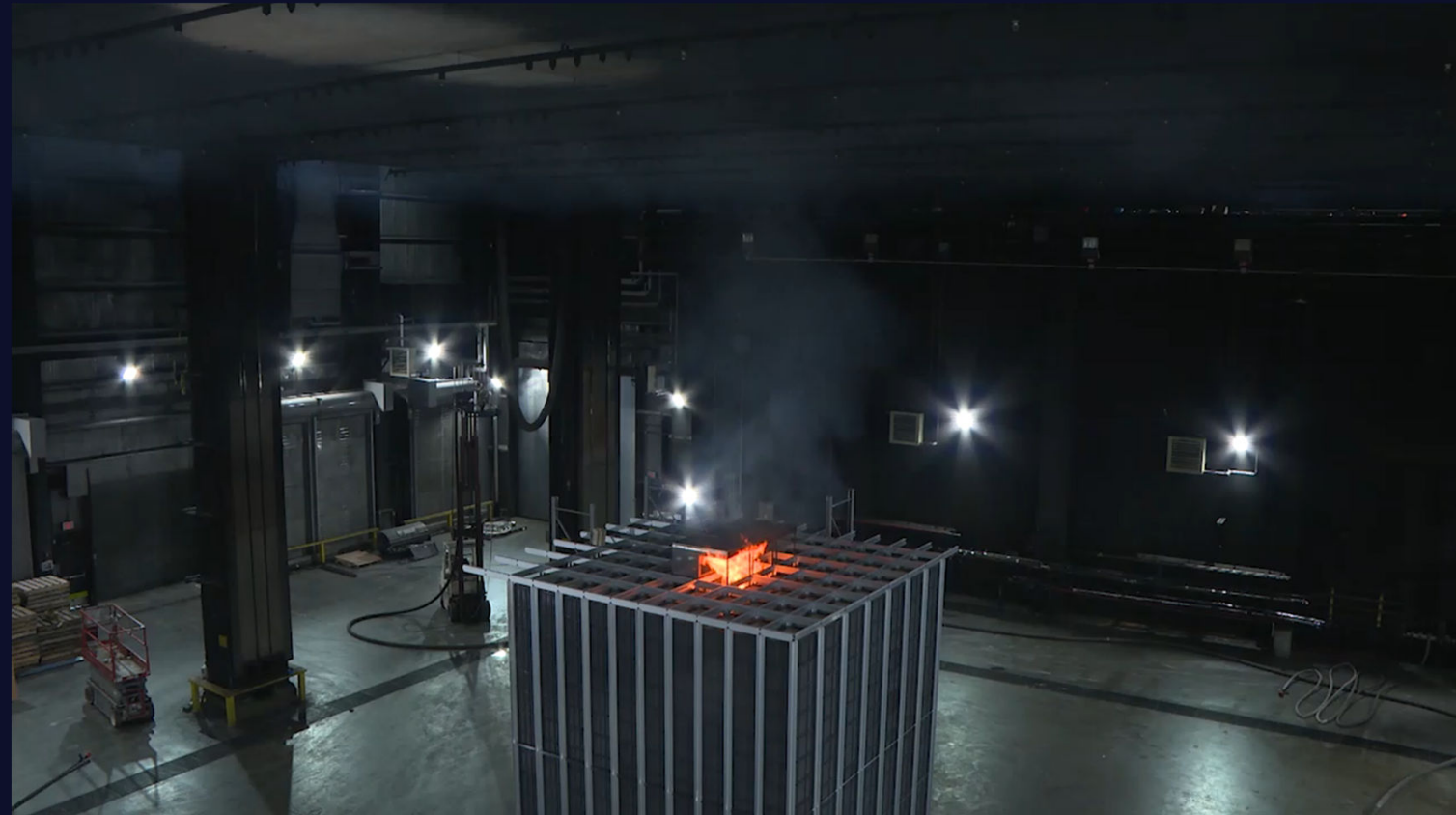
- Area: 200 ft² (19 m²)
- Height: 18 ft (5.5 m)
- Ceiling : 40 ft (12 m)

Ignition

- Base of storage
- Beneath robot
- Under-1 sprinkler

Sprinkler Protection

- K14 (K200), QR
- 75 psi = 1.2 gpm/ft²
(5.2 bar = 49 mm/min)
- Applied for at least 30 minutes



+30 minutes, sprinklers turned off



Infamous loss...

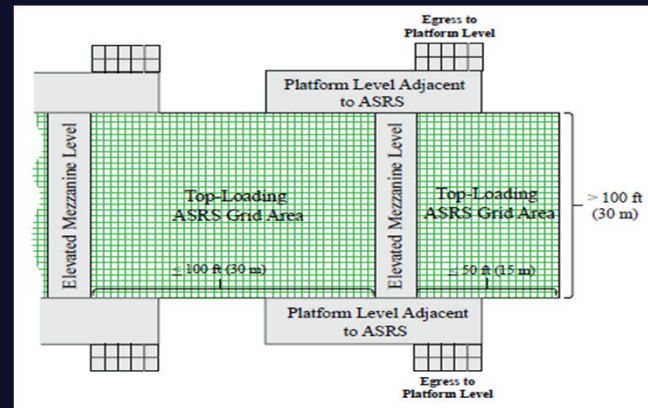


Protection Challenge – Final Extinguishment



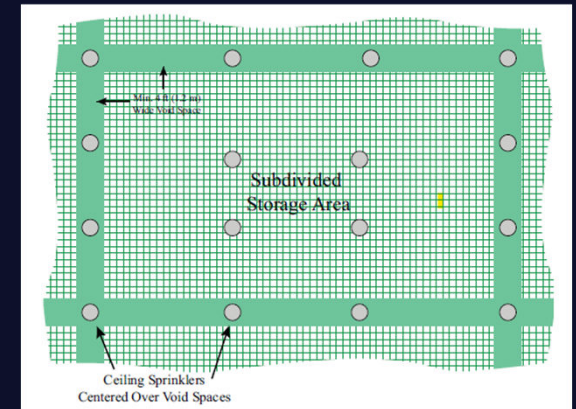
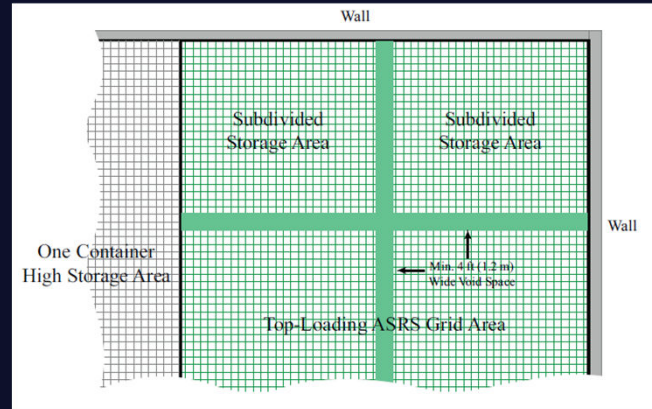
Protection Challenge – Final Extinguishment

- Elevated mezzanines for fire fighter access
- Monitor nozzles
- Infrared cameras
- 4-hour water supply
- **Agreement and written pre-fire plan with fire department**



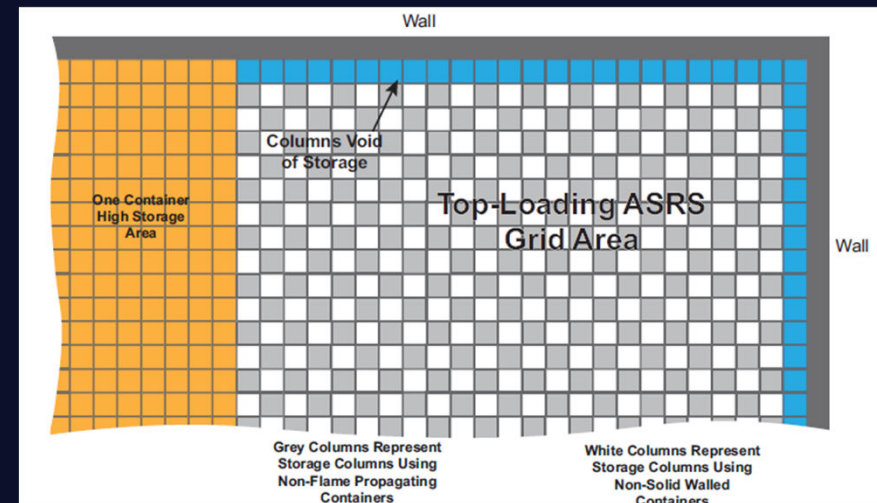
Non-Solid Walled Containers, additionally

- Subdivision (aisles) within the storage grid
- Voids (flues) that line up with ceiling sprinklers



Or

- A checkerboard pattern of combustible non-solid wall containers and FM Approved non-flame propagating containers



Solid-Walled Containers: Sprinkler designs that reduce final extinguishment recommendations

- Ceiling at 7.6 m, 8.5 m, or 9.1 m above floor level
- Strong sprinkler design
- Fire may be extinguished by sprinklers alone. Pre-fire planning still critical.
- 2-hour water supply
- **Table 2.3.2.3.3.1**



Sprinkler designs that reduce final extinguishment recommendations



Sprinkler designs that reduce final extinguishment recommendations



Sprinkler designs that reduce final extinguishment recommendations



Sprinkler designs that reduce final extinguishment recommendations

Table 2.3.2.3.3.1. Ceiling-Level Sprinkler Protection Guidelines *that Reduce Some of the Final Extinguishment Recommendations when Protecting Solid-Walled Containers Stored to a Maximum Height of 20 ft (6.1 m) in a Top-Loading ASRS Storage Arrangement; Maximum Ceiling Height of 30 ft (9.1 m)*

Max. Ceiling Height, ft (m)	Maximum Vertical Distance of Sprinkler Thermal Element Below Ceiling, in. (mm)	Ceiling-Level Sprinkler Protection Options for Solid-Walled Containers to Maximum 20 ft (6.1 m) in a Top-Loading ASRS Storage Arrangement; No. of AS @ psi (bar)					
		Wet Sprinkler System Using Quick-Response 160°F (70°C) Pendent Storage Sprinklers					
		K14.0 (K200)	K16.8 (K240)	K22.4 (K320)	K25.2 (K360)	K28.0 (K400)	K33.6 (K480)
25 (7.6)*	13 (325)	9 @ 50 (3.5)	9 @ 35 (2.4)	6 @ 50 (3.5)	6 @ 39 (2.7)	6 @ 32 (2.2)	6 @ 22 (1.5)
28 (8.5)	13 (325)			6 @ 85 (5.9)	6 @ 65 (4.5)	6 @ 53 (3.7)	6 @ 36 (2.5)
30 (9.1)	13 (325)				6 @ 120 (8.3)	6 @ 95 (6.6)	6 @ 65 (4.5)

*This ceiling height is recommended only for locations where the grid that supports the robots is at least 8 ft (2.4 m) below the underside of the ceiling.

CAUTION: Seems AutoStore are offering their system with an 8 m storage height. Table 2.3.2.3.3.1 would not apply. More fire testing needed.

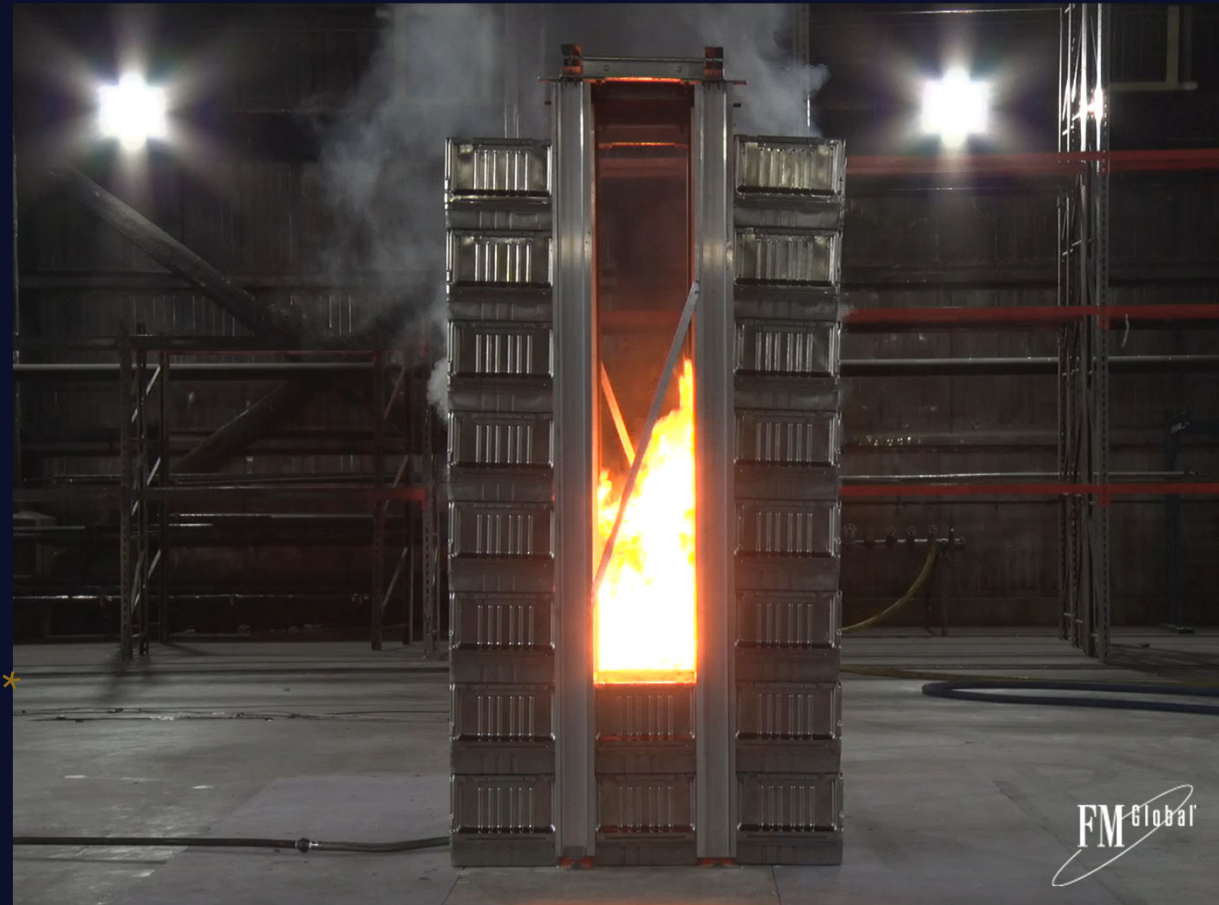
New Standard: FM 4994, Non-Flame-Propagating Containers

Publish Date · 25 January 2024



FM Approved Non-Flame-Propagating containers

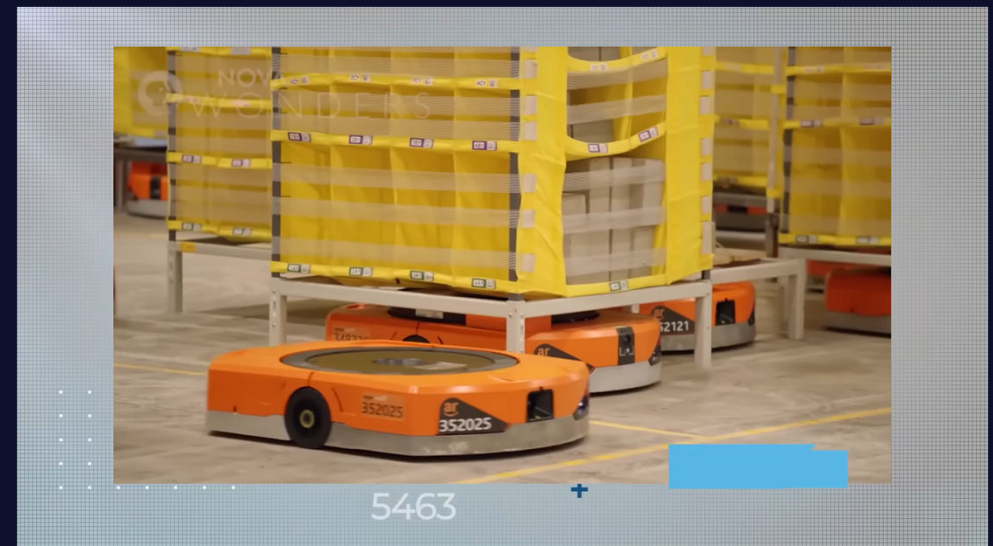
- No fire spread
- Limited damage to the storage structure
- Greatly reduced smoke damage
- Protection designed for the surrounding occupancy
- Containers do not need to be metal (can be composite)

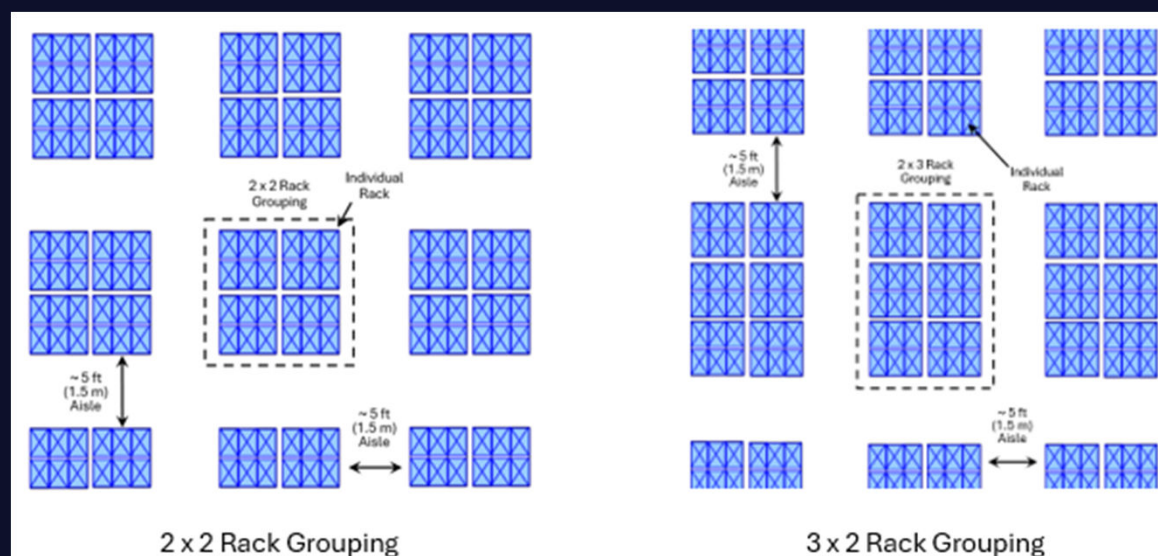


Demonstration Test

Other ASRS

- Vertically enclosed ASRS (e.g., Kardex)
- Bottom-Loading ASRS
 - No protection guidance yet
- Robotic retrieval systems
 - Fire testing ongoing with some suppliers







Storage of hazardous goods in ASRS

Ignitable Liquids and Aerosols in ASRS

- DS 8-34 has removed the exclusion for ignitable liquids and aerosols, and points to DS 7-29 and DS 7-31.
- Limitations for different ASRS type on:
 - Liquid/aerosol type.
 - Product container type/volume.
 - Total volume of liquid per ASRS container (bin).
- TL-ASRS and mini-loads require use of:
 - FM Approved non-flame propagating containers.
 - Metal containers.
 - Full-height liquid-tight metal liners in plastic containers.

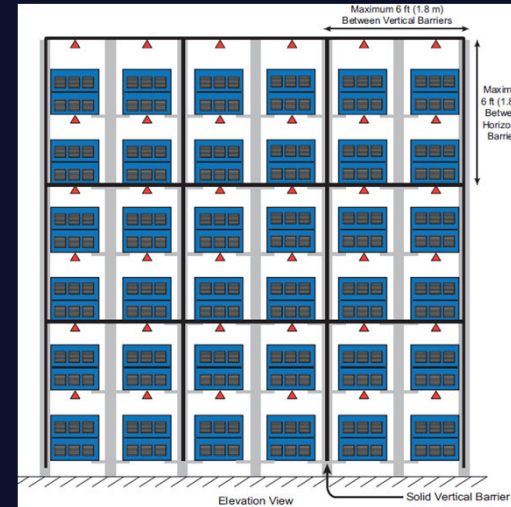


Ignitable Liquids and Aerosols in ASRS

- Reasonable options for water-miscible liquids e.g., alcohol based
- More options for shuttle systems than miniloads
- Some options for high-flashpoint ignitable liquids in shuttle systems
- Very limited options for low-flashpoint (<93C) non-water miscible liquids, containers limited to 15 ml i.e., nail polish

Lithium-Ion Batteries in ASRS

- Covered in DS 7-112.
- For bulk storage of finished cells, use the formation and aging rack protection guidance.
- For storage of batteries in finished products, the key is **State of Charge (SOC)**.



Lithium-Ion Batteries in ASRS

- SOC < 30%, ignore the battery and classify the finished product as normal
- SOC 30 – 60%, store in:
 - Horizontal-loading ASRS only, and
 - FM Approved non-flame propagating containers, metal containers, or metal lined in plastic containers
- SOC > 60%, do not store in ASRS

FM



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