Storage hazards & Protection

9&10 June 2026

Protection Design

01 Commodity Classification

02 Storage Hazards

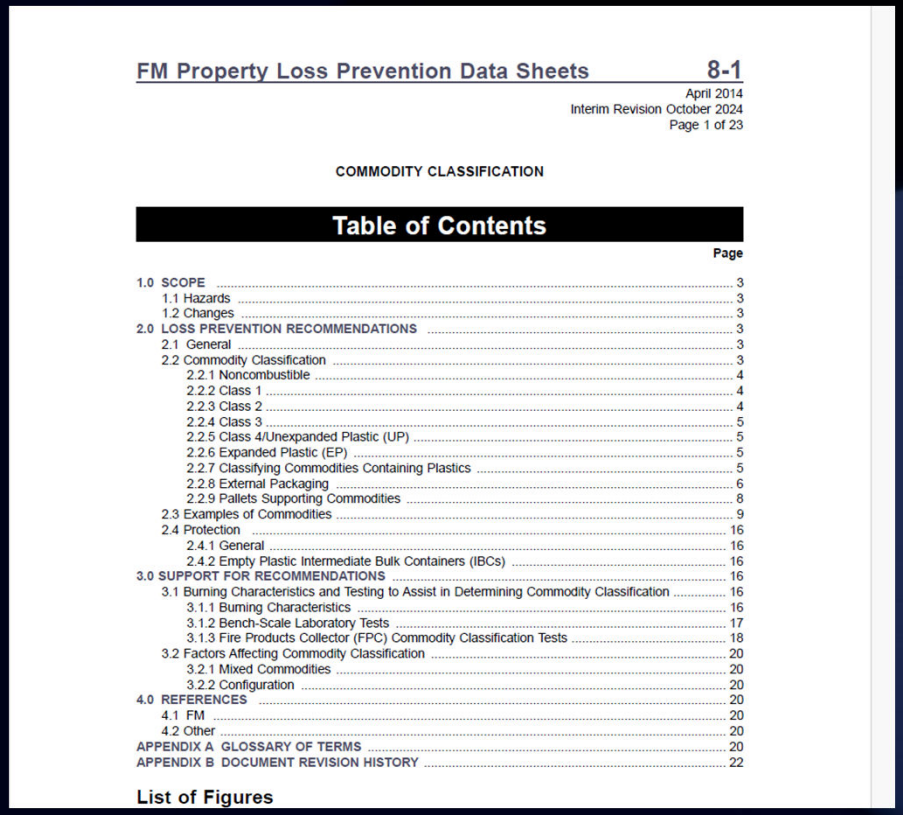
03 Special Hazards

04 Open Top Containers

05 Automated Storage

Commodity classification

FM Property Loss Prevention Data Sheet 8-1



FM Property Loss Prevention Data Sheets 8-1

April 2014
Interim Revision October 2024
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COMMODITY CLASSIFICATION

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Goal:

- Recognize the different commodities in storage arrangements per Data sheet 8-1
- Review some special commodities

Storage Standards

Protecting General Storage

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7 Series Data Sheets

COMMODITY CLASSIFICATION

What is the storage commodity?

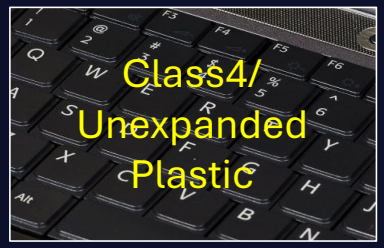
Material and internal packaging

External packaging

Pallet

FM Data Sheet 8-1

- Volume of plastics > 1 m³ (not nested)



PLASTIC COMMODITY CLASSIFICATION
FM DATA SHEET 8-1, SECTIONS 2.1 AND 2.3

Cartoned unexpanded plastic (CUP)

Cartoned expanded plastic (CEP)

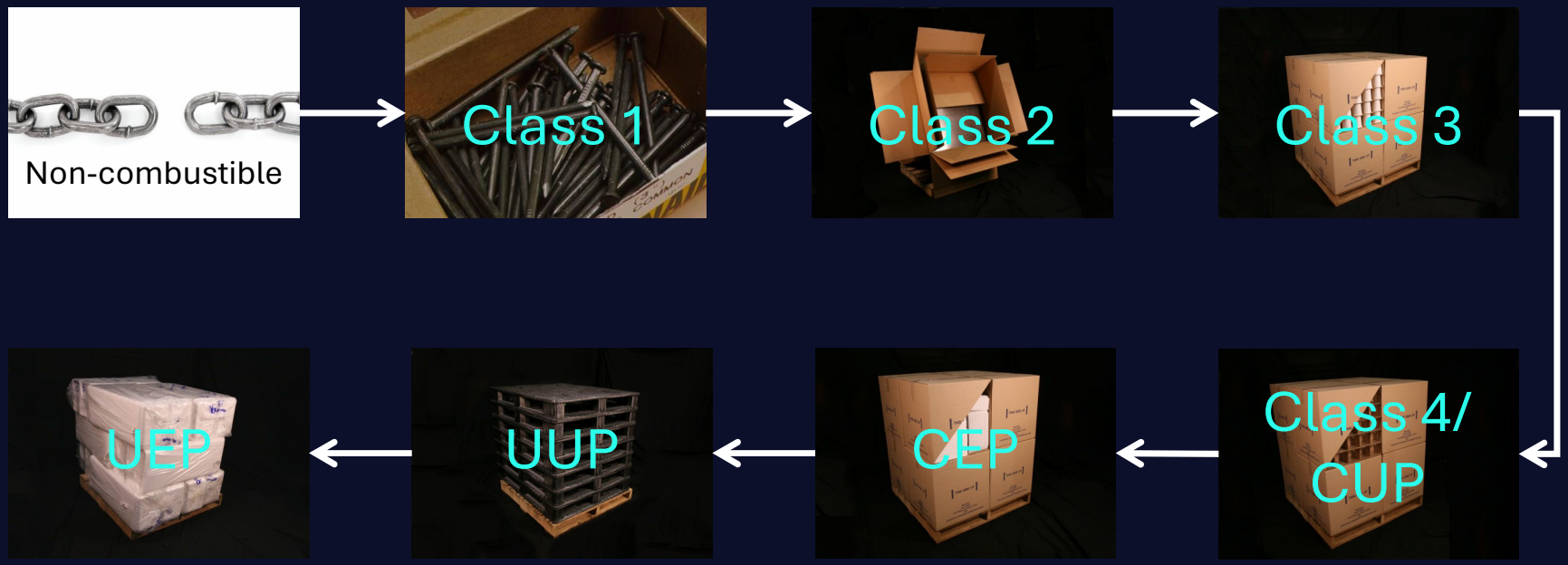
Uncartoned unexpanded plastic (UUP)

Uncartoned expanded plastic (UEP)

COMMODITY CLASSIFICATION

FM Data Sheet 8-1, Section 2.1

Increasing challenge for the sprinklers



Plastics vs Ordinary combustibles

Heat of combustion ordinary combustibles:

14.000-18.600 kJ/kg

Heat of combustion Plastics:

28.000-46.500 kJ/kg

Burning rate of plastics is higher, especially the expanded plastics.

COMMODITY CLASSIFICATION

Comparison with EN12845

- Category I
  - e.g. meat, ceramics, tinned food
- Category II
  - e.g. tobacco products, books, cardboard flats
- Category III
  - e.g. exposed unexpanded plastics, medium or heavy rolled paper on end.
- Category IV
  - e.g. exposed, expanded plastic, rolled tissue, tyres , rolled corrugated cardboard on end.

Up to Class 3 per FM

Up to Uncartoned Unexpanded plastic per FM

Uncartoned Expanded Plastic or specific for special hazards (Tyres, roll paper, etc.) per FM

How to evaluate a commodity?

Step 1:
Material und internal packaging

Step 2:
External packaging

Step 3:
Pallet

Step 1: Material and internal packaging

Commodity classification

- What’s in the box?
- Use of packaging material?
- Are there plastics?
- What kind of plastics?
- If mixed, calculate percentage
- Use Figure 2.2.7 flowchart for evaluation of plastic materials

COMMODITY CLASSIFICATION

Material ....

… and internal packaging

Material and internal packaging
FM Data Sheet 8-1, Section 2.2.7

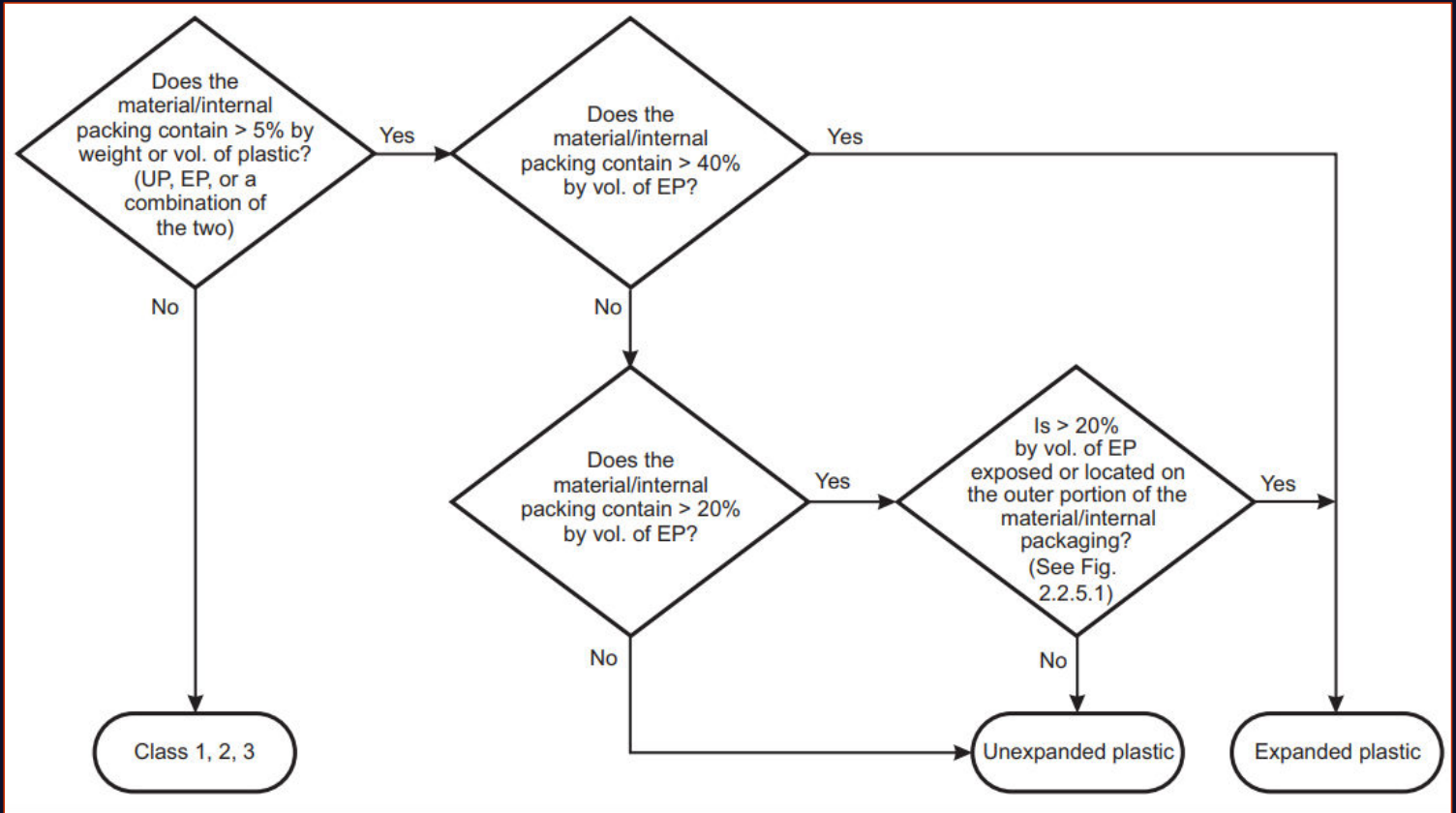


Fig. 2.2.7. Classify cartoned commodities containing plastic

Step 2: External packaging

- How is the material stored?
- Corrugated cardboard box?
- Metal container?
- Plastic container?
- Thickness of the plastic container?

Future Proof!

- Design for the worst case, not for the most common. If CUP, can you trust it will be like this in the future?
- How does the storage look like in other warehouses?

COMMODITY CLASSIFICATION

Cardboard cartons

Advantage:

- Absorbs sprinkler water
- Pre-wet commodity and reduce fire spread
- Spreads fire rapidly in flue spaces of racks and activates the sprinklers quickly

Disadvantage:

- Easier to ignite

Step 3: Material handling

How is the material being transported?

- Wood pallet?
- FM Approved pallet?
- Plastic pallet?

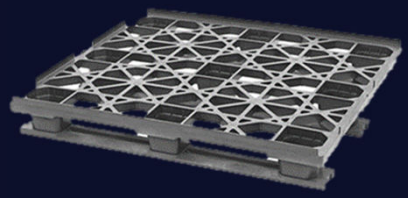
Pallets

Wood or FM Approved unexpanded plastic pallets:

- No effect on commodity, except:
  Noncombustible materials → class 1

Unexpanded plastic pallets (not FM Approved):

- No effect on commodity, if material is considered a plastic
- Otherwise, increase commodity by one level



COMMODITY CLASSIFICATION

Empty plastic containers

Empty plastic containers > 1liter = Uncartoned Expanded Plastic

Nested Empty plastic containers > 1liter = Uncartoned Unexpanded Plastic

Empty plastic containers < 1liter = Uncartoned unexpanded Plastic

a) Empty containers (UEP) b) Nested containers (UUP)

COMMODITY CLASSIFICATION

Special storage occupancies

- Rolled paper
- Baled wastepaper
- Rubber tires
- Idle pallets
- Ignitable liquids/gases
- Non-wovens
- Hanging garments
- Lithium-ion batteries
- Carpets, etc.

COMMODITY CLASSIFICATION

Rubber tires (DS 8-3)

- When rubber tires burn, they…
  - Generate tremendous heat
  - Produce huge amounts of toxic smoke
  - Are extremely difficult to extinguish
    - Fire burrows into rubber materials.
    - No pre-wetting.
    - The shape of a tire shields growing flames.
    - Fire re-develops.

COMMODITY CLASSIFICATION

Idle pallets (DS 8-24)

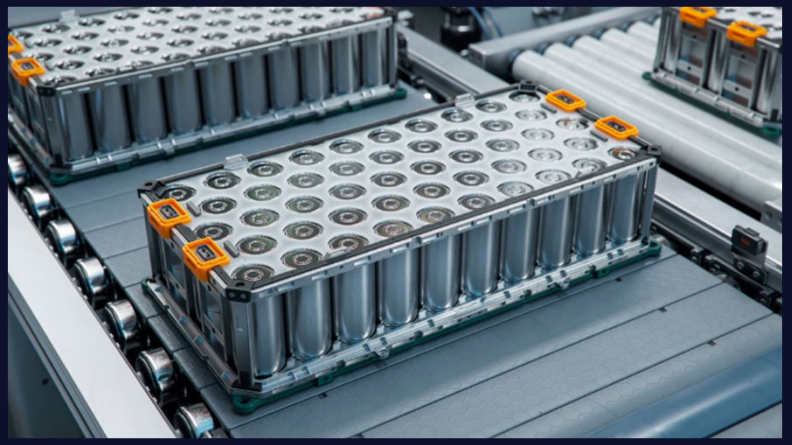
- The configuration of a typical pallet (plenty of fuel) is virtually the same as that required for a healthy campfire.
- The spaces between the top and bottom of the pallet and between the slats allow for plenty of air access.
- These same spaces are near enough together to allow for optimum heat feedback

Protection:

- Plastic pallets:
  - Protect as Uncartoned Unexpanded Plastic (DS 8-9)
- Wood Pallets:
  - Protect per Table 3 of OS 8-24
  - If different k-factor or height than table 3 protect as plastic pallet

COMMODITY CLASSIFICATION

Lithium-Ion Batteries (DS 7-112)



Thermal runaway

- Cell produces flammable gas
- Accumulates gas in the cell
- Pressure relief of cell vents hot gasses towards adjacent cells
- Propagate thermal runaway to other cells

Cause:

- Electrical abuse
- Thermal abuse
- Mechanical abuse

COMMODITY CLASSIFICATION

Lithium-Ion Batteries (DS 7-112)

63 Ah pouch cell, NMC, 50% SOC

63 Ah pouch cell, NMC, 100% SOC

COMMODITY CLASSIFICATION

Lithium-Ion Batteries (DS 7-112)

Table 2.4.3.2. Sprinkler Protection for Low-Piled Storage of Lithium-ion Batteries in Plastic Containers

Commodity	Max Ceiling Height, ft (m)	Quick-Response						Standard-Response				
		K11.2 (K160)	K14.0 (K200)	K16.8 (K240)	K22.4 (K320)	K25.2 (K360)	K25.2EC (K360EC)	K11.2 (K160)	K14.0 (K200)	K19.6 (K280)	K25.2 (K360)	K25.2EC (K360EC)
Wet System, Pendent Sprinklers, 160°F (70°C), Number of AS @ psi (bar)												
UUP	30 (9)	25 @ 50(3.4)	10 @ 62(4.3)	10 @ 43(3)	14 @ 24(1.7)	14 @ 19(1.3)	12 @ 38(2.6)	25 @ 50(3.4)	25 @ 32(2.2)	25 @ 16(1.1)	25 @ 10(0.7)	25 @ 50(3.4)
	45 (14)		10 @ 62(4.3)1	10 @ 43(3)	14 @ 24(1.7)	14 @ 19(1.3)						
	60 (18)				10 @ 50(3.4)	10 @ 40(2.8)						
Wet System, Upright Sprinklers, 160°F (70°C), Number of AS @ psi (bar)												
UUP	30 (9)	25 @ 50(3.4)	10 @ 62(4.3)	10 @ 43(3)			12 @ 38(2.6)	25 @ 50(3.4)	25 @ 22(1.5)		25 @ 10(0.7)	
	45 (14)		10 @ 62(4.3)	10 @ 43(3)								

Treat as low piled UUP

In plastic containers

COMMODITY CLASSIFICATION

Lithium-Ion Batteries (DS 7-112)

Storage commodity

- Initial fire growth is similar and dominated by the packaging
- Packaging, plastic content, and density of packed batteries drive the hazard (for SOC ≤60%)

COMMODITY CLASSIFICATION

Lithium-Ion Batteries (DS 7-112)

Palletized storage, new or refurbished:

- Min 3 m between piles or other combustibles

Table 2.4.5.1-1. Protection Guidelines for Lithium-Ion Cells/Modules/Batteries in Solid-Piled or Palletized Storage Arrangements

Maximum Lithium-ion Cell/Module State of Charge	*Maximum Ceiling Height*	*Storage Height*	*Packaging*	*Protection (QR Sprinklers only)*
60%	45 ft (13.5 m)	15 ft (4.5 m)	Wood crate, metal encased or corrugated carton with cellulosic and/or unexpanded plastic internal packaging only	CUP per Data Sheet 8-9 (Note 1)
			Corrugated carton with expanded plastic internal packaging	CEP per Data Sheet 8-9 (Note 1)
			Unexpanded Plastic external packaging	UUP per Data Sheet 8-9 (Note 1)
			Unexpanded Plastic external packaging with > 40% expanded plastic (by volume) inside	UEP per Data Sheet 8-9 (Note 1)

Note 1. Use the Data Sheet 8-9 protection table based upon the storage configuration (solid-pile or palletized) and the protection option based on the ceiling height.

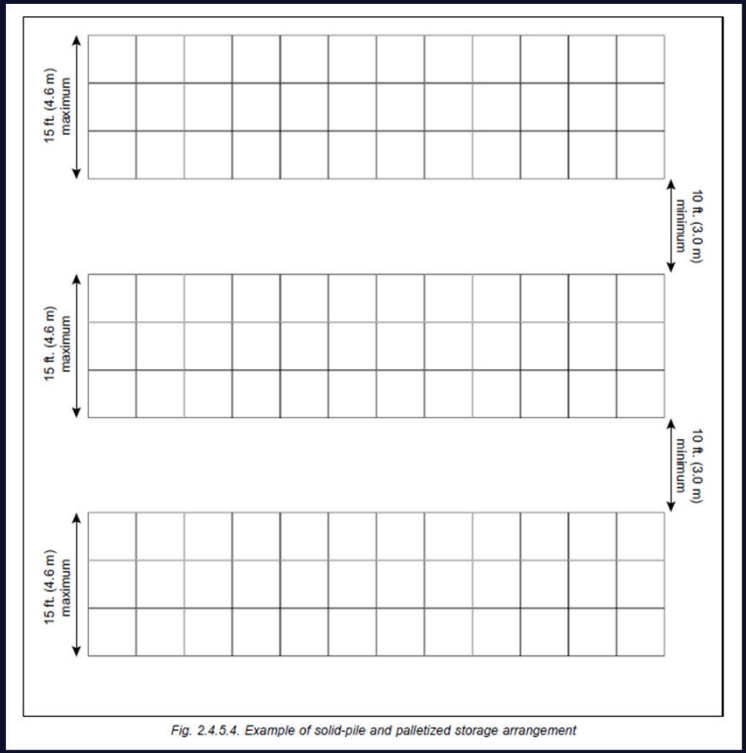


Fig. 2.4.5.4. Example of solid-pile and palletized storage arrangement

COMMODITY CLASSIFICATION

Lithium-Ion Batteries (DS 7-112)

Rack storage:

- Min 3 m space to other combustibles
- No storage above Ceiling only protection options

Table 2.4.5.1-2. Protection Guidelines for Lithium-Ion Cells/Modules/Batteries in Open-Frame Rack Storage Arrangements

Lithium-ion Cell/Module State of Charge	*Maximum Ceiling Height*	*Maximum Storage Height*	*Packaging*	*Ceiling Protection (QR sprinklers only)*	*In-Rack Protection*
≤ 60%	45 ft (13.5 m)	15 ft (4.5 m) (Maximum of 3 tiers)	Wood crate, metal encased or corrugated carton with cellulosic and/or unexpanded plastic internal packaging only	CUP per Data Sheet 8-9 (Note 1)	NA
			Corrugated carton with expanded plastic internal packaging	CEP per Data Sheet 8-9 (Note 1)	NA
			Unexpanded plastic external packaging with ≤ 40% expanded plastic (by volume) inside	UUP per Data Sheet 8-9 (Note 1)	NA
			Unexpanded plastic external packaging with > 40% expanded plastic (by volume) inside; or expanded plastic external packaging	UEP per Data Sheet 8-9 (Note 1)	NA
			Uncartoned	Per surrounding occupancy	See Section 2.4.5.5 and 2.4.5.6
	> 45 ft (13.5 m)	NA	Cartoned or uncartoned	Per surrounding occupancySee	
> 60%	NA		Cartoned or uncartoned	Per surrounding occupancy	

Note 1. Use the Data Sheet 8-9 protection table based upon the storage configuration (open-frame rack, solid-pile or palletized) and the protection option based on the ceiling height.

Lithium-Ion Batteries (DS 7-112)

Rack storage, with in-racks:

- Horizontal barriers
- Design demand Scheme A DS 8.9
- Balancing not needed

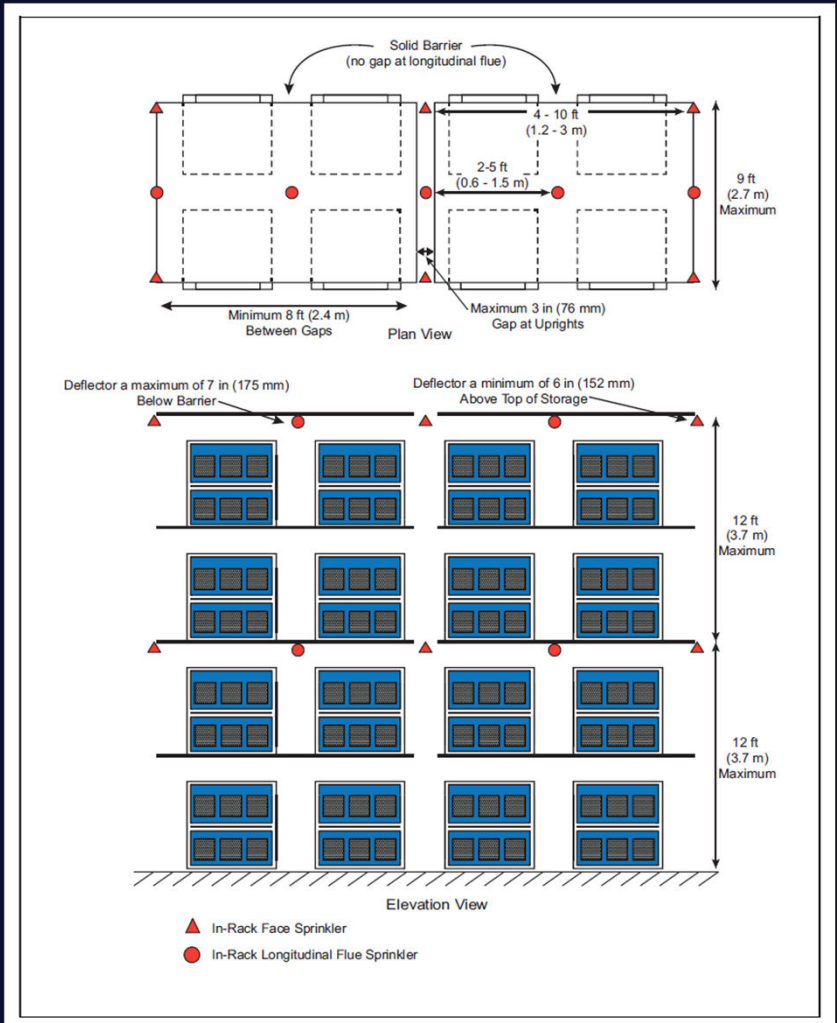


Fig. 2.4.5.5-2 In-rack sprinkler layout for Li-ion cells/modules/batteries in double-row rack storage arrangements

COMMODITY CLASSIFICATION

Lithium-Ion Batteries (DS 7-112)

Warehouse Storage Test

Storage: 4.5 m
Ceiling: 12.2 m
Sprinkler: K320 @ 2.1 bar (52 mm/min)

20 Ah pouch cell, 50% SOC

Plastic dividers + cardboard carton
24 pallet loads (~27,000 cells)

COMMODITY CLASSIFICATION

Warehouse Storage Test

- Fire controlled by 1 sprinkler
- Damage limited to ignition area
- Minimal battery involvment

Just a fire!

COMMODITY CLASSIFICATION

Lithium-Ion Batteries (DS 7-112)

Finished products containing Li-ion batteries

- SOC ≤ 60% Protect per OS 8-9 using the product commodity classification excluding the battery
- SOC > 60% Protect per OS 8-9 using a design with ceiling and in rack sprinklers for the product commodity classification excluding the battery

COMMODITY CLASSIFICATION

Lithium-Ion Batteries (DS 7-112)

Codes you will find on the packaging:

- UN 3090, Lithium metal batteries (shipped by themselves)
- UN 3480, Lithium-ion batteries (shipped by themselves)
- UN 3091, Lithium metal batteries contained in equipment or packed with equipment
- UN 3481, Lithium-ion batteries contained in equipment or packed with equipment
- UN 3556, Vehicle, Lithium-ion battery powered

Questions?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