

History and development of ESFR sprinkler storage arrangements and challenges

tyco
Fire Protection Products

Presentation Agenda

1. **The evolution of storage vs. sprinkler**

2. **Challenges for Property owners, End users and Insurance companies**

3. **Sprinkler storage, Trends, Present and the Future**

Presentation Agenda

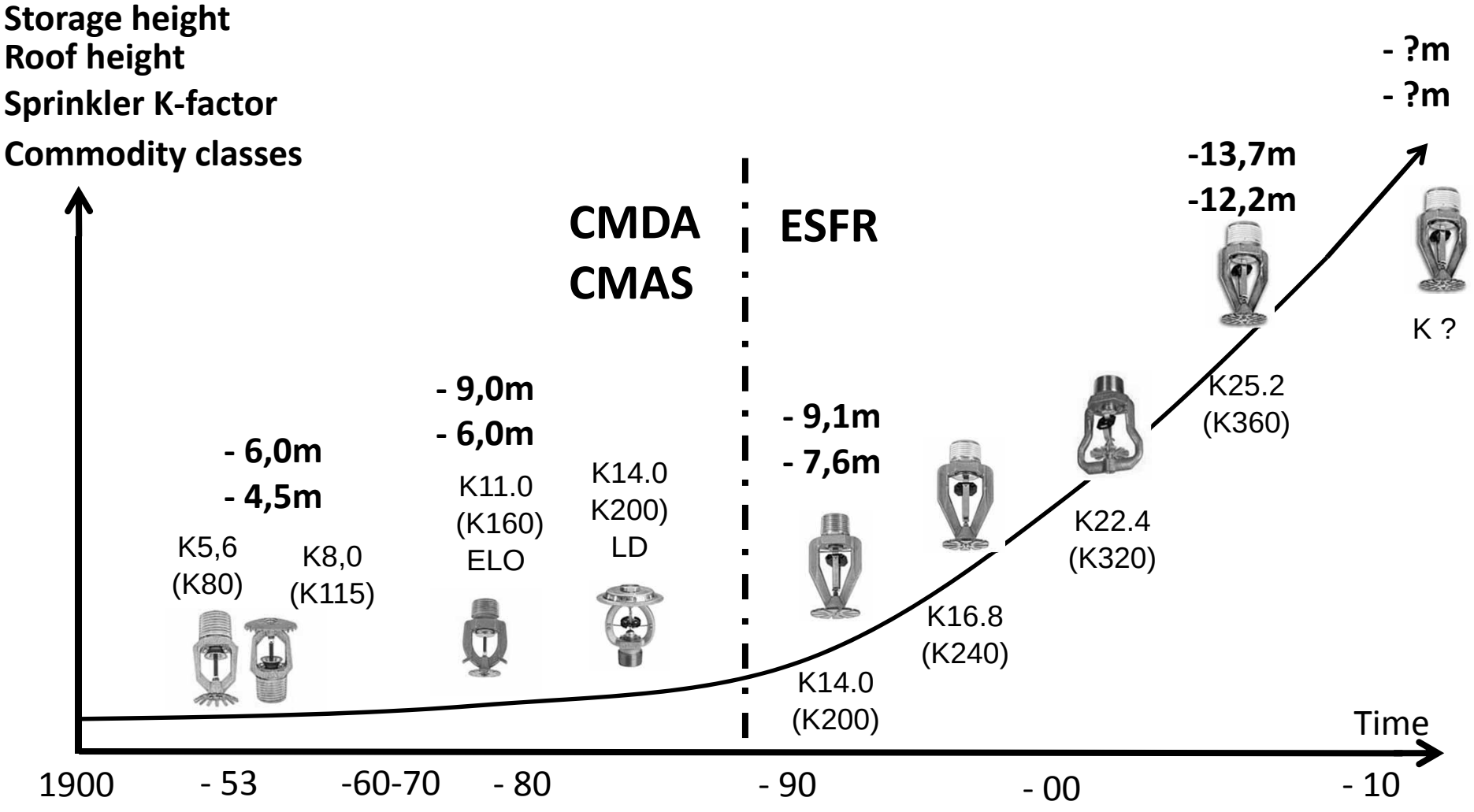
1. The evolution of storage vs. sprinkler

How did we get where we are today?

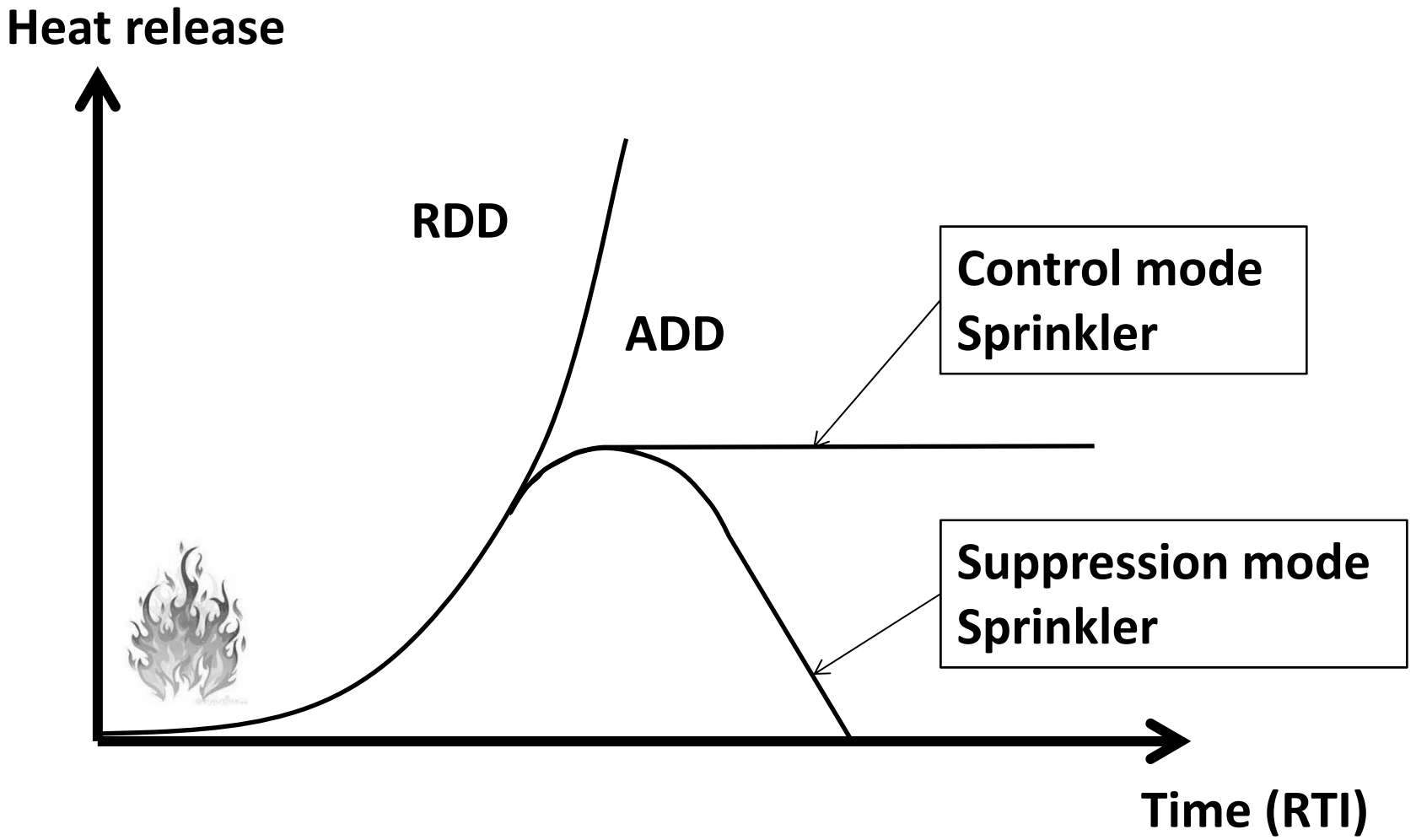


- The NEW moderns sprinkler saw it first light in 1953 (SSP)
- FM (Factory Mutual) - Rack storage test program 1968–1972
  - Showed Inflexibility

Sprinkler K-factor, Storage heights and commodities changes during modern time



// Fire development with and with out Sprinkler



Presentation Agenda

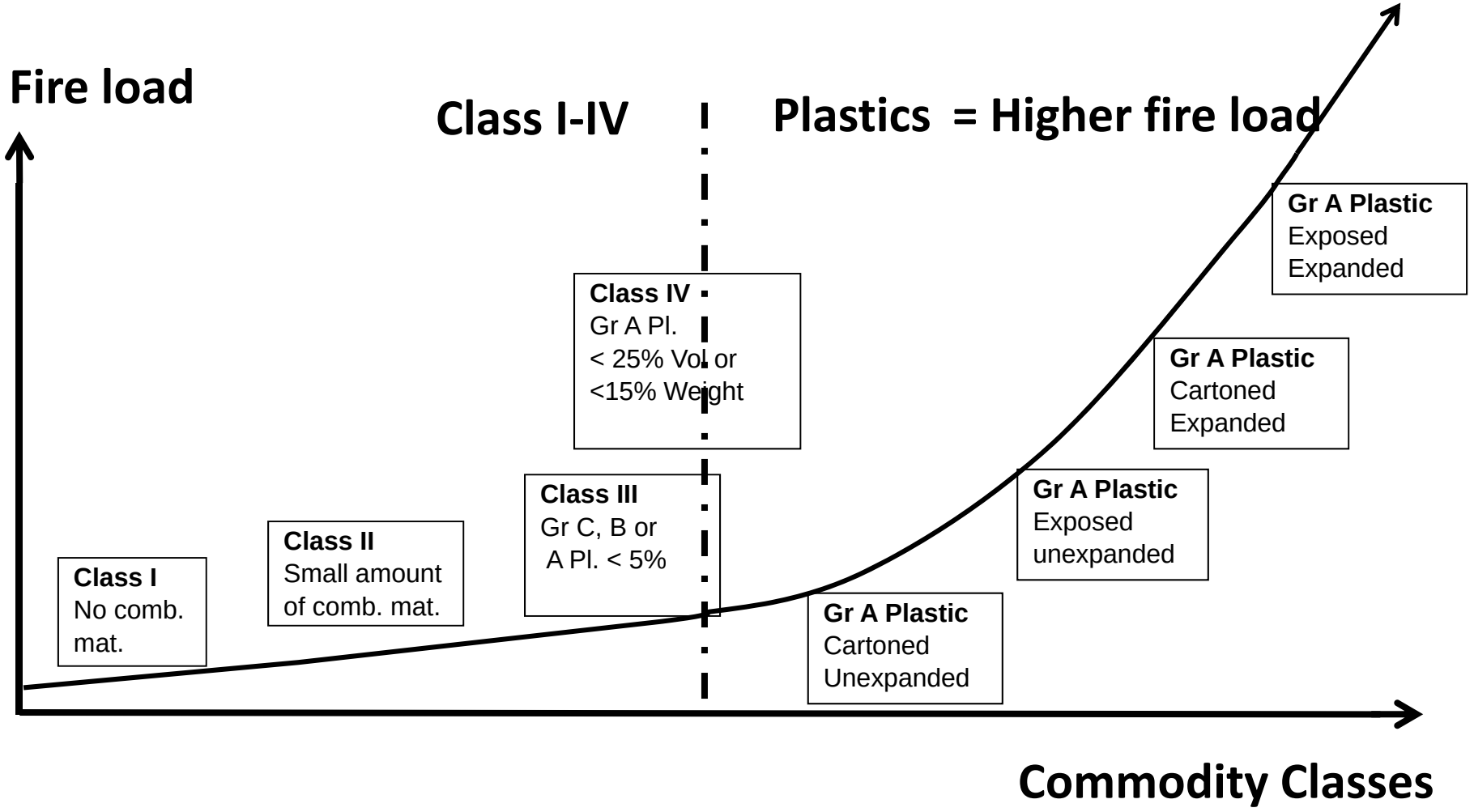
2. Challenges for Property owners, End users and Insurance companies

// Challenges and trends in storage facilities

- Higher and larger storage facilities
- Storage Commodity changes to more plastics
- Flexible storage arrangement
- Correct sprinkler design
- Business interruption
- Increase of insurance premiums



Commodity Classes - NFPA

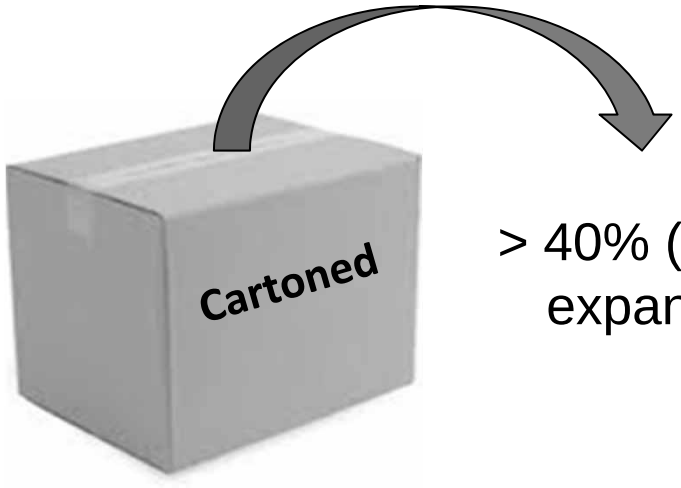


NFPA 13 Commodity Classification



Class or Group	Class or Group Material
Class I	Essentially non-combustible products in corrugated cartons on combustible pallets
Class II	Class I products in slatted wooden crates, solid wooden boxes or multiple thickness paperboard cartons with or without pallets
Class III	Wood, paper, natural fiber cloth or totally Group C plastics with or without pallets. May contain a limited amount (5% by weight or volume or less) of Group A or Group B plastics
Class IV	Class I, II or III commodities in corrugated cartons with appreciable amounts (5-15% by weight, or 5-25% by volume) of Group A plastics or totally Group B plastics
Plastics	Cartoned Unexpanded Group A Plastic
	Exposed Unexpanded Group A Plastic
	Cartoned Expanded Group A Plastic
	Exposed Expanded Group A Plastic

Commodity Classes – Group A



NEW TO NFPA 13 - 2013 EDITION

> 40% (by volume) of expanded plastic = Cartoned expanded plastic

13: 5.6.4.4.1



> 25% (by volume) of expanded plastic = Exposed expanded plastic

13: 5.6.4.4.2

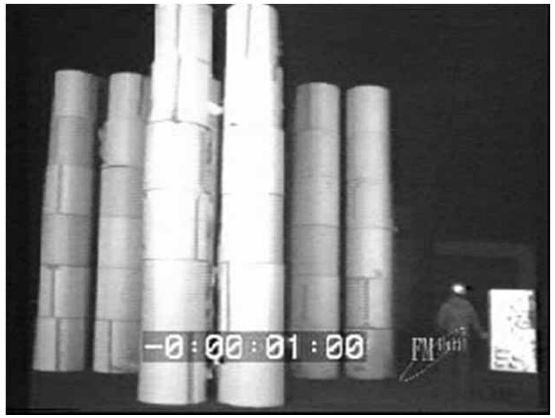
// Other Types of Commodities



Idle Pallet



Baled Cotton



Rolled Paper



Rubber Tire

Mixed Commodities

- In a mixed storage area
- Max 10 pallets with of higher hazards (3716m2) is allowed
- Mixed commodity storage shall be protected for the highest classified commodity.
- **Most cases an increase of commodity class is needed !**



Presentation Agenda

3. Sprinkler storage – Trends, Present and Future

//Trends in Storage facilities







- Larger
- Higher
- More complex

Trends in Storage facilities

- Higher and bigger warehouses
- More plastic commodities in all products
  - Examples
    - Cars and car parts
    - Furniture
    - Clothing
    - Shoes
    - Toys
- Big challenges for property owner/end users and sprinkler system designer

Sprinkler storage applications

- Most moderns mixed storage arrangement gets classified as some type of Group A plastic

1. Non-Expanded

(cartoned or exposed)

2. Expanded

(cartoned or exposed)

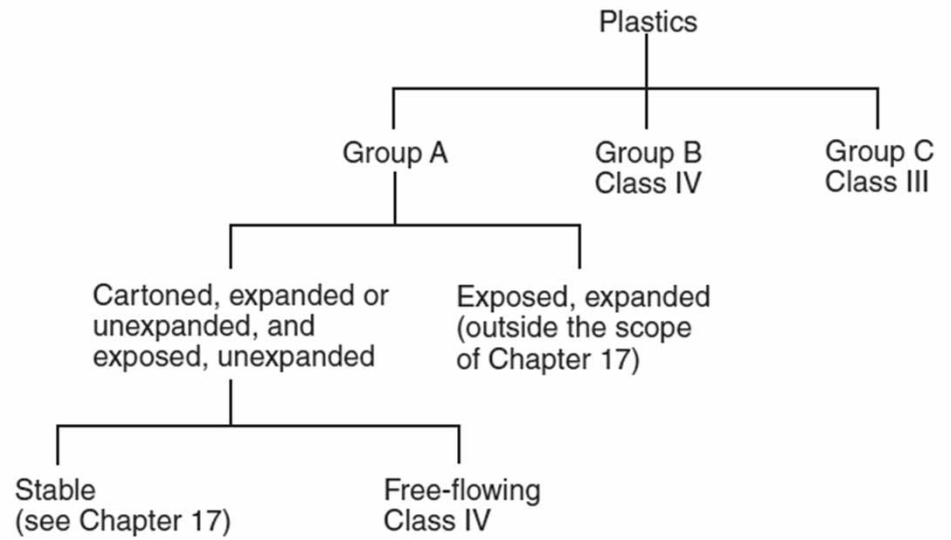


FIGURE 17.1.2.1 Decision Tree.

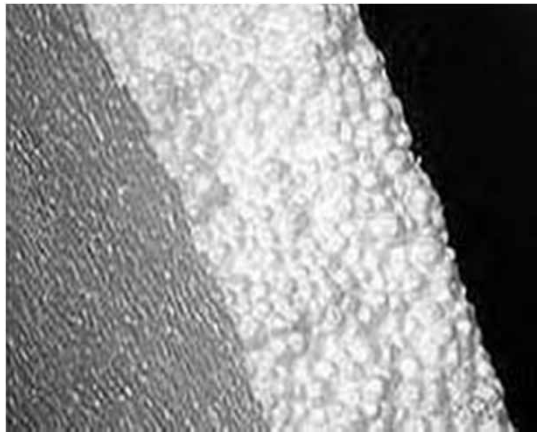
//Trends in storage commodities



Mixed commodities



Plastics commodities

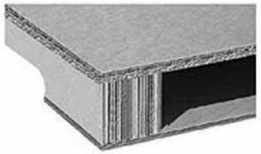


Expanded plastic



Plastic Pallet Types





Paper pallet types



Encapsulation

Sprinkler storage applications

- The biggest challenge in sprinkler storage application is to:

1. Find correct commodity classification

2. Have correct and most economical design

3. Having a flexible solution

// Sprinkler storage applications - ESFR

- The most efficient sprinkler design for high storage and building with high ceilings is the ESFR concept

- Which ESPR sprinkler is the most useful and flexible today?

- ESFR K25



Sprinkler storage applications - ESFR

- Why is it so ?

1. ESFR 25 provides the most flexible design and suppression efficiency

   (no in rack spr. up to 12,2m for exposed. exp. Plastic (FM 8-9))

2. In plastic storage arrangement it is the most economical installation
3. ESFR-25 provides protection for cartoned and exposed, expanded plastics
4. Most future proof ESFR solution

Sprinkler storage applications - ESFR

- **Some ESFR sprinkler limitations**
  - **Wet system only**
  - **Smooth ceiling**
  - **Obstruction sensible**
  - **No automatic smoke ventilation**
  - **Ceiling Slope Maximum:**
    - **2 in 12 (16.7%) or**
    - **9.5 degrees.**



New fire tests result from UL

- Rack - Exposed Expanded Plastic
- Sprinkler type - ESFR
- Commodity class – Exposed Expanded Plastic
- Vertical Barrier in every second tiers
- ESFR K25 was the only sprinkler to pass the test.

Exposed Expanded Group A Plastic Test Series

Test Summary

FIRE TEST	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Test 8	Test 9	Test 10
Test Date	July 9, 2012	July 18, 2012	July 30, 2012	July 25, 2012	Oct. 31, 2012	Nov. 8, 2012	June 8, 2013	June 19, 2014	Oct. 28, 2014	Oct. 30, 2014
Test Parameters										
Storage Type	Double Row Rack									
Commodity Type	Exposed Expanded Group A Plastic (Bagged Meat Trays on Hardwood Pallets)									
Pallet Type	2 way entry, stringer, hardwood									
Vertical Barriers	16 ft. on center - Main Array (Non-combustible)	16 ft. on center - Main Array (Non-combustible)	16 ft. on center - Main Array (Non-combustible)	20 ft. on center - Main Array (Non-combustible)	24 ft. on center - Main Array (3/8 in plywood)	16 ft. on center - Main Array (3/8 in. plywood)				
Horizontal Blocking of Transverse Flues in Main Array (non-combustible)	**18 flues inside vertical barriers**	12 flues inside vertical barriers – None at uprights	**72 flues** - None at the uprights and vertical barriers	**60 flues** - None at the uprights and vertical barriers	96 flues - None at the uprights and vertical barriers	**60 flues** - None at the uprights and vertical barriers	None			
Length of Main Storage Array, ft.	32	32	56	68	56	56	40	56	32	32
Nominal Storage Height, ft.	20	20	35	30	40	30	30	35	20	25
Ceiling Height, ft.	40	40	40	35	45	40	40	40	30	30
Nominal Clearance, ft.	20	20	5	5	5	10	10	5	10	5
Aisle Width, ft.	8									
Ignition Location	Between 2 Sprinklers (offset)				Under 1 Sprinkler (offset)			Between 2 Sprinklers (offset)	Under 1 Sprinkler (offset)	Between 2 Sprinklers (offset)
Sprinkler Orientation	Pendent									
Deflector to Ceiling, in.	14									
Sprinkler Spacing, sprinkler by branchline ft. by ft.	10 by 10									
Temperature Rating, F	212	214	214	212	214					
Sprinkler Type	ESFR									
Nominal Sprinkler Discharge Coefficient K, gpm/psig $^{0.5}$	22.4	25.2	25.2	16.8	25.2					
Nominal Discharge Density, gpm/ft^2	1.58	1.95	1.95	1.19 - 0.99	1.95				1.38	1.38
Nominal Discharge Pressure, psig	50	60	60	50 psig for 4 sprinklers then 35 psig for remainder of operating sprinklers	60				30	30
Test Results										
Length of Test, minutes	31	31	31	31	31	31	31	31	31	31
First Sprinkler Operation Time, min:sec	0:39	0:44	0:52	0:47	0:47	0:48	0:47	0:48	0:47	0:53
Last Sprinkler Operation Time, min:sec	8:23	3:21	1:45	2:44	1:39	4:35	1:28	2:28	1:24	1:14
Number of Operated Sprinklers	[redacted]	6	[redacted]	[redacted]	[redacted]	[redacted]	7	7	7	7
Peak Gas Temperature at Ceiling Above Ignition, °F	564	558	1138	1163	1002	241	414	877	204	990
Maximum 1 minute Average Gas Temperature at Ceiling Above Ignition, °F	255	220	353	496	489	151	191	303	138	477
Peak Steel Temperature at Ceiling Above Ignition, °F	126	119	145	164	160	129	133	136	114	149
Maximum 1 minute Average Steel Temperature at Ceiling Above Ignition, °F	124	117	141	164	156	127	127	134	112	142
Fire Travel to Extremities of Test Array	Yes (East and West end of	Yes (West end of	No	No	Yes (North Target Array Burned Through to	Yes (South Target Array Burned Through to	No	No	No	No

// UL - Exposed Expanded plastic fire test



Result of test 2
Ceiling height: 12,2m
Storage height: 6.1m
Clearance: 6.1m

TEST OK

Result of test 8
Ceiling height: 12,2m
Storage height: 10,6m
Clearance: 1,5m

TEST OK



Comparison with ESFR K-25 vs K-22

Cartoned & exposed expanded plastics

- FM 8-9, K-25 is approved up to 40ft (12.2m).

- FM 8-9, K-22 is only approved up to 30ft (9m)

Example:

- K25 -> 2.1bar -> 521 l/m ->12 spr -> 6260 lit/min
- K22 -> 4,8bar -> 701 l/m ->12 spr -> 8413 lit/min

The difference is 2153 lit/min to K25 advantage

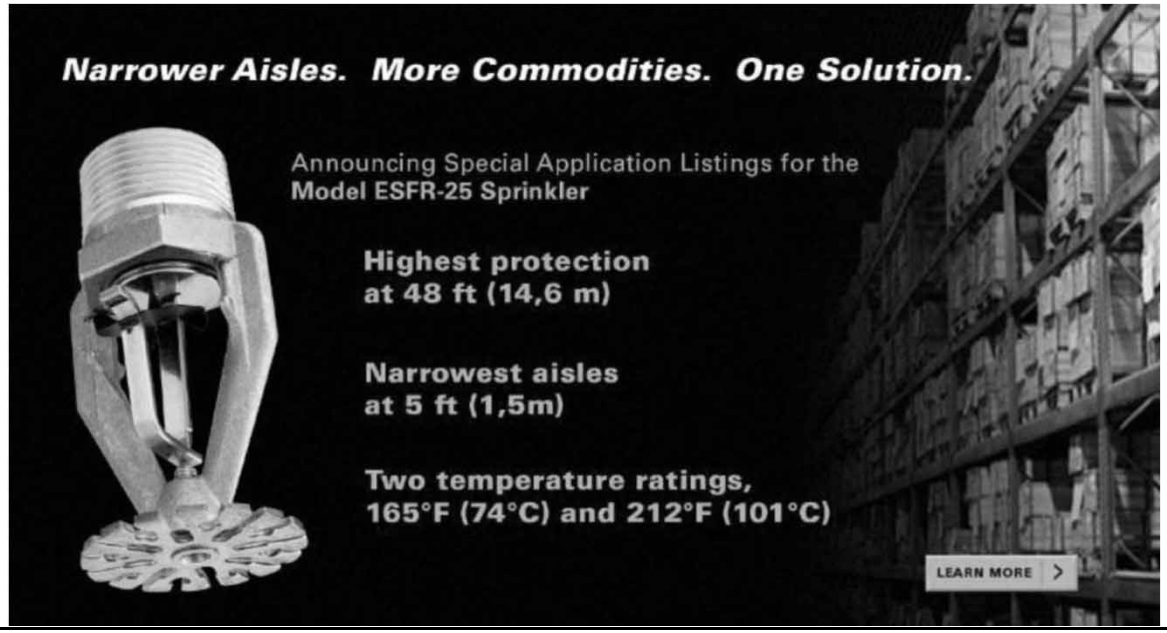
Comparison with ESFR K-25 vs K-22

- Conclusion from previous slid
  - The K-25 will have lower installed cost than the K-22:
  - Why?
    - Lower design pressures
    - Resulting in lower water demands.
  - The result gives normally smaller pipes and pumps

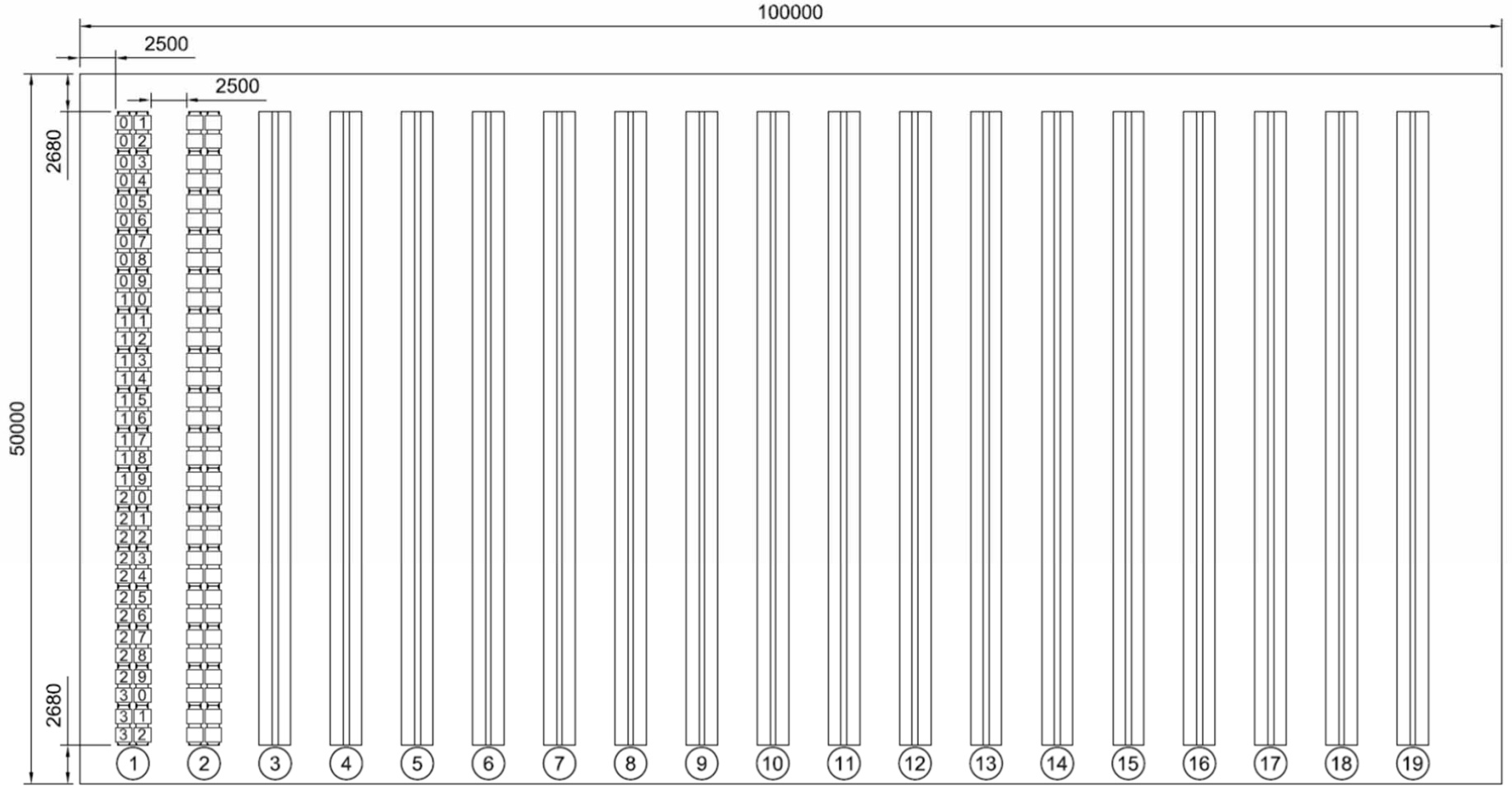
// ESFR Sprinkler Heads

Greater Installation Flexibility

- Narrower aisles
- Multiple Commodities
- One Solution
- Maximum Coverage Area of 9,3 m² / 100 ft²
- Ceiling storage protection of maximum 14,6 m / 48 ft. building height (UL only for single- and double row racks)

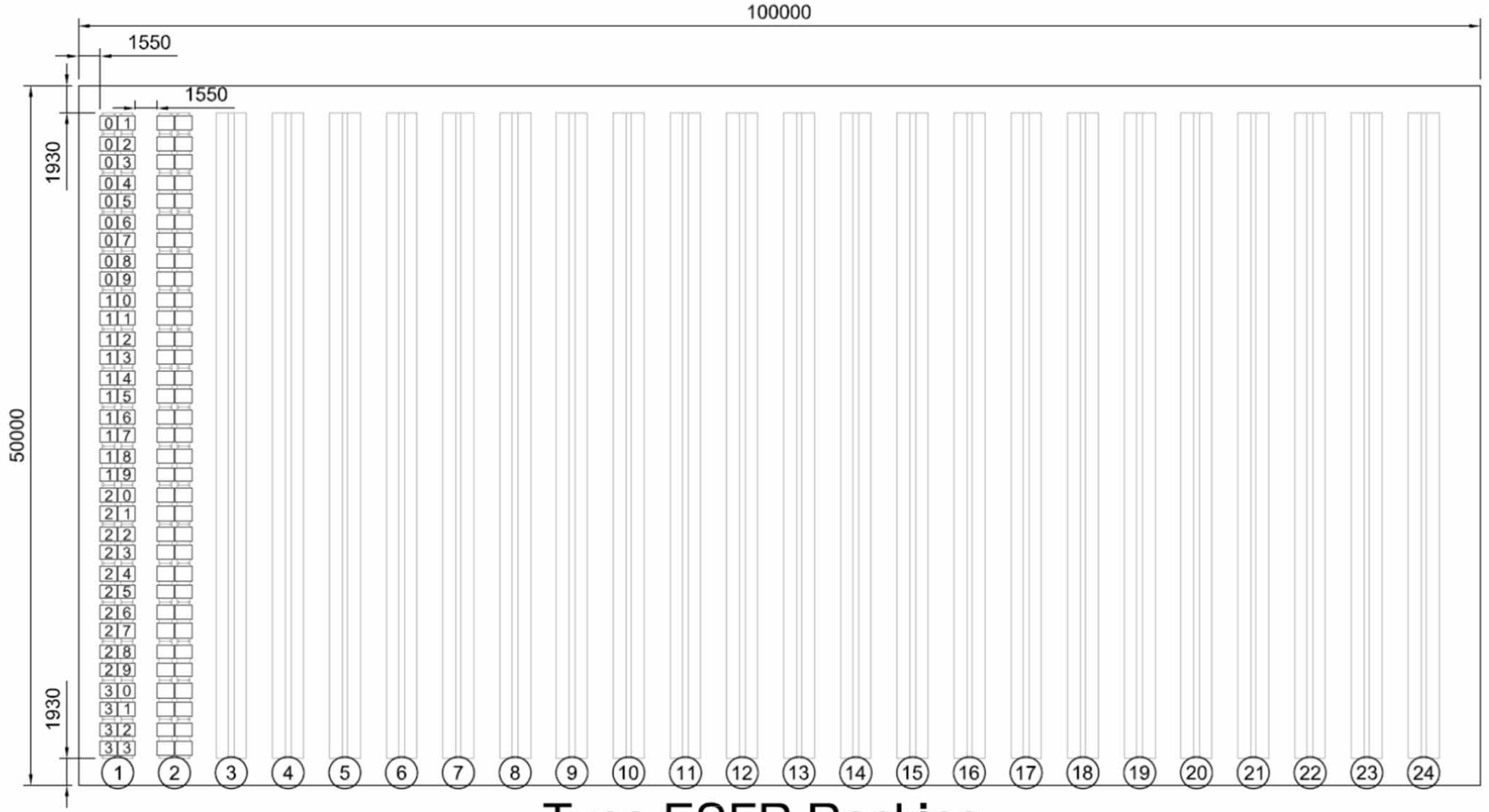


Storage with 8ft Aisle Width



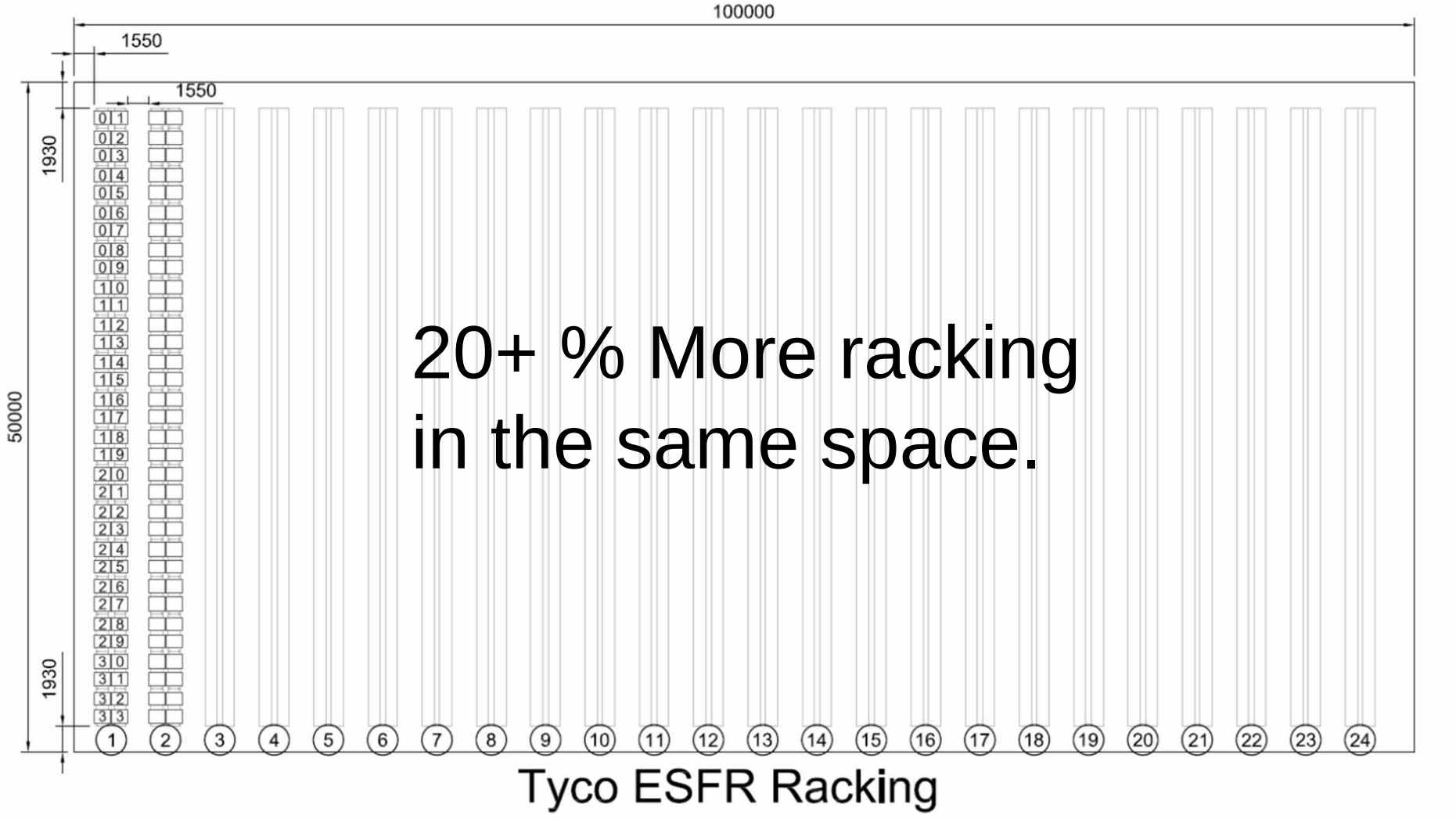
Competitor ESFR Racking

Storage with 5ft Aisle Width

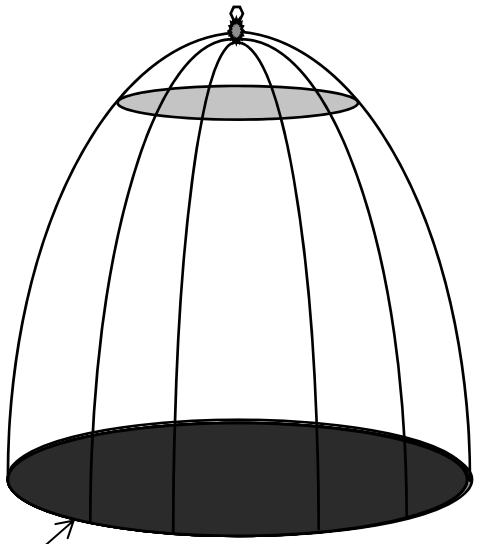


Tyco ESFR Racking

Storage with 5ft Aisle Width

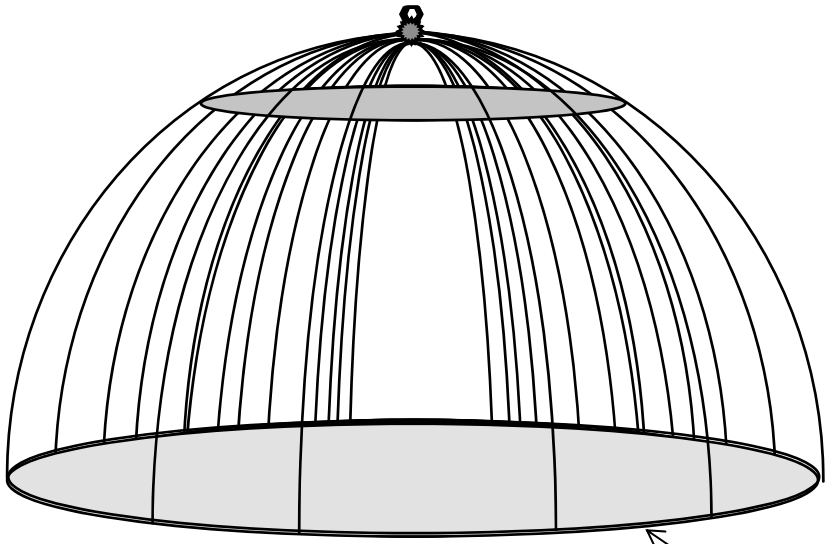


Alternative sprinkler design to ESFR is EC25



Standard Spray

100 sq ft / 9 sq m



Extended Coverage

196 sq ft / 18 sq m

Roughly 50% fewer sprinklers on an area basis

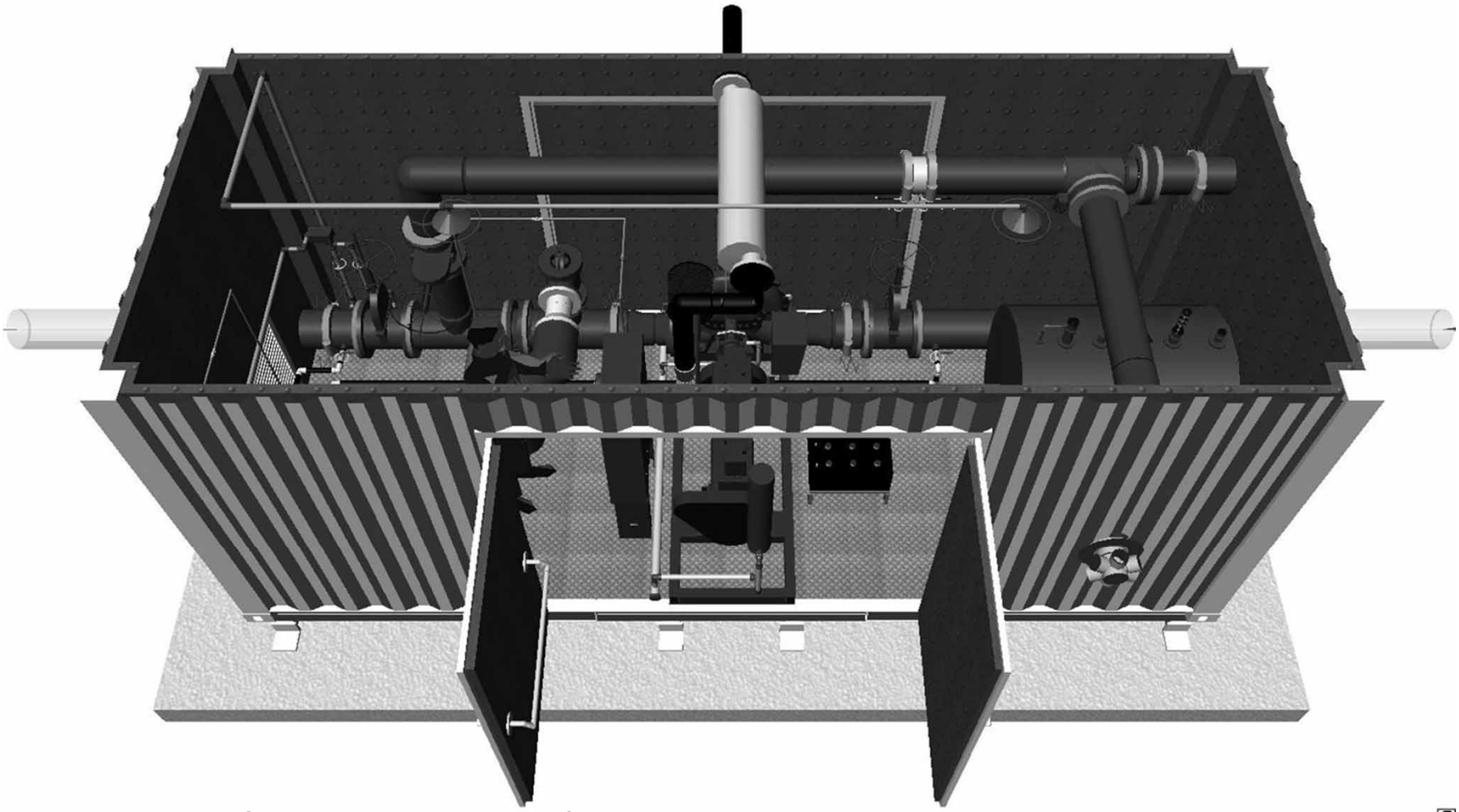
Alternative sprinkler design - EC25

- K25.2 (K360) Extended-coverage Storage sprinklers.

- Benefits:
  - Fewer required sprinklers (up to half)
  - Fewer branch lines
  - Fewer required connections
  - Less overall piping
  - Less installation labor

- Generally a very cost effective solution

Alternative sprinkler design - EC25



Pipe Size and Fire Pump Considerations

Alternative sprinkler design - EC25

- EC K25.2 (K360) Extended-coverage Storage sprinklers has flexible design and is economical

- Max Storage Commodity class:
  - Class IV & Cartoned unexpanded plastic

Example of NFPA Design criteria EC K25:
(table 21.2.2)

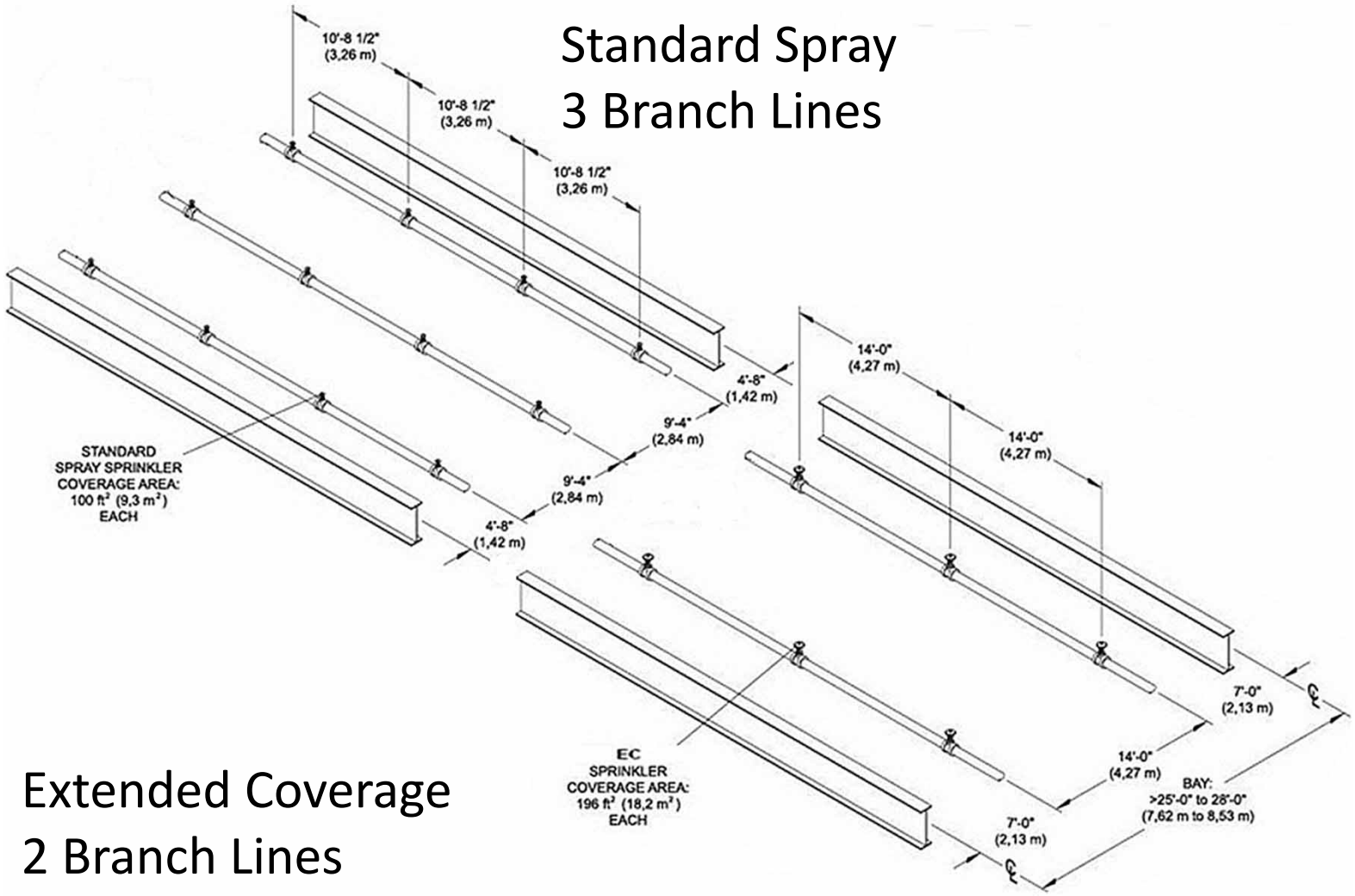
- Max 11m ceiling height
- Max 9,1m storage height
- 18m2 coverage area per sprinkler (normal 9m2)

Alternative sprinkler design - EC25

- Features
  - Fewer sprinklers per square meter with coverage up to 18,21 m2
  - Fewer branch lines with spacing up to 4,6 m
  - Lower operating pressures (NFPA) minimum 0,48 bar

EC -25 - Fewer Branch Lines

Standard Spray
3 Branch Lines



Extended Coverage
2 Branch Lines

Example – ESFR 14 Versus EC-25

FM Global Protection Guidelines

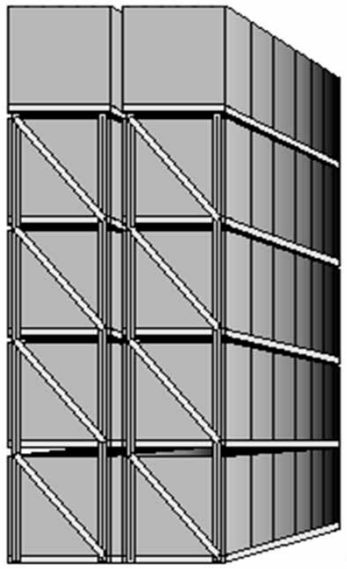
- Ceiling Height: 30 Ft / 7,5 m
- Class 4 and Cartoned Unexpanded Plastics
- For a 215,280 ft2 / 20.000 m2 Warehouse between 40% - 50% fewer sprinklers
- EC-25: 1098 sprinklers
- ESFR 14: 2152 sprinklers

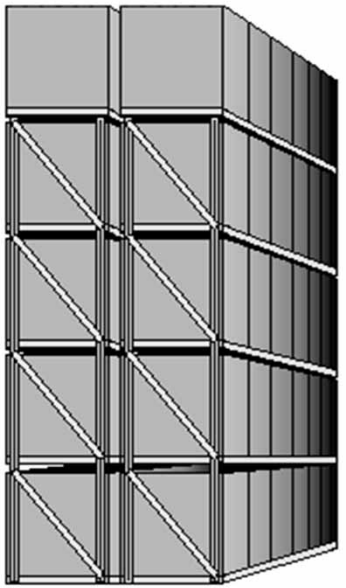


12 sprinklers @
50 psi / 3,5 bar
1,188 gpm / 4.490 lpm
100 ft² / 9 m²



6 sprinklers @
30 psi / 2,1 bar
828 gpm / 3.130 lpm
196 ft² / 18 m²

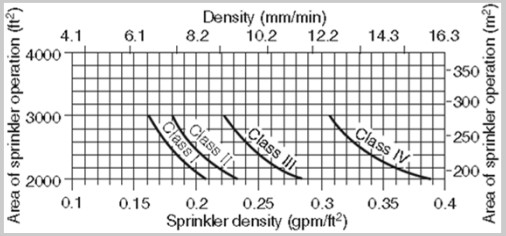




ESFR vs EC K25 (FM 8-9 Example - 30 ft (9.1m) Class IV Palletized Storage under a 35 ft (10.6m) Ceiling – Wet System - *Table 3. Ceiling-Level Protection Guidelines for Class 4 and Cartoned Unexpanded Plastic Commodities in a Solid-Piled, Palletized, Shelf, or Bin-Box Storage Arrangement*

Ceiling Height, ft (m)*	Wet System, Pendent Sprinklers, 160°F (70°C)**									
	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)
15 (4.5)	20 @ 7 (0.5)	12 @ 50 (3.5)	12 @ 35 (2.4)	12 @ 25 (1.7)	12 @ 20 (1.4)	6 @ 20 (1.4)	20 @ 7 (0.5)	20 @ 7 (0.5)	12 @ 16 (1.1)	12 @ 7 (0.5)
Without Hose	2,263	4,490	4,462	5,007	5,111	2,556	2,263	2,828	3,524	3,055
With hose	4,163	5,440	5,412	5,957	6,061	3,506	4,163	4,728	4,474	4,005
20 (6.0)	15 @ 20 (1.4)	12 @ 50 (3.5)	12 @ 35 (2.4)	12 @ 25 (1.7)	12 @ 20 (1.4)	6 @ 20 (1.4)	15 @ 20 (1.4)	15 @ 15 (1.0)	12 @ 16 (1.1)	12 @ 7 (0.5)
Without Hose	2,840	4,490	4,462	5,007	5,111	2,556	2,840	3,000	3,524	3,055
With hose	4,740	5,440	5,412	5,957	6,061	3,506	4,740	4,900	4,474	4,005
25 (7.5)	15 @ 50 (3.5)	12 @ 50 (3.5)	12 @ 35 (2.4)	12 @ 25 (1.7)	12 @ 20 (1.4)	6 @ 20 (1.4)	15 @ 50 (3.5)	15 @ 35 (2.4)	12 @ 16 (1.1)	15 @ 10 (0.7)
Without Hose	4,490	4,490	4,462	5,007	5,111	2,556	4,490	4,648	3,524	4,518
With hose	6,390	5,440	5,412	5,957	6,061	3,506	6,390	6,548	4,474	6,418
30 (9.0)	20 @ 50 (3.5)	12 @ 50 (3.5)	12 @ 35 (2.4)	12 @ 25 (1.7)	12 @ 20 (1.4)	6 @ 25 (1.7)	20 @ 50 (3.5)	20 @ 35 (2.4)	12 @ 16 (1.1)	20 @ 10 (0.7)
Without Hose	5,987	4,490	4,462	5,007	5,111	2,816	5,987	6,197	3,524	6,024
With hose	7,887	5,440	5,412	5,957	6,061	3,766	7,887	8,097	4,474	7,924
35 (10.5)		12 @ 75 (5.2)	12 @ 50 (3.5)	12 @ 35 (2.4)	12 @ 30 (2.1)	8 @ 40 (2.8) Note 1			15 @ 25 (1.7)	12 @ 30 (2.1)
Without Hose		5,473	5,388	5,949	6,260	4,819			5,476	6,260
With hose		6,423	6,338	6,899	7,210	5,769			7,376	7,210
40 (12.0)		12 @ 75 (5.2)	12 @ 50 (3.5)	12 @ 45 (3.1)	12 @ 40 (2.8)					12 @ 30 (2.1)
Without Hose		5,473	5,388	6,761	7,229					6,260
With hose		6,423	6,338	7,711	8,179					7,210
45 (13.5)		12 @ 90 (6.2)	12 @ 65 (4.5)	12 @ 50 (3.5)	12 @ 50 (3.5)					
Without Hose		5,976	6,109	7,184	8,082					
With hose		6,926	7,059	8,134	9,032					

Storage Sprinklers – Ceiling System Design

Sprinkler Classification	Ceiling System Design Parameters	
Spray Sprinklers – (CMDA) Standard Coverage or Extended Coverage	Density / Area figures or given density/area from tables	
Control Mode Specific Application (CMSA)	Number of sprinklers at a given pressure	CMSA tables within storage chapters
Early Suppression Fast Response (ESFR)	Number of sprinklers at a given pressure	ESFR tables within storage chapters



Spray Sprinkler – Standard or Extended Coverage (CMDA)



Control Mode Specific Application (CMSA)



Early Suppression Fast Response (ESFR)

The future

What is the future?

- Higher warehouses
- Higher storage arrangement
- More plastic commodities
- Bigger EFSR K-factors

// Make it right, from the beginning !

// Make the right choose on our sprinkler design for storage application and you will have a big advantage:

- As Designer
- As Property owner
- As end user

// Any Questions?

